Medical Imaging

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Medical Imaging

Introduction

- See inside the human (or animal) body?
  - Cut it open (i.e., surgery)
  - Medical imaging: less invasive method (or completely non-invasive)
- Metabolic / functional / molecular activities
  - Invisible to naked eye
- 2D signal $f(x, y)$ or 3D $f(x, y, z)$

Types

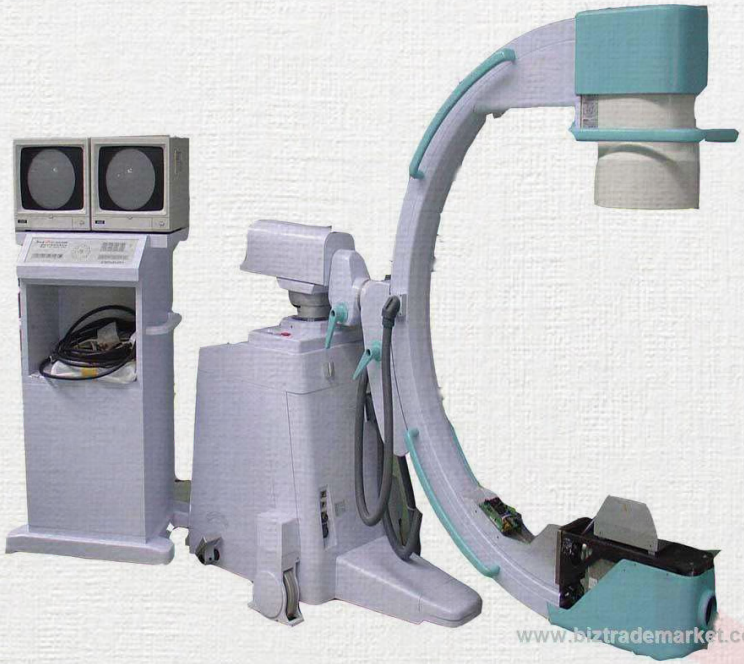
- Radiological technologies
  - X-ray (projection)
  - computed tomography (CT)
  - mammography
- Magnetic resonance imaging (MRI)
- Nuclear medicine imaging
  - single photon computed tomography (SPECT)
  - positron emission tomography (PET)
- Ultrasound (US)
- Other imaging techniques

