Are we too reliant on medical imaging?

Delivering modern health care in 2022

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Medical Imaging

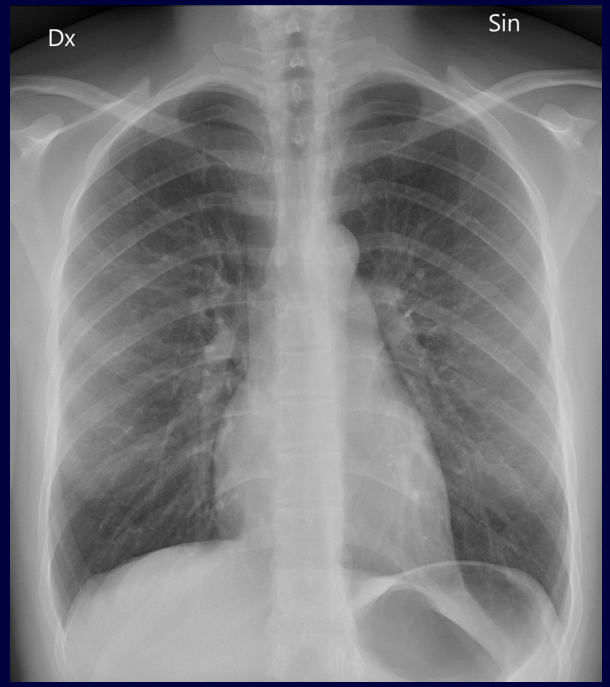
What is it ?

Diagnosis, surveillance, screening, treatment

Why important ?

Risks of over-scanning vs under-scanning

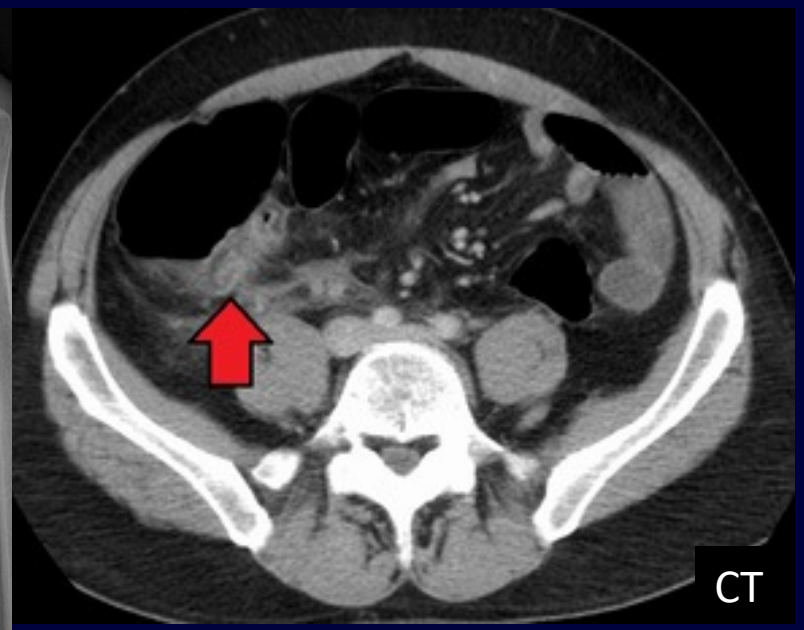
Impact of COVID-19 pandemic?

