

Advances and Technical Challenges in Medical Image Processing

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Topics

- ▶ Diagnostic Imaging
- ▶ Milestones
- ▶ CT and PET
- ▶ Limitations and challenges in the radiology

Diagnostic imaging

- ▶ Empowers medical doctors to exclude, detect, characterize and eventually treat diseases
- ▶ Medicine today is unthinkable without imaging modalities
 - ▶ Computed Tomography,
 - ▶ Magnetic Resonance Imaging,
 - ▶ Ultrasound
 - ▶ Positron Emission Tomography
 - ▶ Combined hybrid technologies such as PET-CT and PET-MRI and image fusion
- ▶ This ranges from fetal ultrasound monitoring and early breast cancer screening to pre-operative planning of e.g. liver surgeries, to mention only a few applications.

Milestones in Radiology: from 1895



Wilhelm Conrad Roentgen
1845 - 1923



Foot with shoe, Boston 1896
Exposure time: 20 min



Godfrey Newbolt Hounsfield
1920 - 2004



Prototype CT scanner

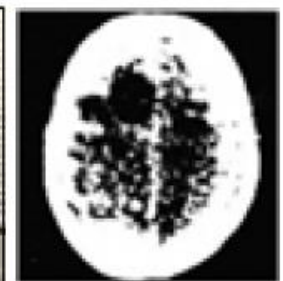
Scan time: 9 days
Reconstruction: 2.5 hrs
Print image: 2.0 hrs
Resolution: 80 x 80



Old Photography, New Photography
Life 27, 1986



Hounsfield and the first EMI Head Scanner



Early CT scan of
the human brain,
Atkinson-Morley
Hospital, London
1971

Milestones in Nuclear Medicine: from 1950



György de Hevesy
1885 - 1966

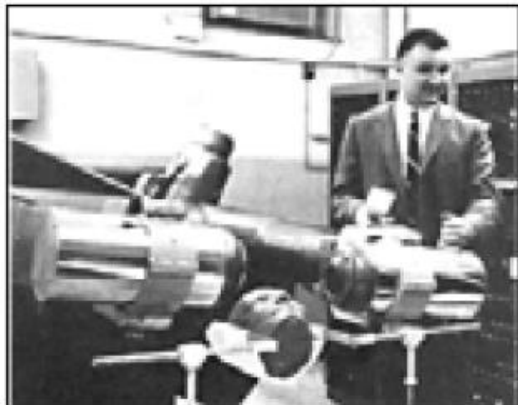
Developed the
Tracer Technique



Benedict Cassen (1902 – 1972)
Rectilinear scanner, 1951



Hal O. Anger (1920 – 2005)
Scintillation camera, 1957



David E Kuhl, Mark II scanner
(1974)



SPECT
Rotating Chair
1974



Tom Budinger



Gerd Muehllehner



Early PET scanner PC II, 1975



Gordon
Brownell



Michael Phelps

Milestones in Magnetic Resonance Imaging: from 1980



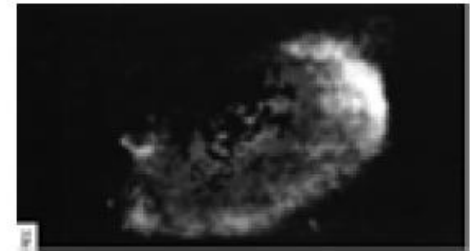
Paul Lauterbur
1929 - 2007



Peter Mansfield



Nottingham, UK, 1978



Mansfield, 1978



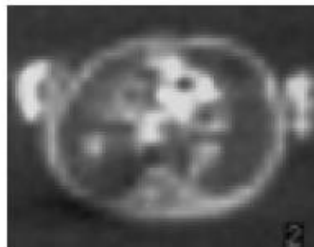
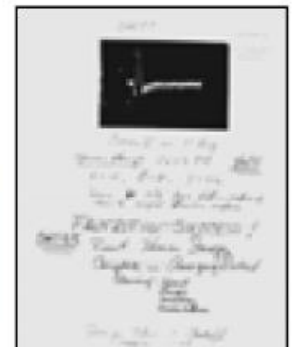
First patient, Aberdeen 1980