Appliances

CT Scanner

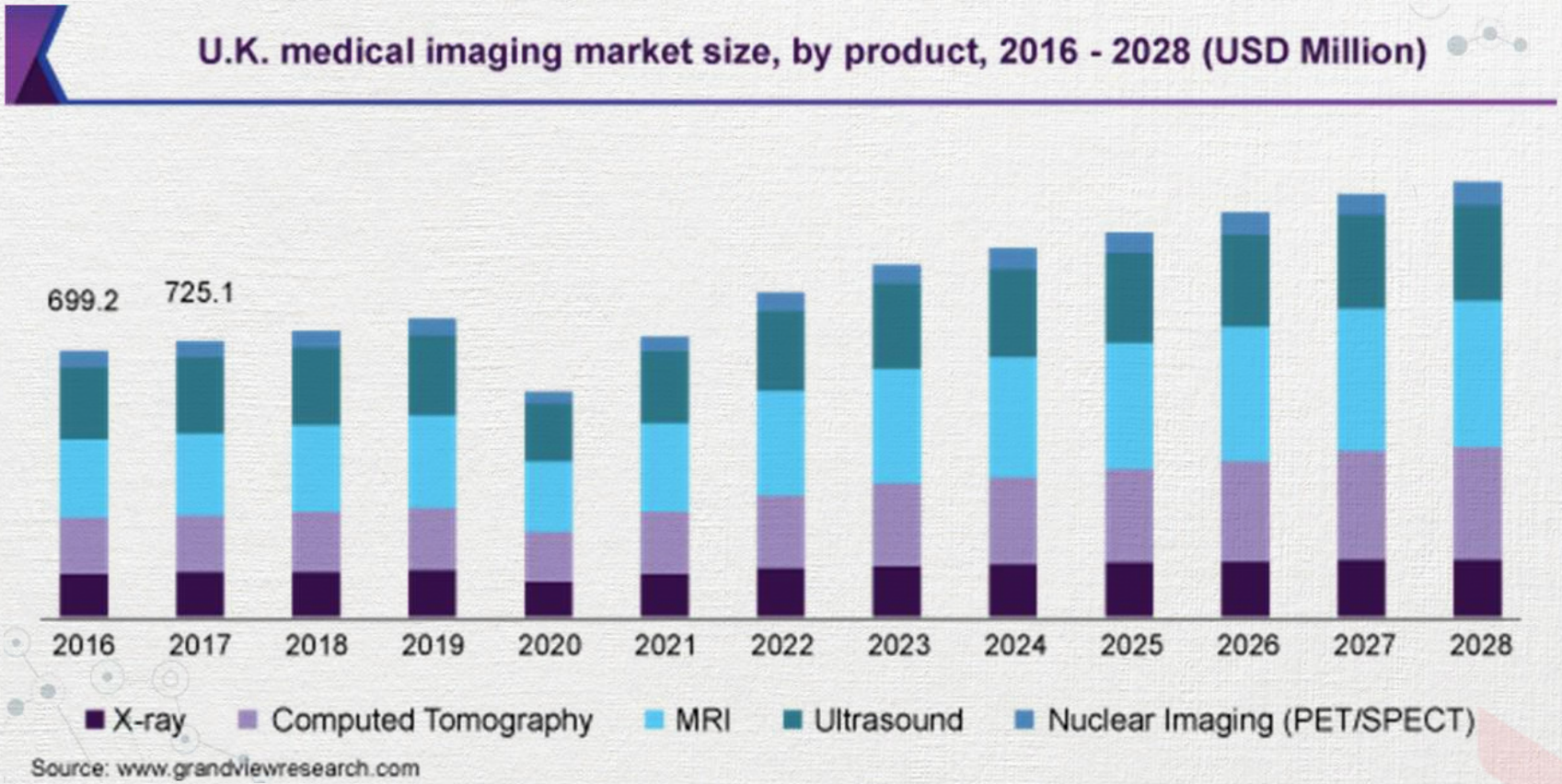
MRI Scanner

Appliances



X-ray Machine

Appliances



COVID-19 impact: 17% reduction during the pandemic

Invasive or not?