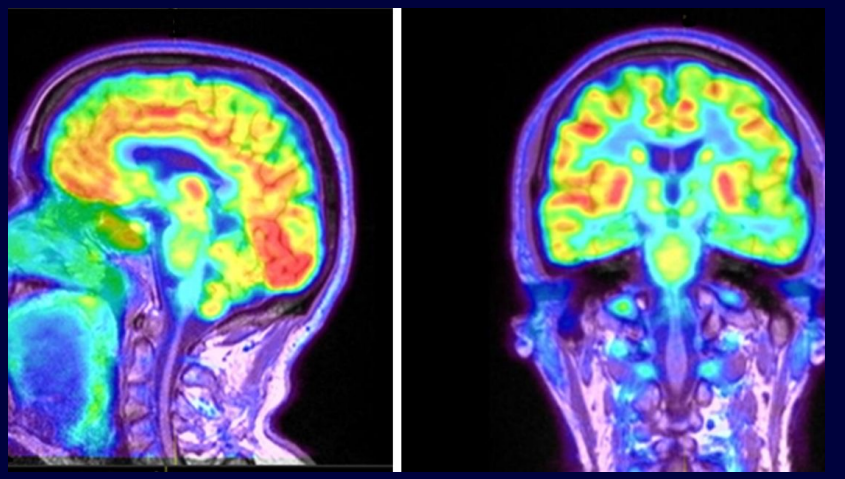


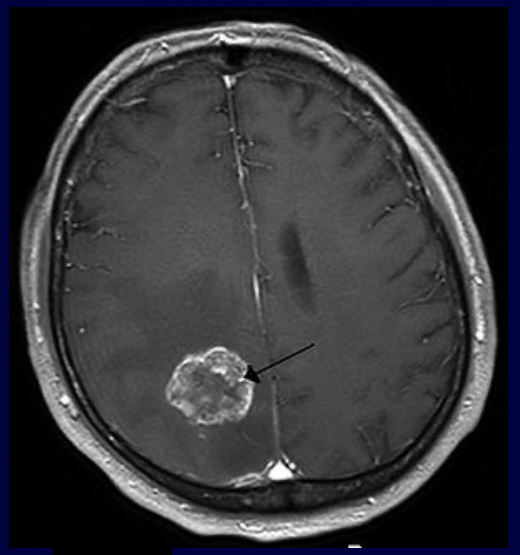
XR

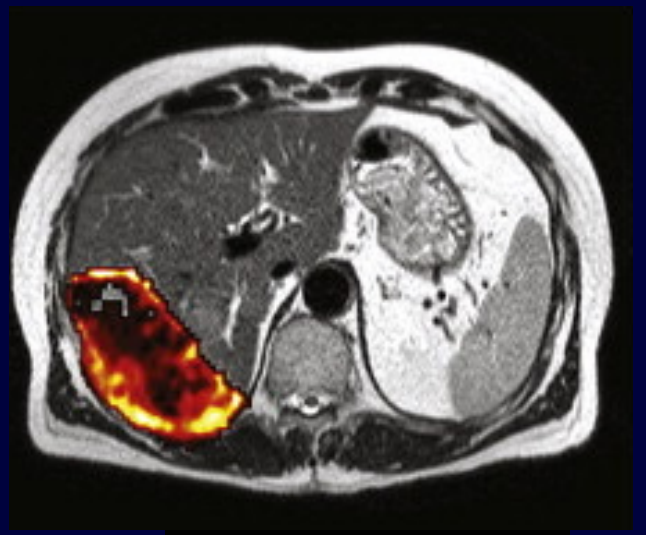
US


Contrast

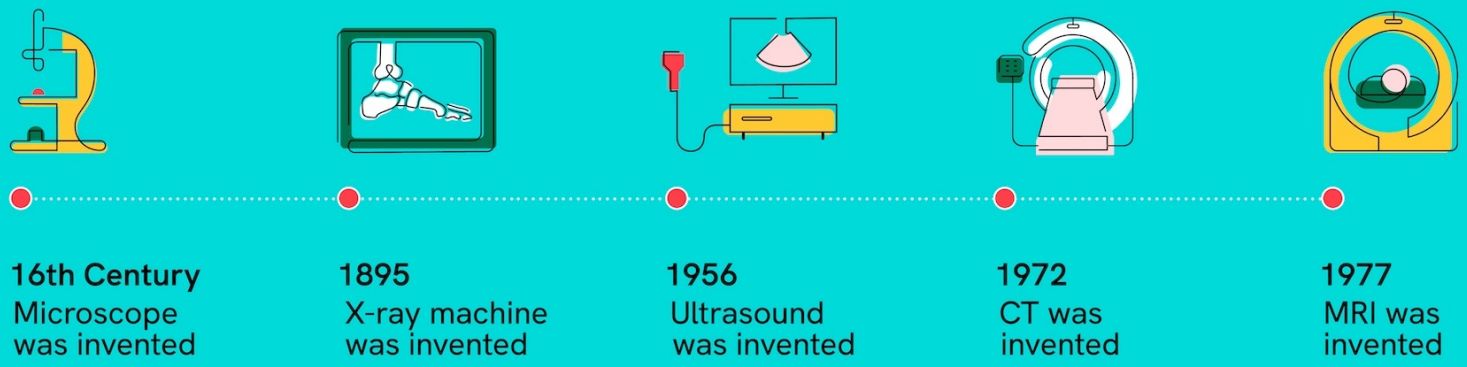

CT


PET scan


MRI


Molecular imaging

Medical Imaging



16th Century
Microscope was invented

1895
X-ray machine was invented

1956
Ultrasound was invented

1972
CT was invented

1977
MRI was invented

https://chanzuckerberg.com/blog/the-past-present-and-future-of-medical-imaging/

Medical Imaging

Medical Imaging

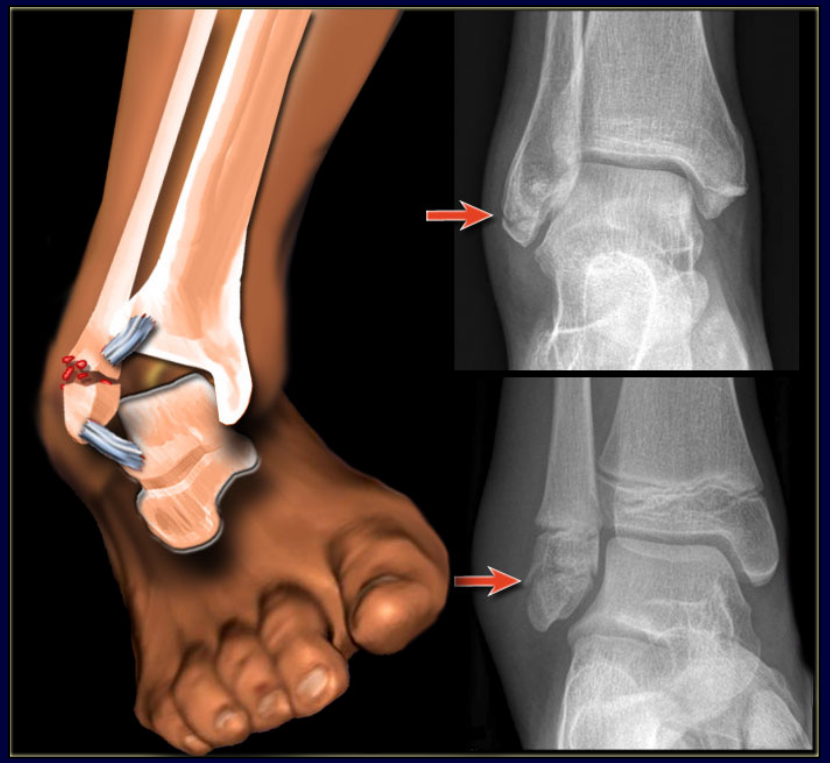
Medical Imaging improves healthcare

Radiology is in the diagnostic pathway in almost every specialty.
Rapid access to imaging is key

Making diagnoses - who needs what?
e.g. Trauma, Stroke imaging

Early diagnosis
e.g. Cancer pathways

Monitoring & surveillance
e.g. Pregnancy scanning



What is medical imaging?

High Tech Scanner

Radiologist

Radiographer, Technologist
Sonographer

+ Admin team
+ Physics support
+ IT & PACS support
+ Assistant Practitioners

Redevelopment Linkoping University Hospital, Sweden
Philips Healthcare

What is “too reliant”?

Risks of under-imaging

- Mistakes, Missed diagnoses
- Delays in treatment - patient
- Fear of being sued - doctor

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Risks of over-imaging

- Scan where no clinical benefit
- Exposure to radiation - patient
- Incidental findings causing anxiety - patient
- Volume (clogging up system) = waiting lists

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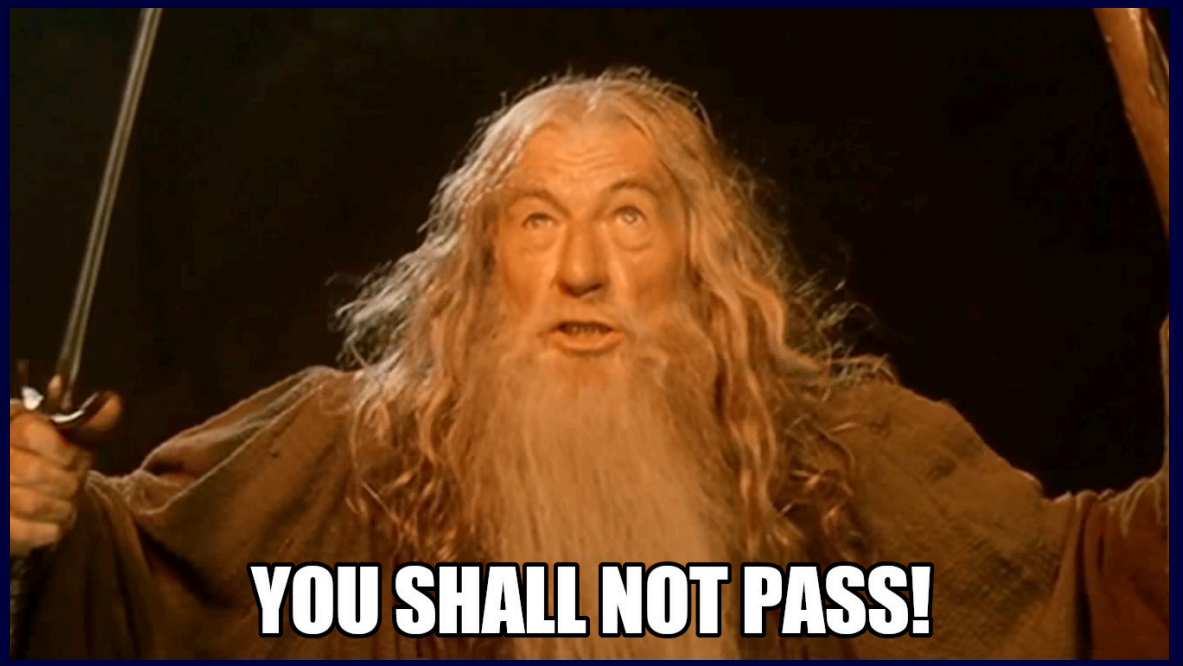

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How big is the problem ?

NHS carries our 43 million radiological procedures per year NHS
120,000 radiological procedures in England per DAY
Increasing by 1.3 million per year

2012 – 2019
Demand for CT doubled from 250,000 to 500,000 / month
Demand for MRI rose from 170,000 to 320,000 / month
Demand now outstrips capacity

GIRFT – RCR
https://www.gettingitrightfirsttime.co.uk/radiology-report/

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Increasin

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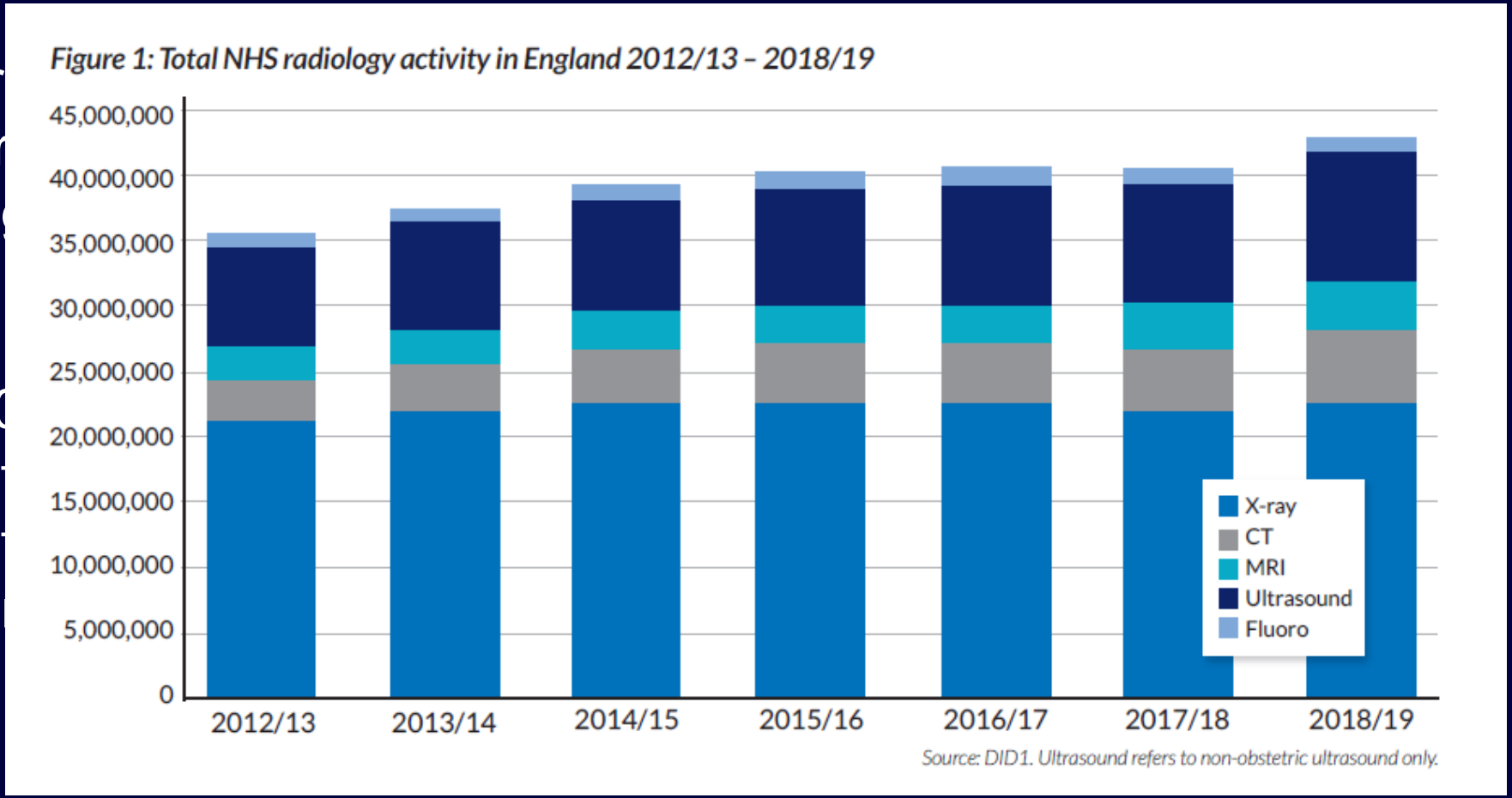