Nottingham, 1983



Raymond Damadian



Mansfield
1983

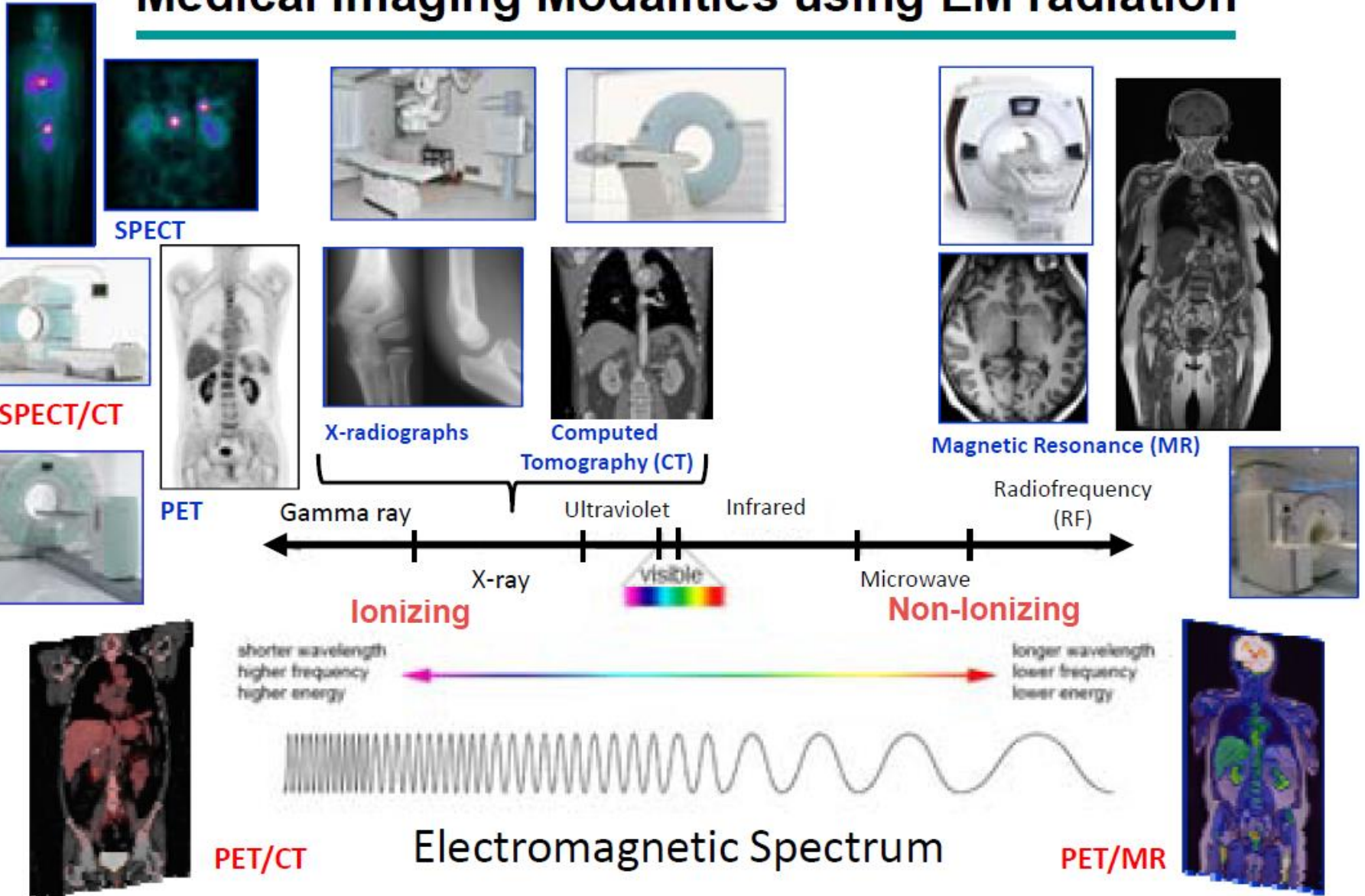


2004

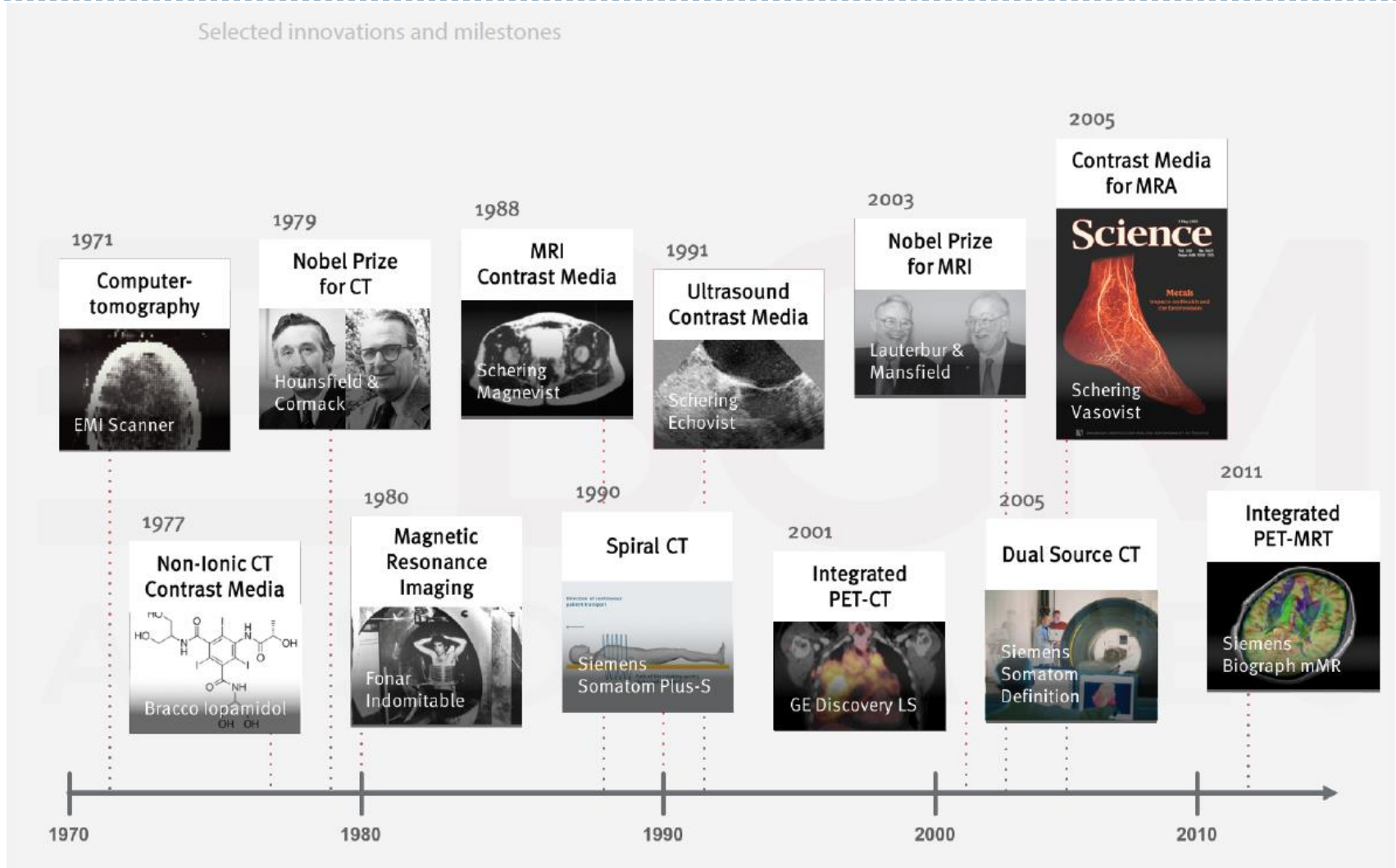


Damadian and coworkers, 1977