Ionizing vs. Nonionizing Radiation

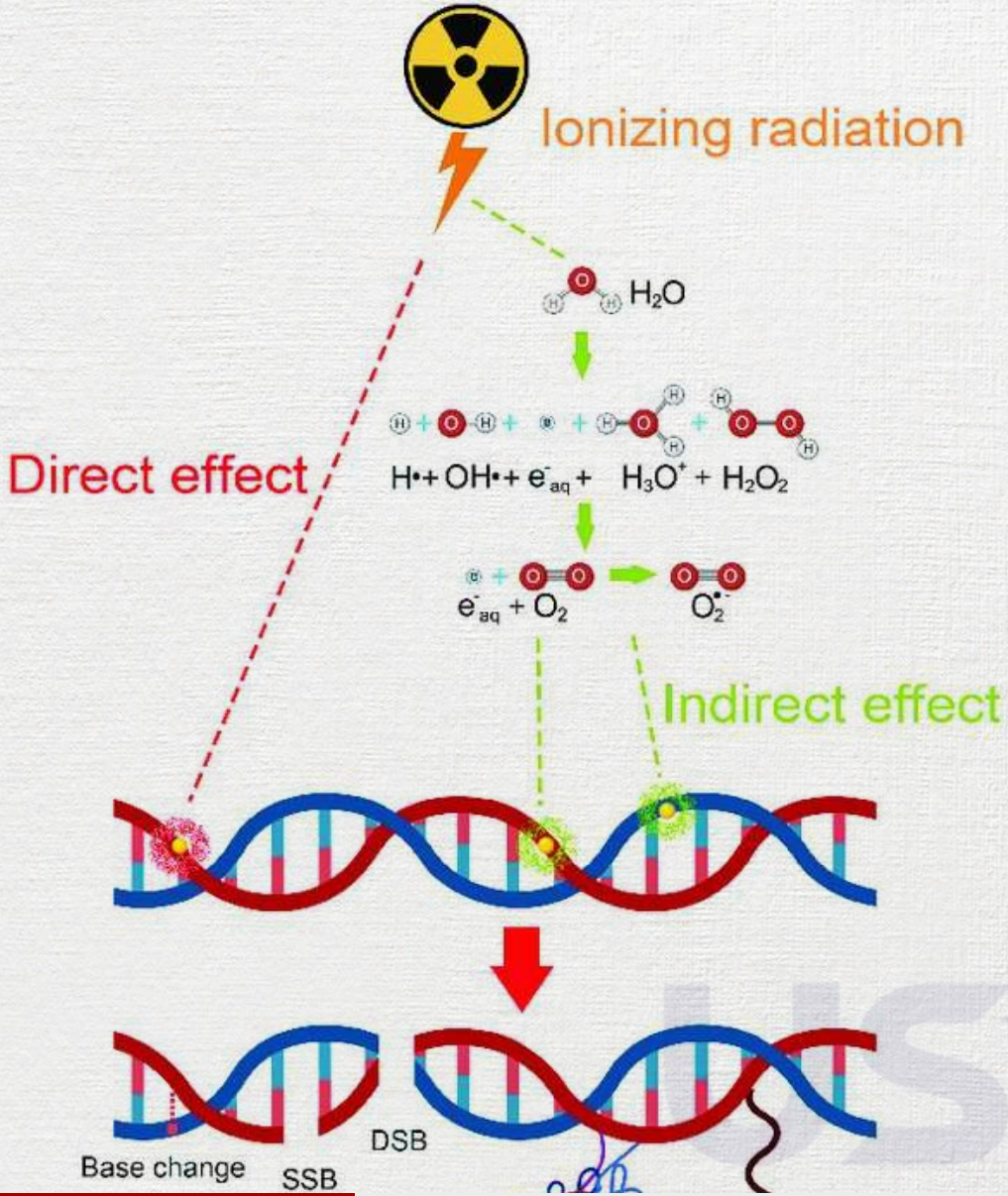
- Radiations can ionize biological molecules
  - X-ray, CT, mammography, SPECT, and PET
  - Cause DNA strand breaks
  - Increase the long-term risk for cancer
- Others (MRI, Ultrasound) do not radiate

Ionizing vs. Nonionizing Radiation

- The minimum energy required to ionize molecules is > 5–100 electron volts (eV).
- 1 eV = Energy acquired by an electron when accelerated across a potential difference of 1V

Type	Imaging procedure	Energy (eV)
Ultrasound waves	US	$< 0.000\ 000\ 04$
Radiofrequency	MRI	< 0.001
X-Rays	X-ray, CT	1,000 – 10,000
γ-Rays	SPECT, PET	100,000 – 500,000