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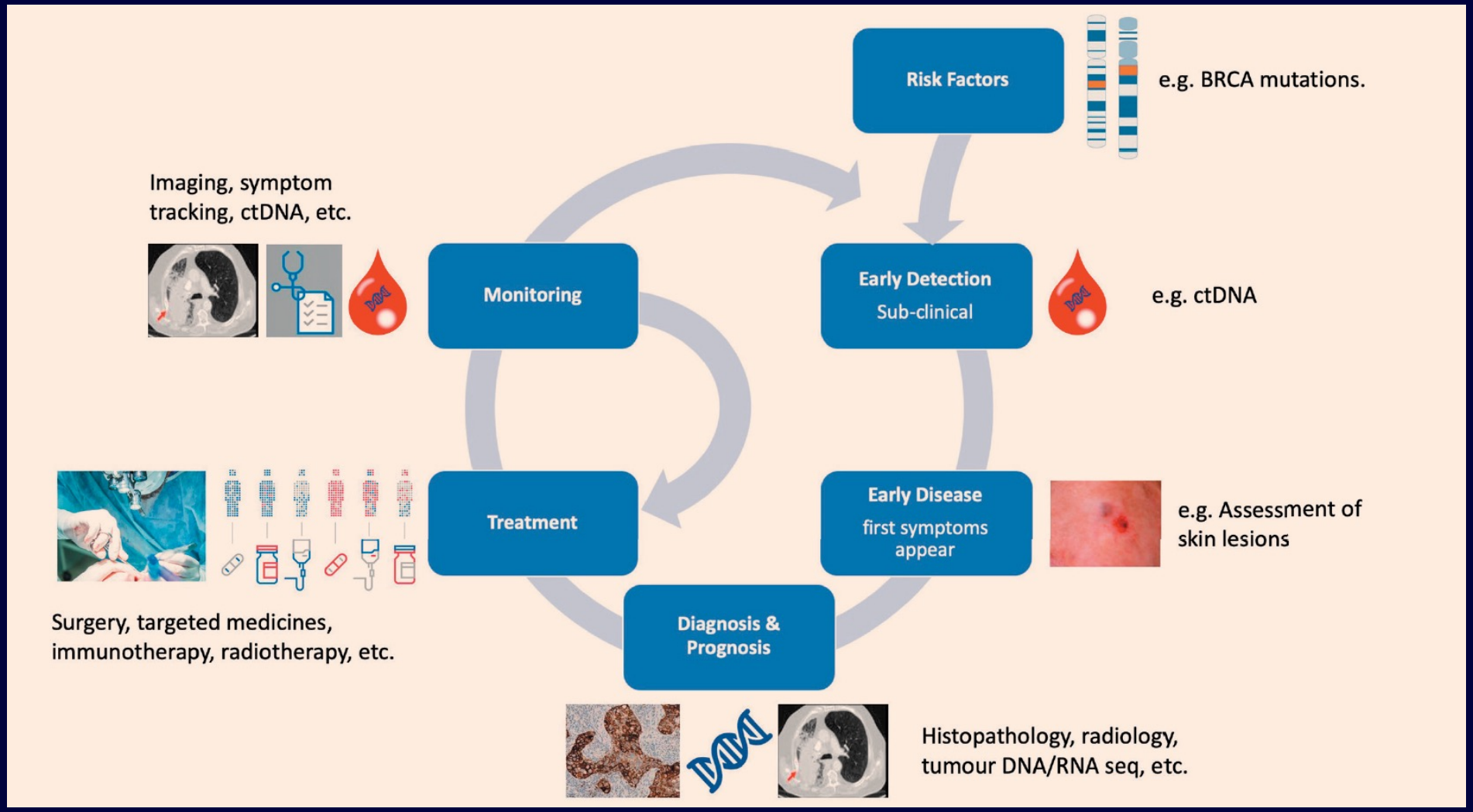
Medical Imaging



Medical Imaging

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4. Screening
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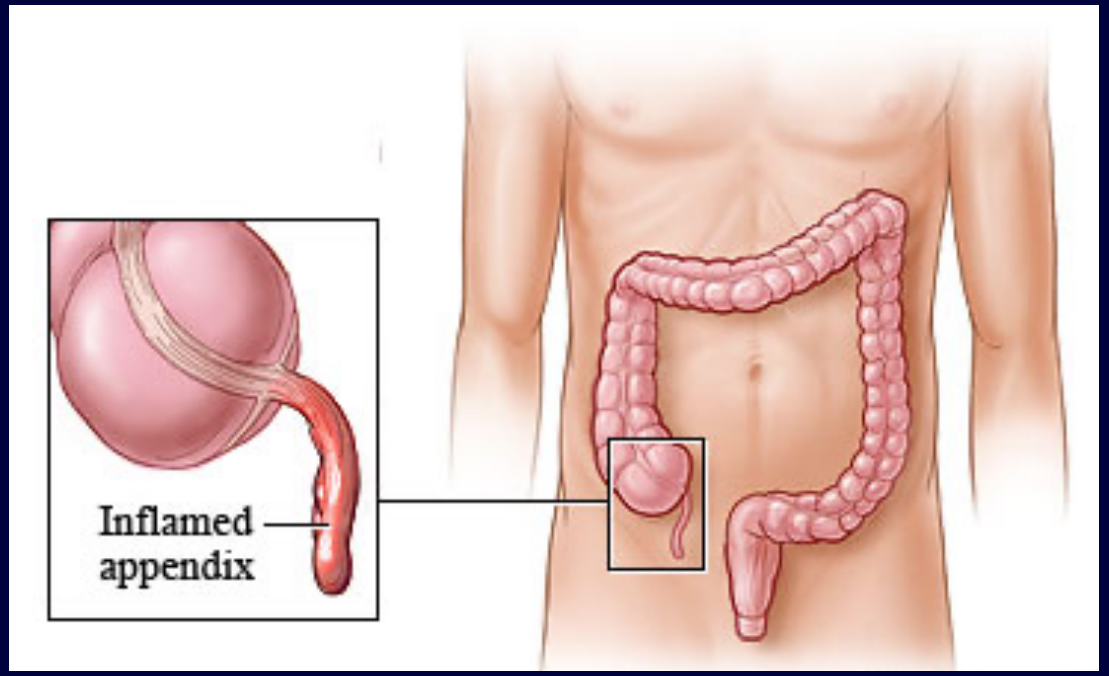
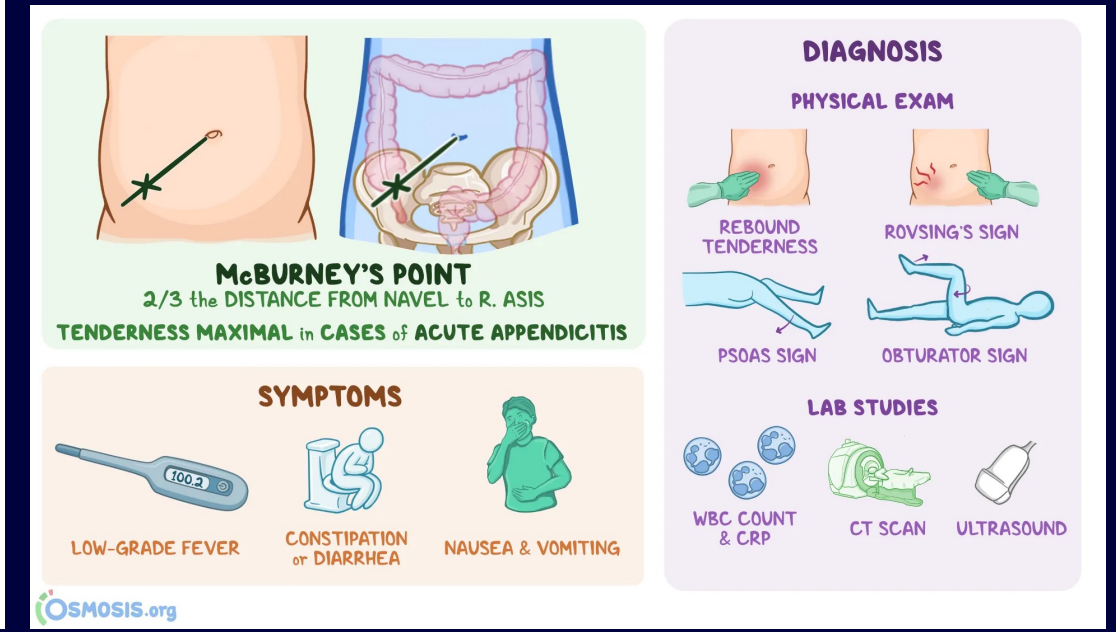
Medical Imaging