Medical Imaging Modalities using EM radiation



Summary – Selected Innovations and Milestones



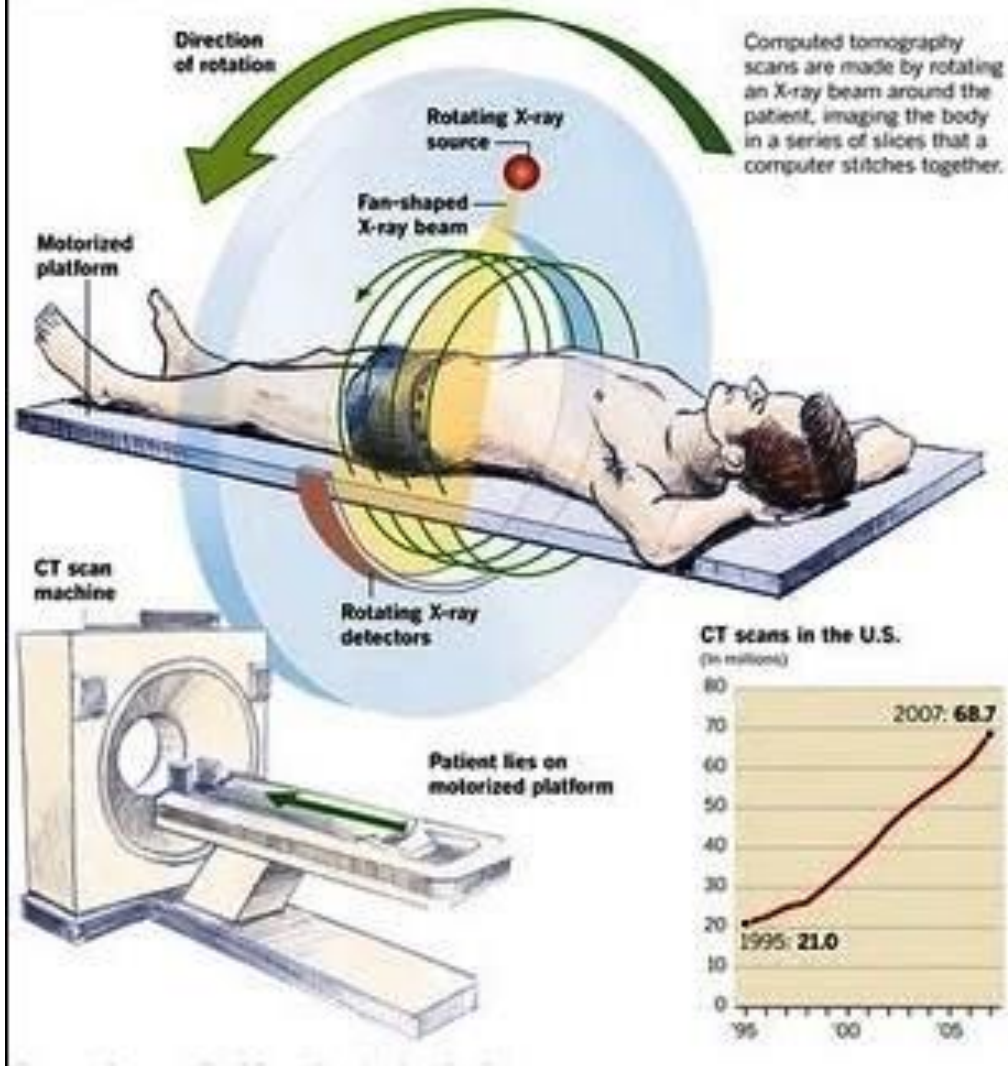
Ionizing: Transmission and emission imaging

Use of ionizing radiation for passive (transmission) and active (emission) imaging. In passive imaging, the radiation source is external whereas in active imaging the source is injected into the patient.