Ionizing vs. Nonionizing Radiation



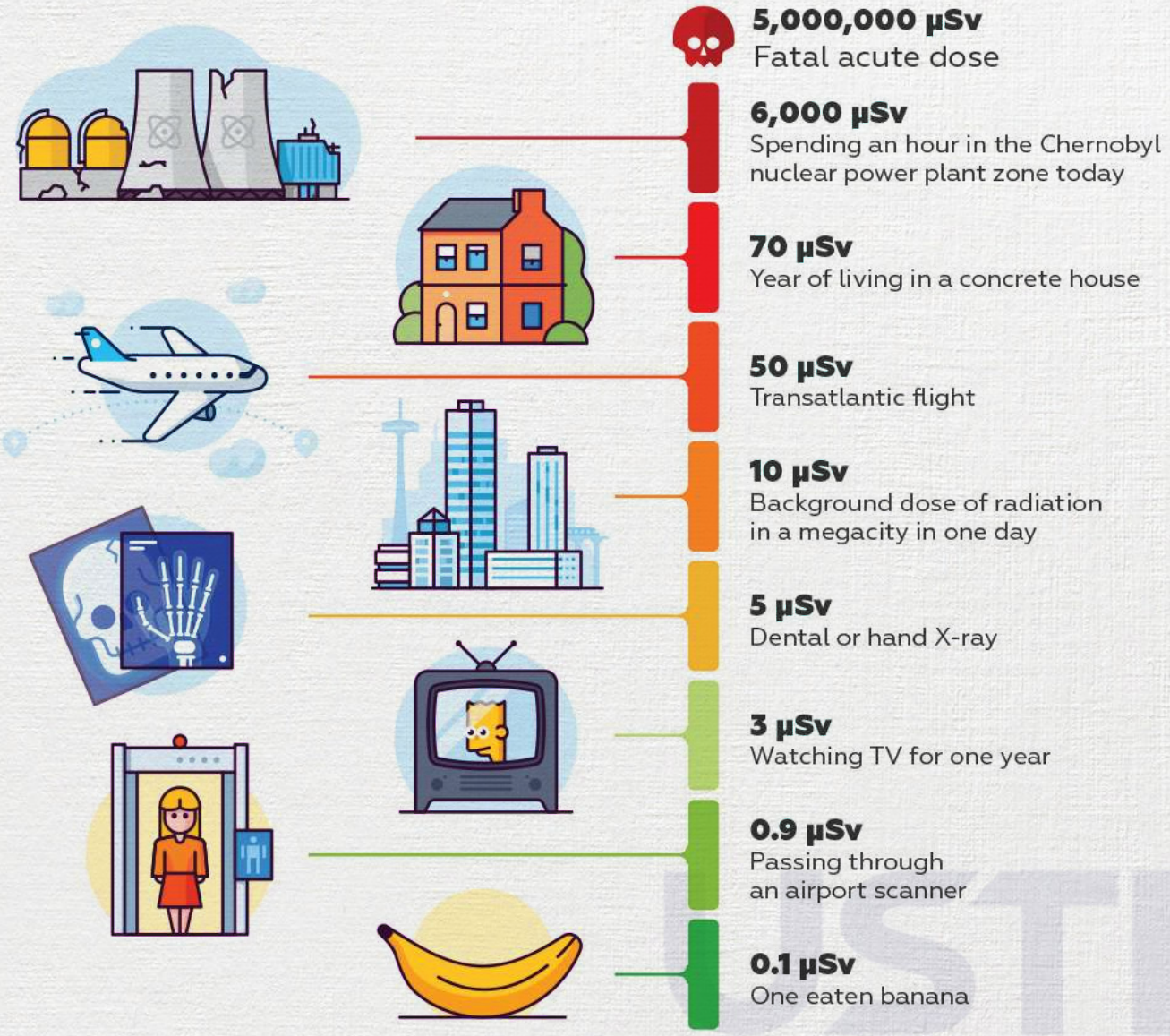
Radiation Doses

- The energy deposited per unit mass of tissue by radiation
- Unit: Sievert (Sv) or rem
  - 1 sievert (Sv) = 100 rem
  - 1 millisievert (mSv) = 0.1 rem

Radiation Doses

Imaging procedure	Modality	Radiation dose (mSv)
Chest	X-ray	0.02–0.04
Lumbar spine	X-ray	0.7
Mammogram	X-ray	0.7
Abdomen	CT	10.0
Coronary angiogram	CT	4.6–15.8
Bone scan (^{99m}Tc-MDP)	SPECT	4.2
V/Q lung scan (^{99m}Tc-MAA/^{99m}Tc aerosol)	SPECT	2.0
Renal scan (^{99m}Tc-MAG_3)	SPECT	3.6–5.2
Myocardial perfusion scan (^{99m}Tc-sestamibi/^{99m}Tc-tetrofosmin)	SPECT	11.2
Whole body scan (^{18}FDG)	PET	14.0

Radiation Doses



Comparison

Method	Chest	Abdomen	Head	Cardiovascular	Skeletal/ muscular
CT	Gold Standard	Need contrast for excellency, widely used	Good for trauma	Gold standard	Gold standard
US	No use, except heart	Problems with gas	Poor	Poor	Elastography
Nuclear	Extensive use in heart and therapy in lung	CT or MRI is merged	Pet	Perfusion	Bone marrow
MRI	Growing cardiac applications	Increased role of MRI	Gold standard	Will replace ct in near future	Excellent