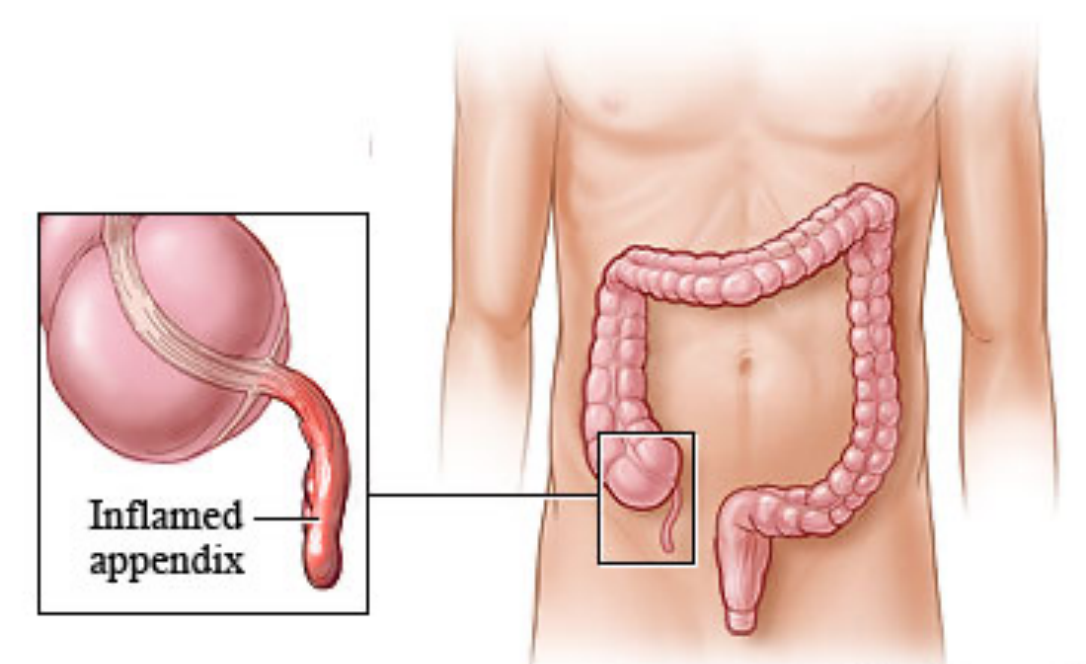
Appendicitis





Medical Imaging

Why do we need imaging ? What about the “good old days” ?



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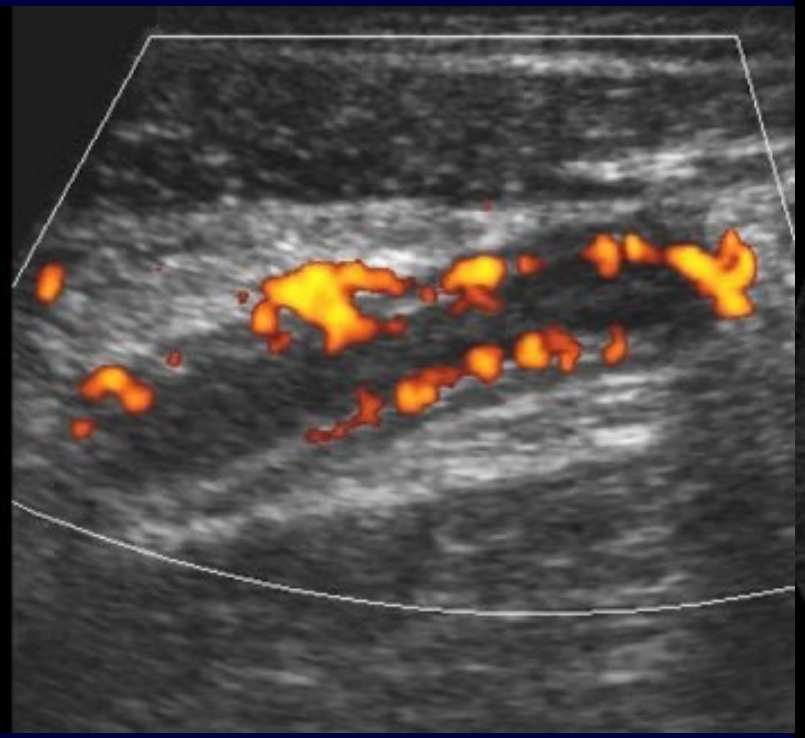

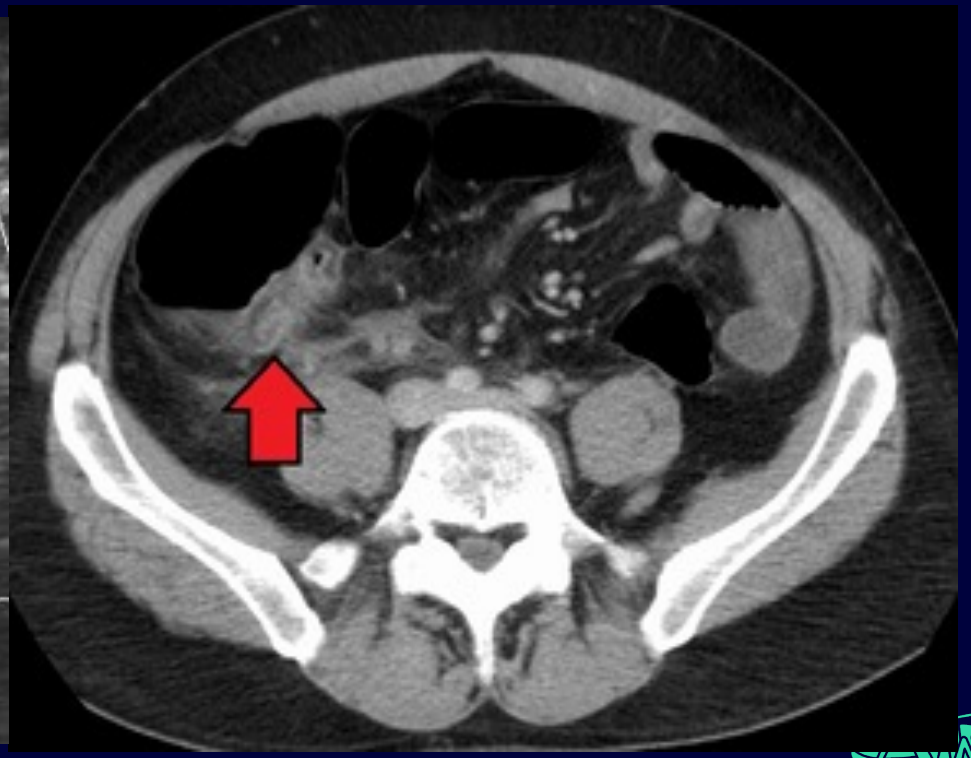

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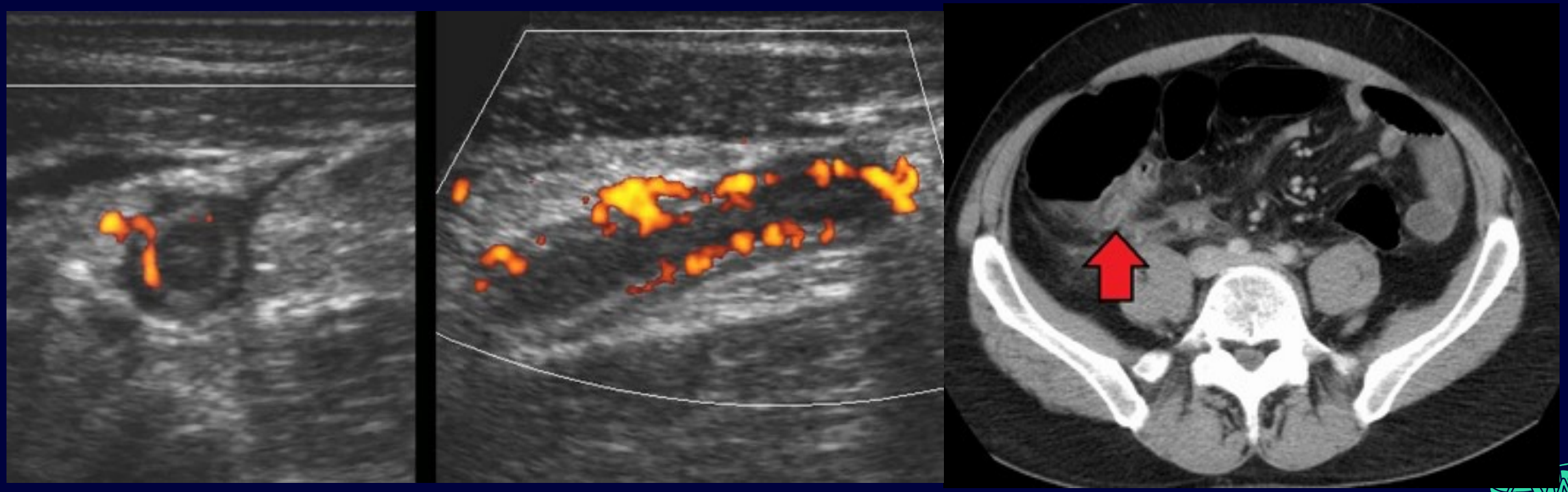

Scan is better than unnecessary operation

Unnecessary appendix surgery 'performed on thousands in UK'

Third of women who enter theatre end up having normal appendix removed, study finds

Appendicectomies are the UK's most common emergency operation. Photograph: Burger/Phanie/Rex Features