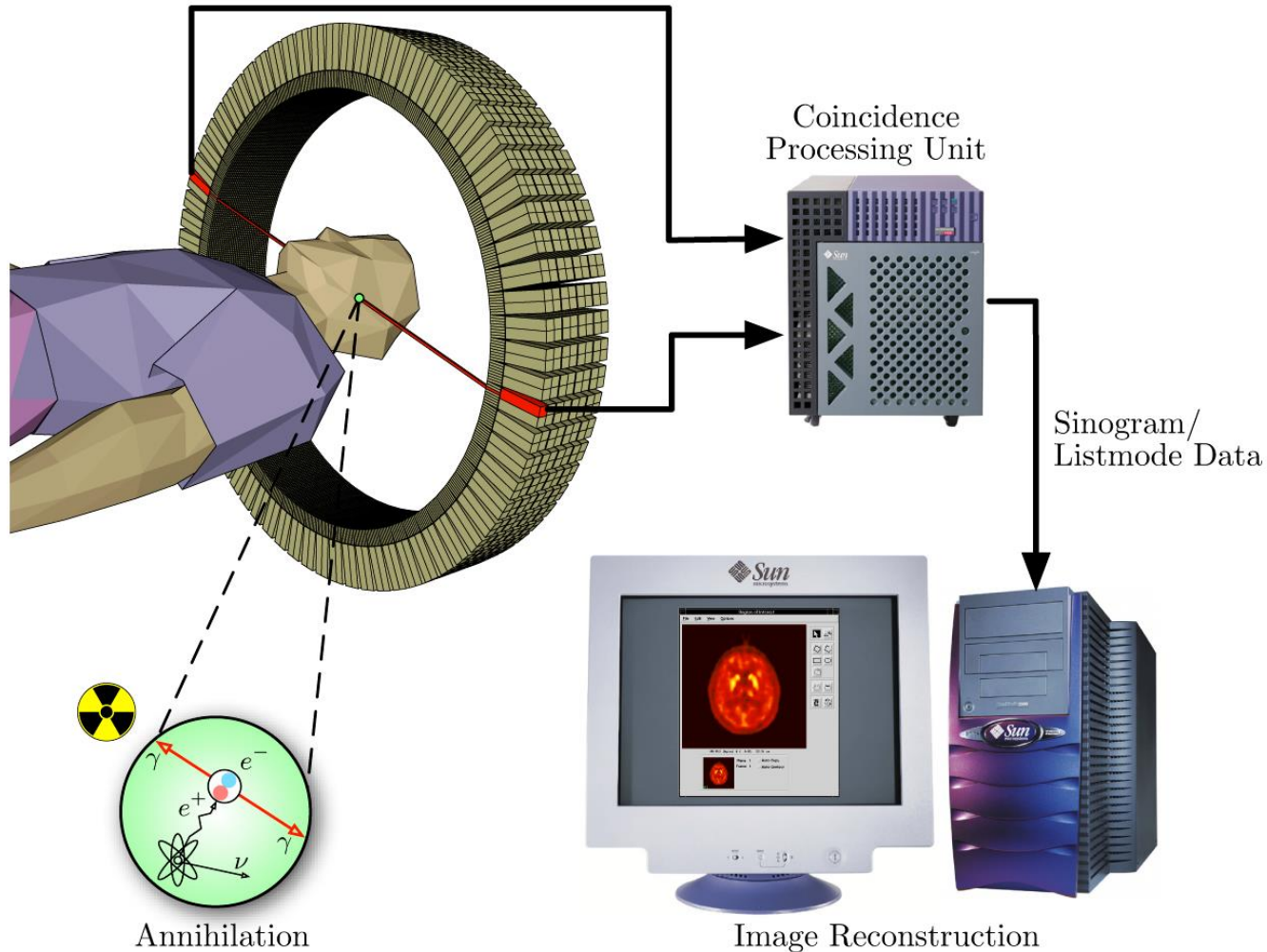
Ionizing: Transmission tomography

Anatomy of a CT scan

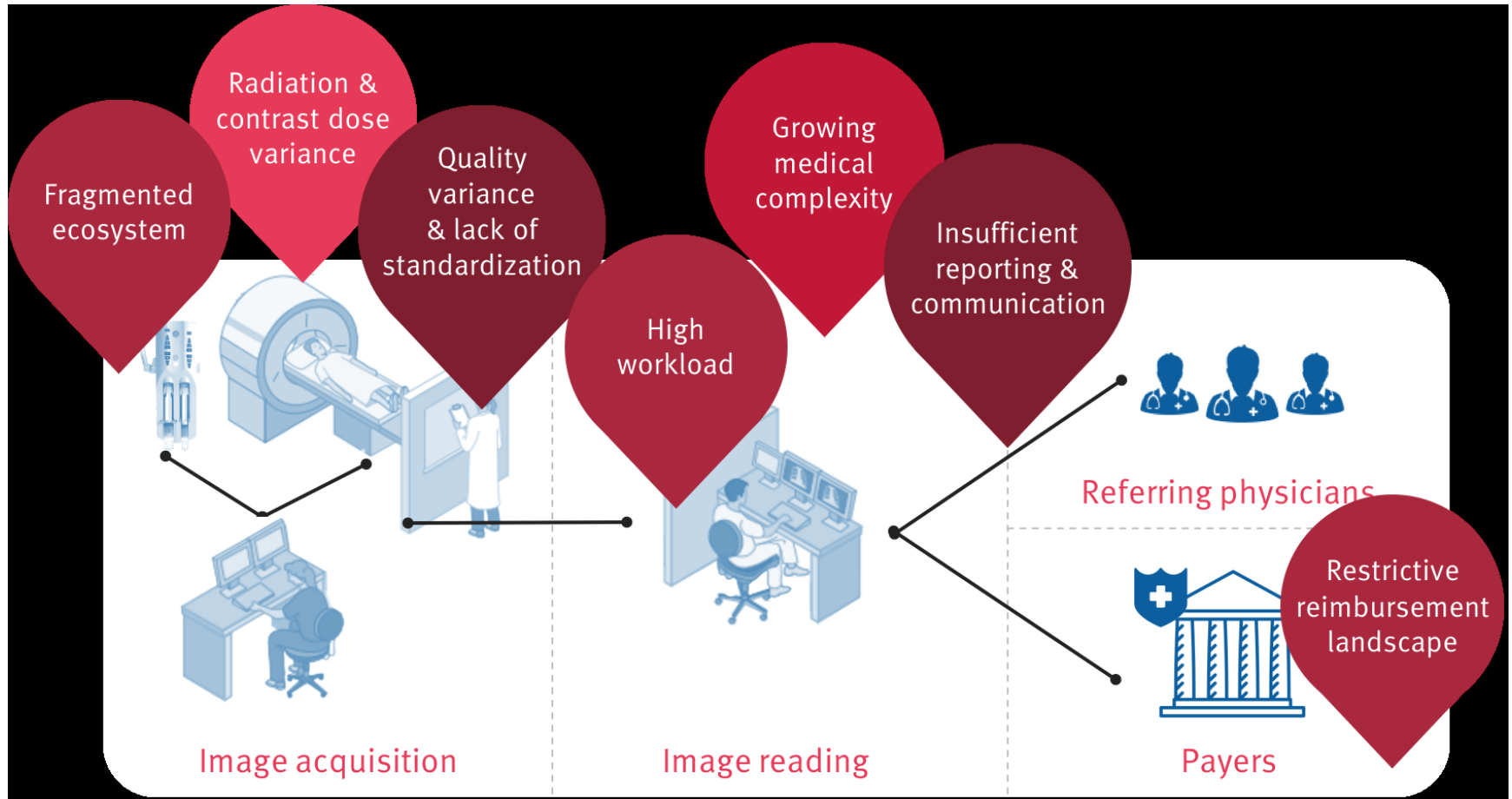
CT scanners give doctors a 3-D view of the body. The images are exquisitely detailed but require a dose of radiation that can be 100 times that of a standard X-ray.