Guardian, Dec 2019

A study found that almost a third of female patients had normal appendixes – more than double the rate for men – after appendicectomies performed across 154 UK hospitals

Confirmed appendicitis | Other appendix pathology | Histologically normal appendix

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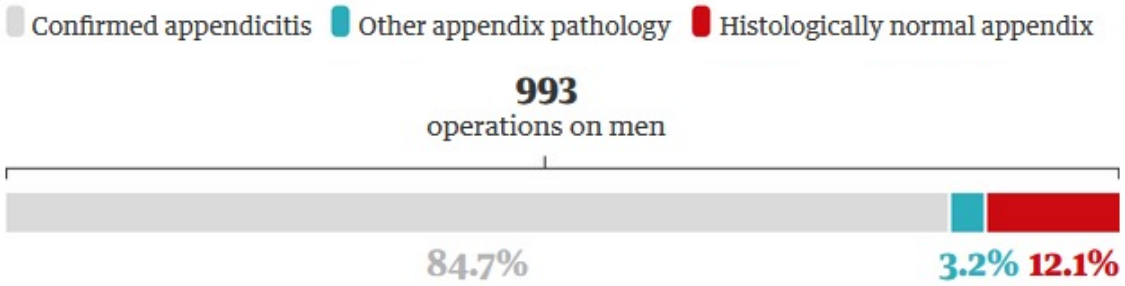

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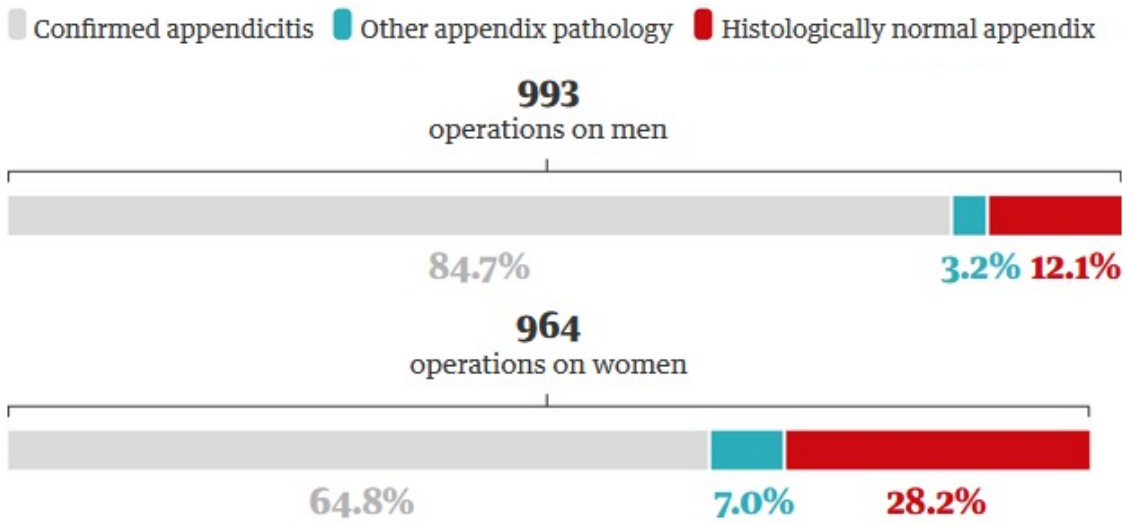

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Unnecessary appendix surgery 'performed on thousands in UK'

Third of women who enter theatre end up having normal appendix removed, study finds

Writing in the British Journal of Surgery, Bhangu and his colleagues report how they asked surgeons in 154 hospitals across the UK to record data from patients aged 16-45 who were admitted with suspected appendicitis over a two-week period during mid-2017.

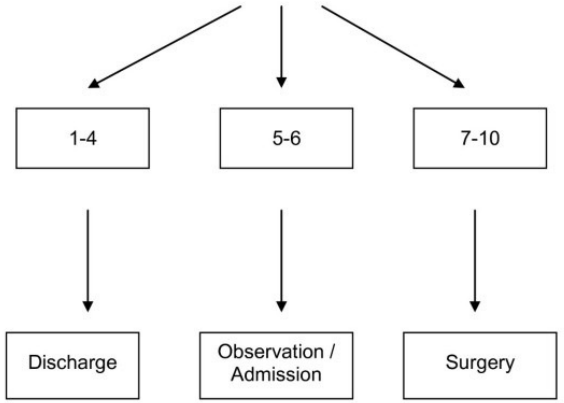
In total 5,345 patients were admitted, two-thirds of whom were women. Just 32 patients were given a risk score based on their symptoms and blood tests to assess their risk of actually having appendicitis.

While women were less likely to have surgery than men, the team found that, of the almost 2,000 patients who had an operation, 28% of women and 12% of men ended up having a normal appendix removed.

The authors say CT imaging has been avoided in the past in the UK, at least in part because of concerns about exposing patients to radiation. However the team say modern scans use low doses and suggest their introduction should be considered.

"It is the same radiation as flying to New York, so we need to start using them," said Bhangu, adding that the costs of the scan would be more than covered by avoiding unnecessary hospital stays and operations.

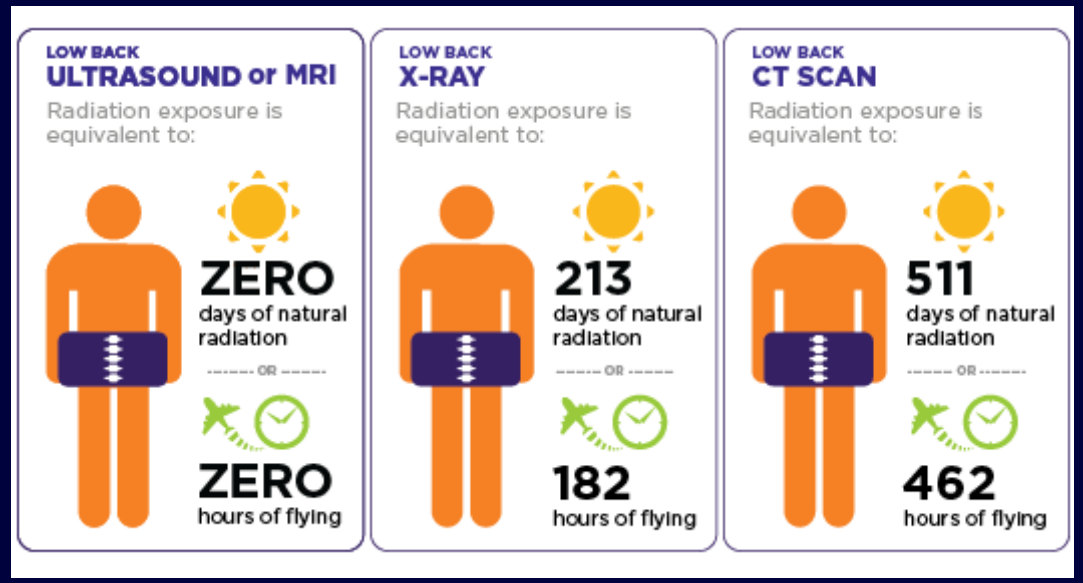
Alvarado score	
Feature	**Score**
Migration of pain	1
Anorexia	1
Nausea	1
Tenderness in right lower quadrant	2
Rebound pain	1
Elevated temperature	1
Leucocytosis	2
Shift of white blood cell count to the left	1
Total	**10**



Predicted number of patients with appendicitis:

- Alvarado score 1-4 - 30%
- Alvarado score 5-6 - 66%
- Alvarado score 7-10 - 93%

Radiation dose



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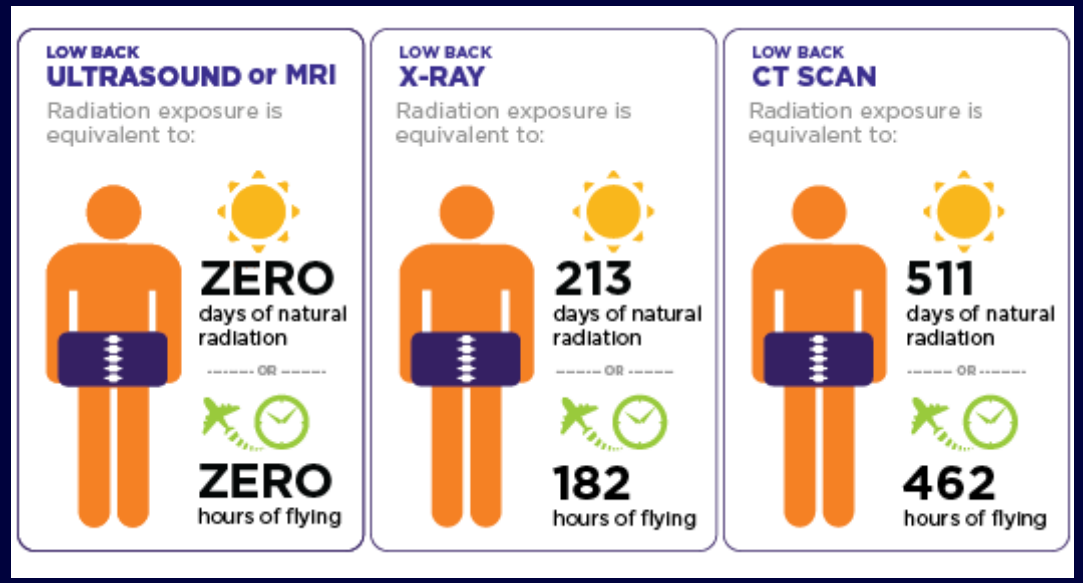

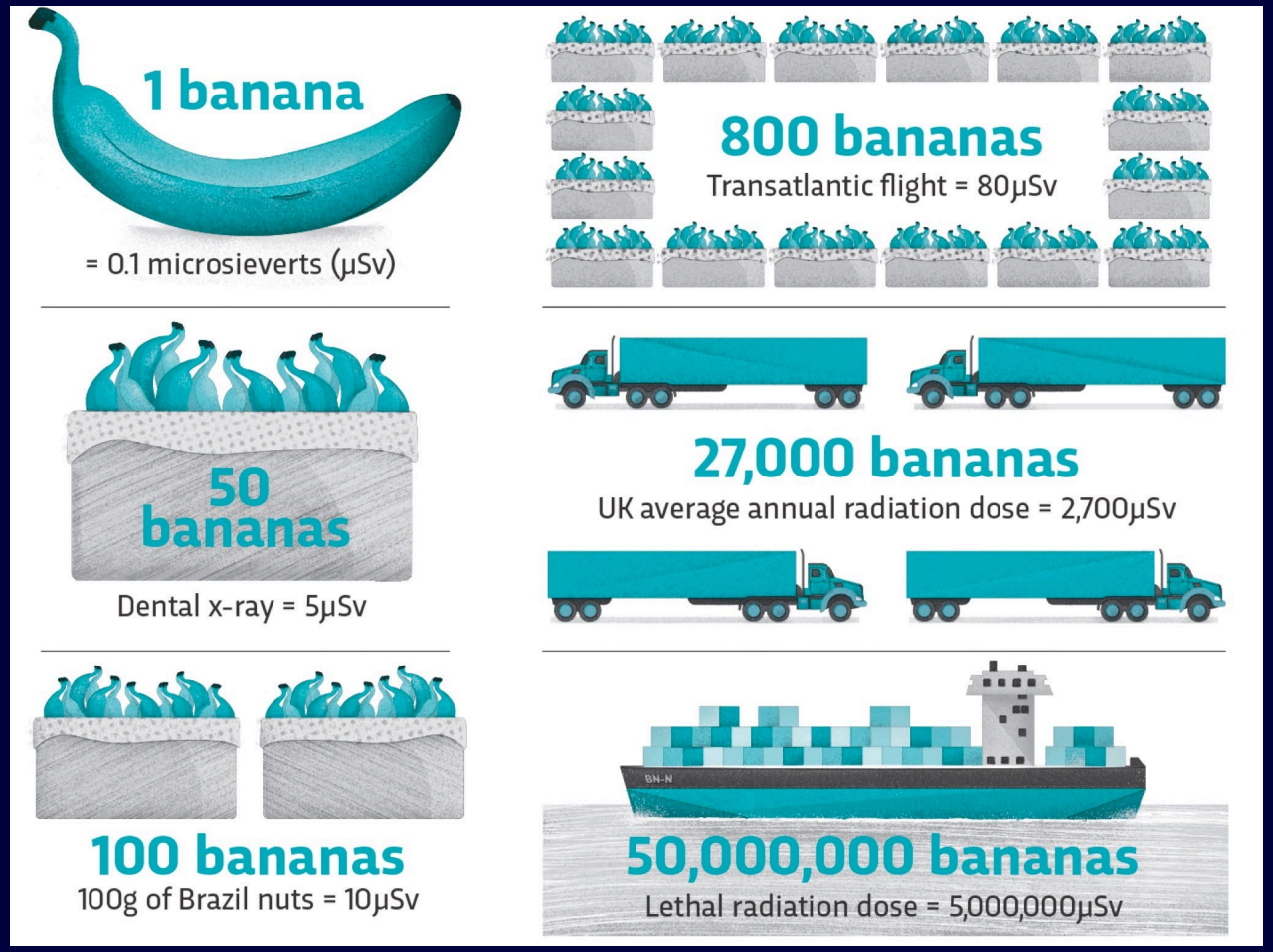

RADIATION IN DAILY LIFE

NATURAL RADIATION | **EFFECTIVE DOSE (mSv)** | **MAN-MADE RADIATION**

20

10 — Unusually high natural radiation dose in downtown Guarapari, Brazil

20 — Annual dose limit for radiation worker

5 — Average annual dose to aircrew flying 800 hours per year

10

10 — Average effective dosage from CT Scan

2.4 — Annual natural background radiation
- Food/drinks
- Radon gas from ground
- Cosmic Rays
- Buildings/Soil

1

1.0 — Annual dose limit for general public (except medical exposure)

0.6 — Average effective dosage from Single Abdominal X-ray

0.4 — Average effective dosage from Mammogram

0.1

0.1 — Average effective dosage of a Chest X-ray

0.08 — Air passage from Hong Kong to North American

0.01

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1 banana

= 0.1 microsieverts (µSv)

50 bananas

Dental x-ray = 5µSv

100 bananas

100g of Brazil nuts = 10µSv

800 bananas

Transatlantic flight = 80µSv

27,000 bananas

UK average annual radiation dose = 2,700µSv

50,000,000 bananas

Lethal radiation dose = 5,000,000µSv

GIRFT – RCR

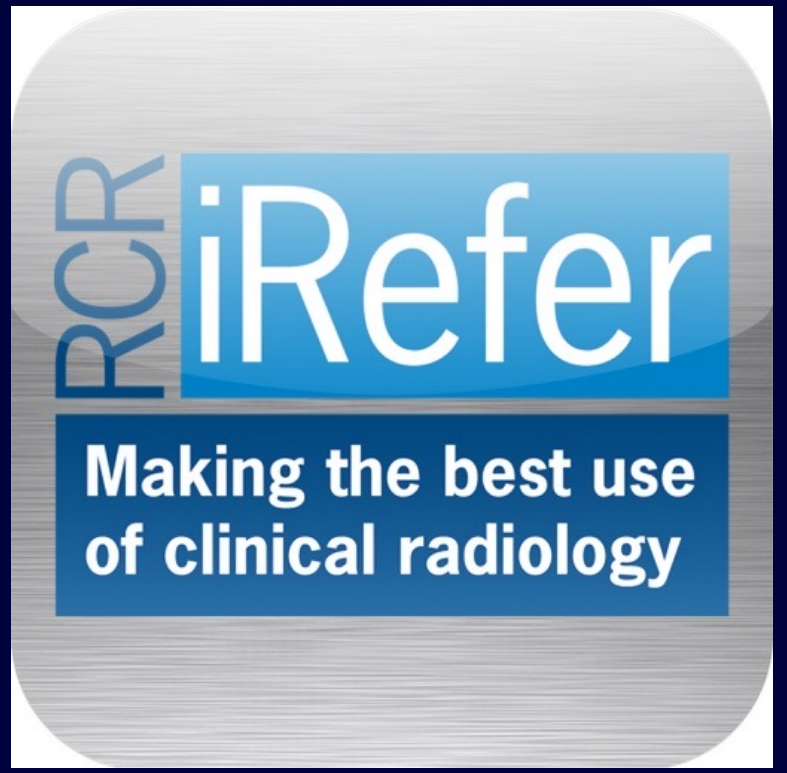
Getting it Right First Time

GIRFT – RCR

Getting it Right First Time in Radiology

National standardization

- Facilities, infrastructure, IT support
- Cancer pathways
- RCR iRefer clinical decision support tool