Ionizing: Emission tomography



Limitations and challenges in the radiology



Limitations and challenges in the radiology

- ▶ (I) Fragmented ecosystem and outdated equipment
 - ▶ The radiology ecosystem – namely scanner, PACS workstation, image archive, contrast media and injectors – remains largely fragmented today: the devices do barely communicate with each other and are insufficiently geared to each other.
 - ▶ For instance, radiology technicians in many hospitals still have to note contrast media injection parameters in a dedicated book, which is time consuming and makes follow-ups difficult and quality management impossible.
 - ▶ This issue is accentuated by the fact that there is a large number of outdated imaging systems installed, which produce insufficient image quality at too high doses and are difficult to integrate with other systems.

Limitations and challenges in the radiology

- ▶ (2) Quality variance & lack of standardization
 - ▶ Both image acquisition and image interpretation highly depend on the individual equipment and operator experience and training.
 - ▶ Hence, there is great potential for improvement through standardization
 - ▶ As a result of quality variance, the radiological discipline gets increasingly under pressure by payors and referring physicians.

Limitations and challenges in the radiology

- ▶ (3) Radiation and contrast dose variance
 - ▶ Recent studies and shed more light on the large variance of both radiation and contrast media dose in CT imaging.
 - ▶ Despite the great achievements of radiation and contrast media dose reduction through modern imaging and injection equipment, individual imaging and injection protocols still cause risky overdosing in some CT exams.

Limitations and challenges in the radiology

- ▶ (4) High workload
 - ▶ Radiologists and technicians face an ever-growing workload due to the large number of imaging examinations as well as the quantity of images that needs to be read per study.
 - ▶ This holds true across the globe and is accentuated by country-specific circumstances.
 - ▶ In China, a case in point of other emerging countries, demand for imaging studies grows faster than buildup of imaging capacity resulting in tremendous workload, reducing the time per patient, which, in turn, increases the risk of suboptimal imaging procedures and reading errors.

Limitations and challenges in the radiology

- ▶ (5) Growing complexity & radiological education
 - ▶ While technological advances and increasing medical knowledge expand the areas of application of medical imaging and, hence, present a great gift for physicians and patients alike, they also make radiology ever more complex.
 - ▶ A look at the decision support database of the American College of Radiology gives an idea of the vast amount of options and application parameters in diagnostic imaging.
 - ▶ Against this background, '**clinical decision-support software**' has become a great subject of debate in the USA and shall become mandatory by 2017/2018.
 - ▶ Continued training is an effective means to ensure that novel scientific discoveries and technologies find their way into clinical practice.

Limitations and challenges in the radiology

- ▶ (6) Reporting & communication
 - ▶ Referring physicians, in particular, demand radiologists to standardize their reporting.
 - ▶ Radiologists' reports often lack standardized formatting and language.
 - ▶ This makes it more difficult for other radiologists and referring physicians to interpret the results and for software to automatically read and connect the findings to the patient data.

Limitations and challenges in the radiology

- ▶ (7) Restrictive reimbursement
 - ▶ In an environment of medical cost containment, radiology is no exception to the rule.
 - ▶ In the United States, for example, reimbursement rates were cut by almost 50% between 2000 and 2015.
 - ▶ Similar reductions can be seen in major European countries and in advanced Asian countries

Conclusion

- ▶ The incumbent imaging equipment manufacturers face increasing competition from new entrants, such as the South Korean electronics giant **Samsung** that has recently presented a **128-slice highend CT machine** with a **speed of 0.25 s per rotation**.
- ▶ China's Neusoft Medical that has recently received CE-clearance for its 128-slice CT machine in Europe, or also Mindray of China.
- ▶ It will be hard to compete with only incremental innovation and lifecycle management.
- ▶ These companies are closing the technology gap and build organic sales and service capabilities through partnerships, acquisitions and high-profile hires.
- ▶ These challengers will not only compete on price but also go for high-end solutions and incorporate incremental innovations.

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