Right person, right scan, right time

GIRFT
GETTING IT RIGHT FIRST TIME

Medical Imaging

1. Diagnostic imaging
2. Imaging as part of treatment – biopsy, therapy
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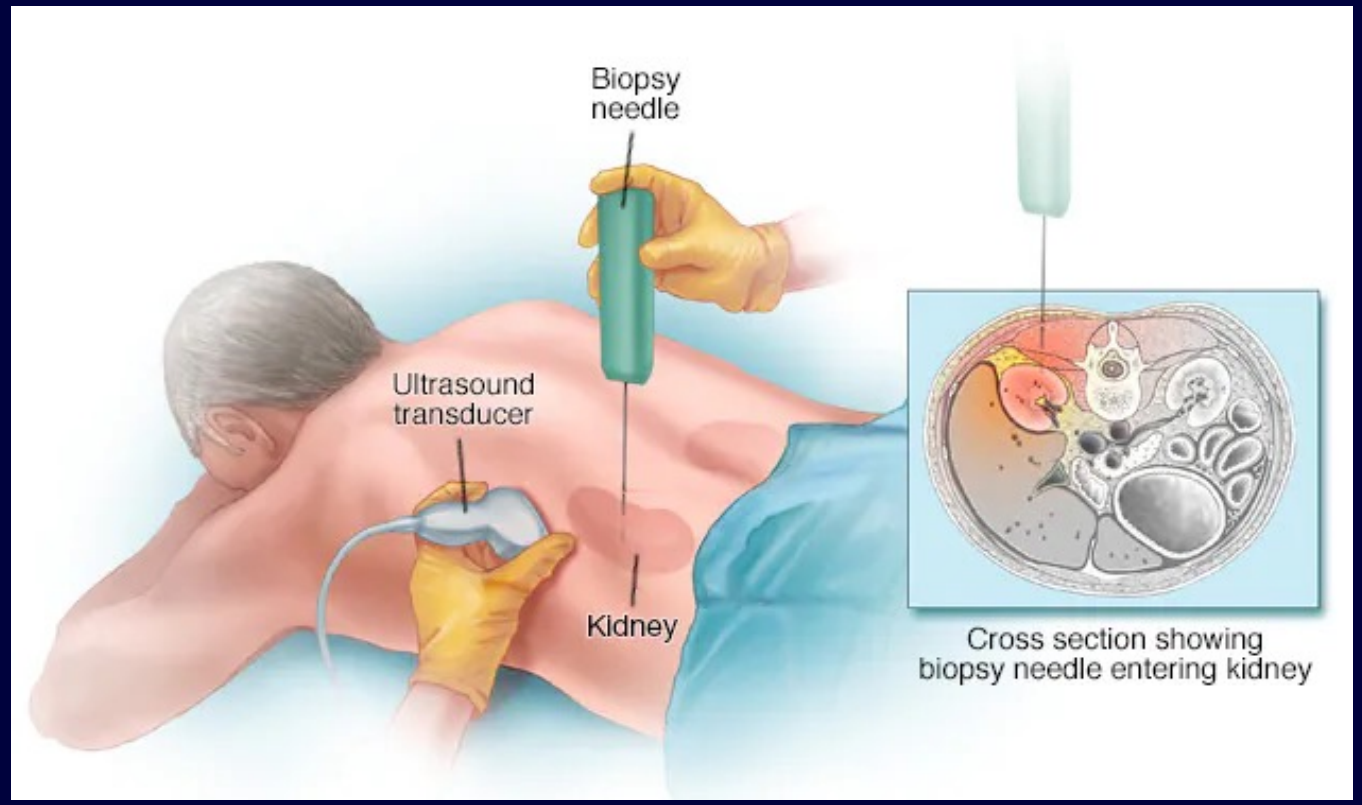
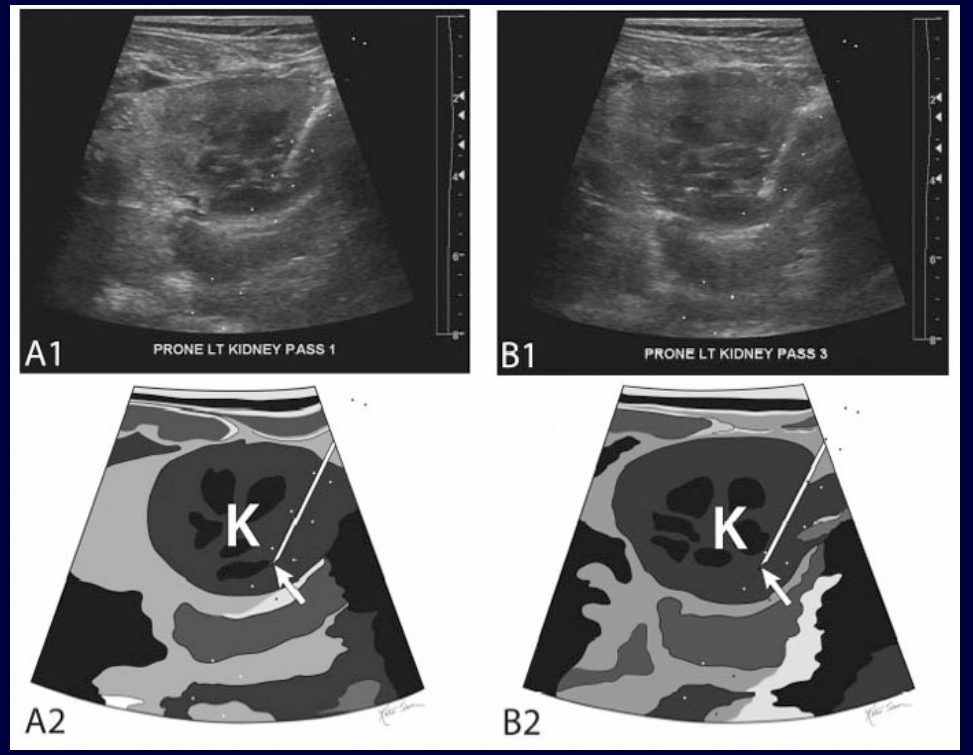
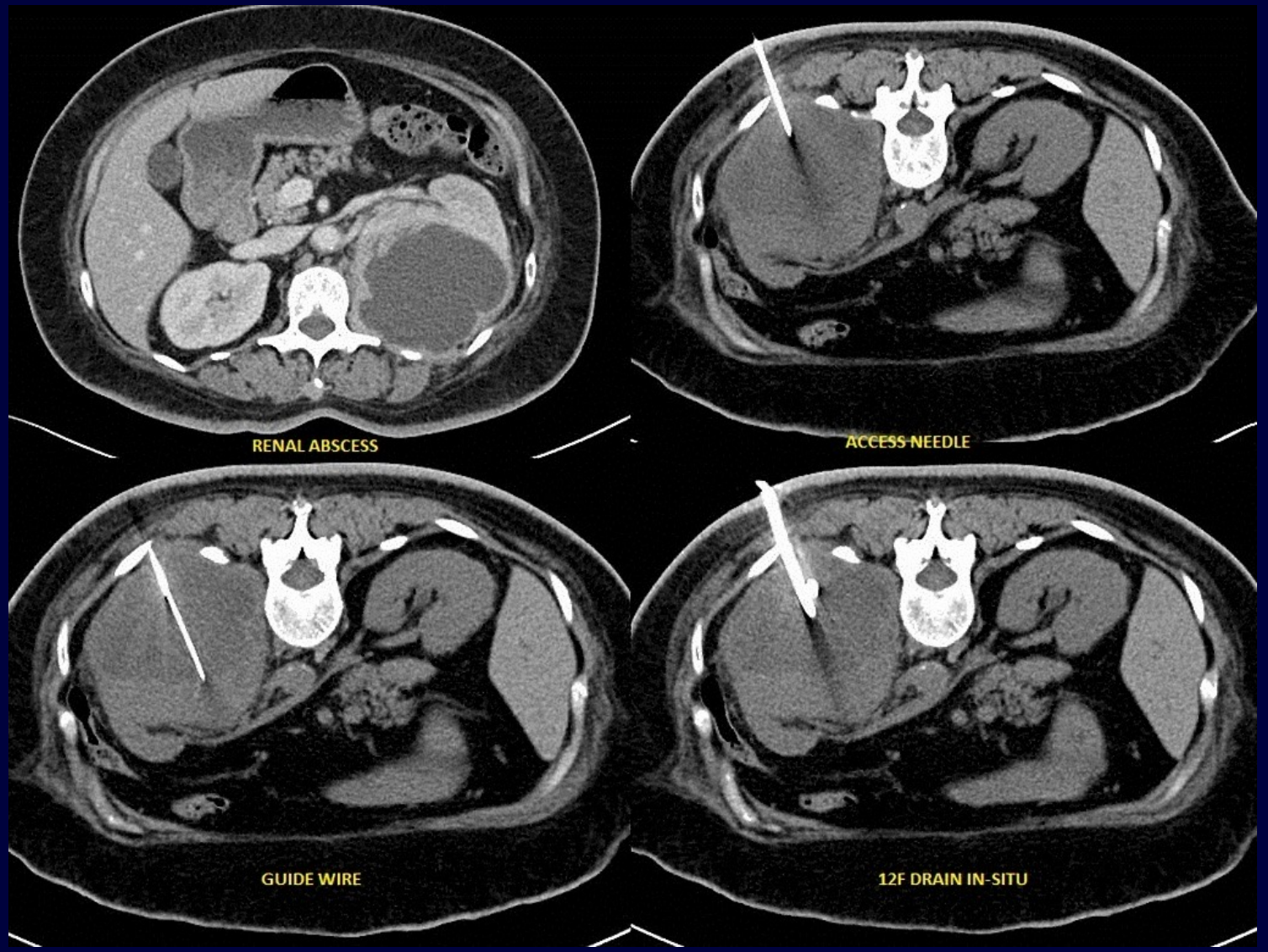
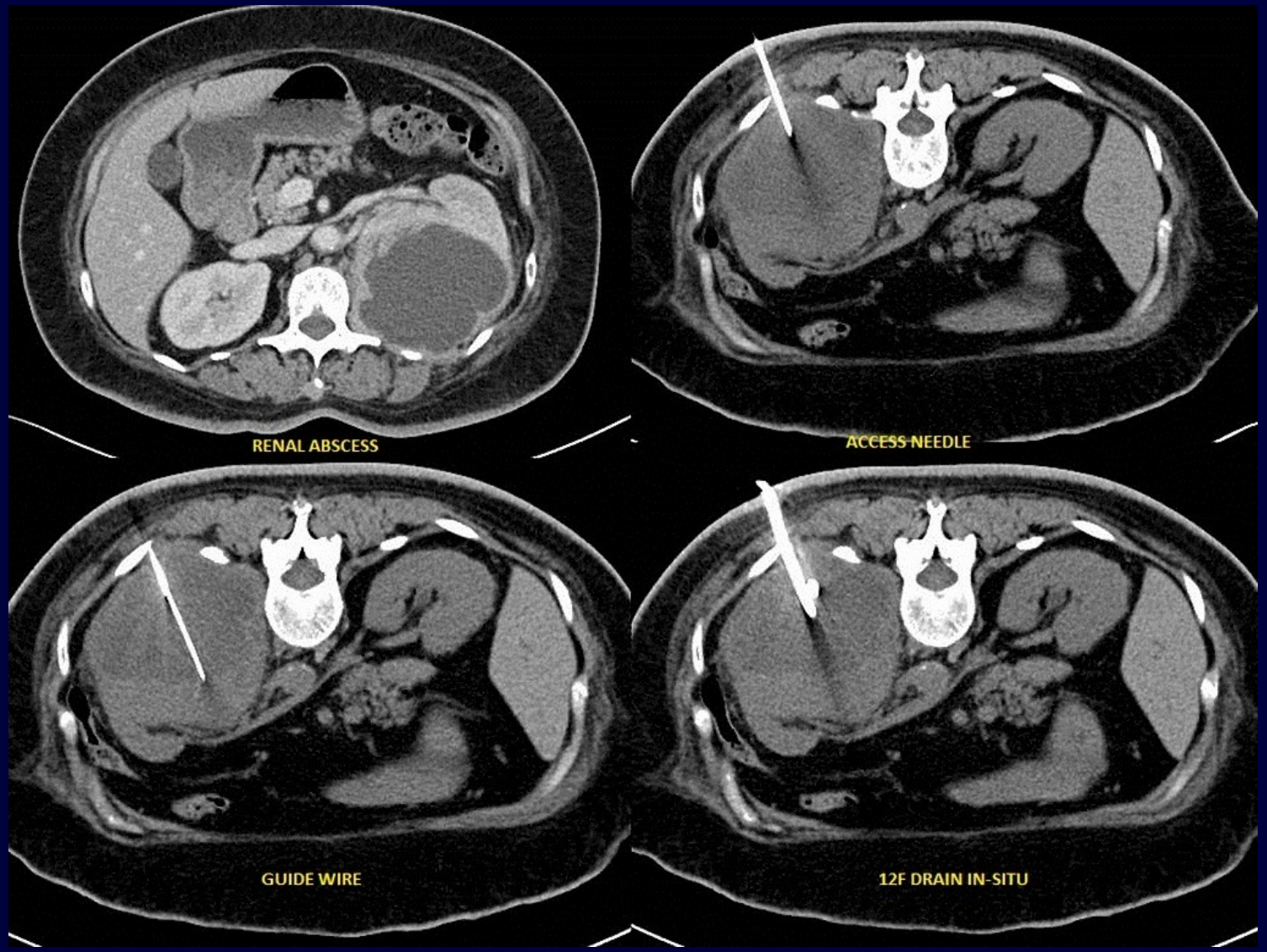
5. Incidental findings

Medical Imaging as part of treatment



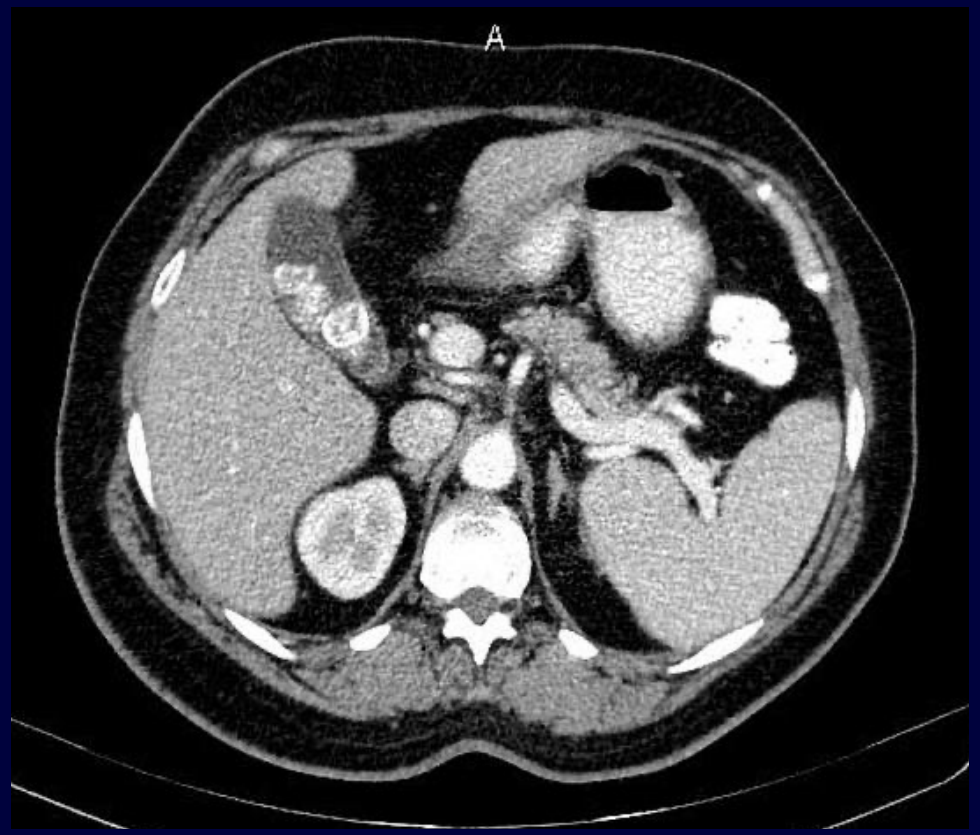


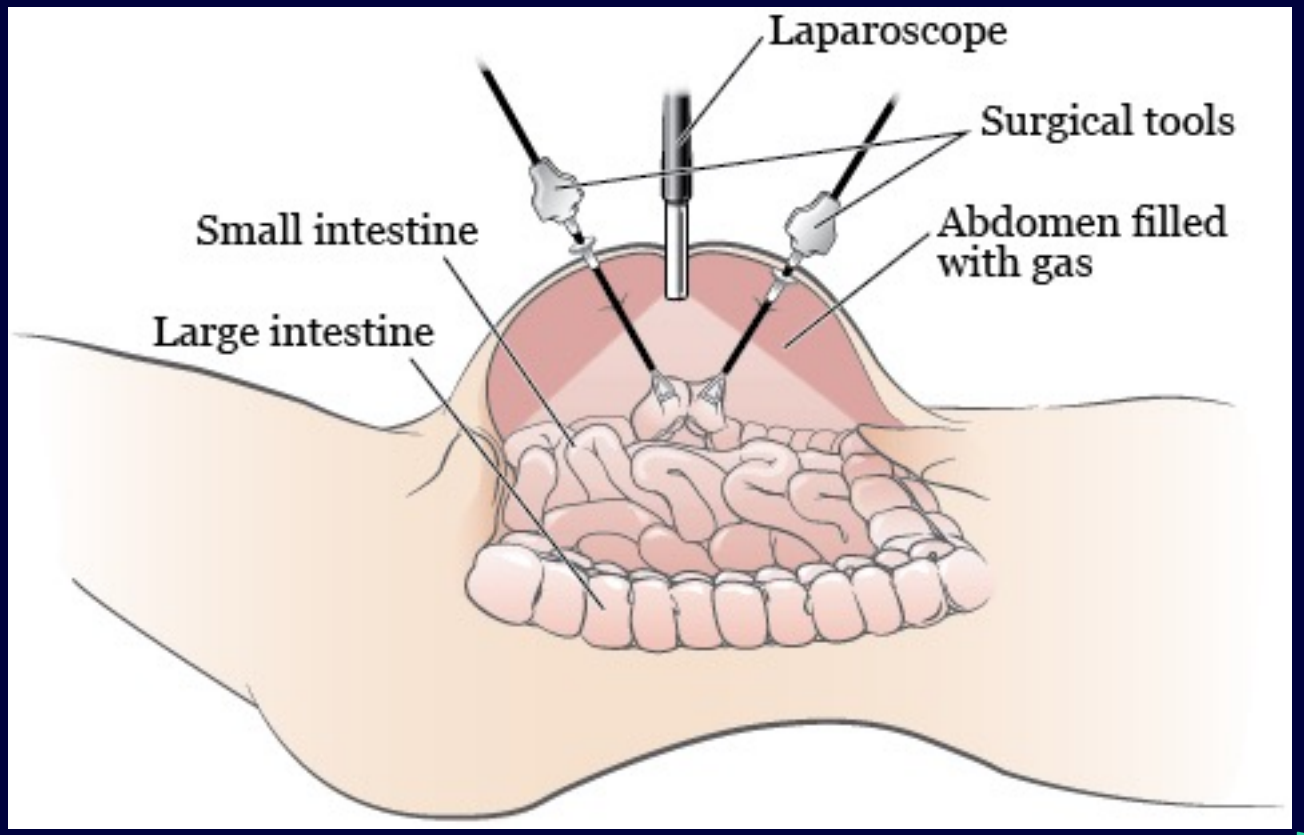

RENAL ABSCESS
ACCESS NEEDLE
GUIDE WIRE
12F DRAIN IN-SITU



Scan is part of the operation !

Medical Imaging as part of treatment





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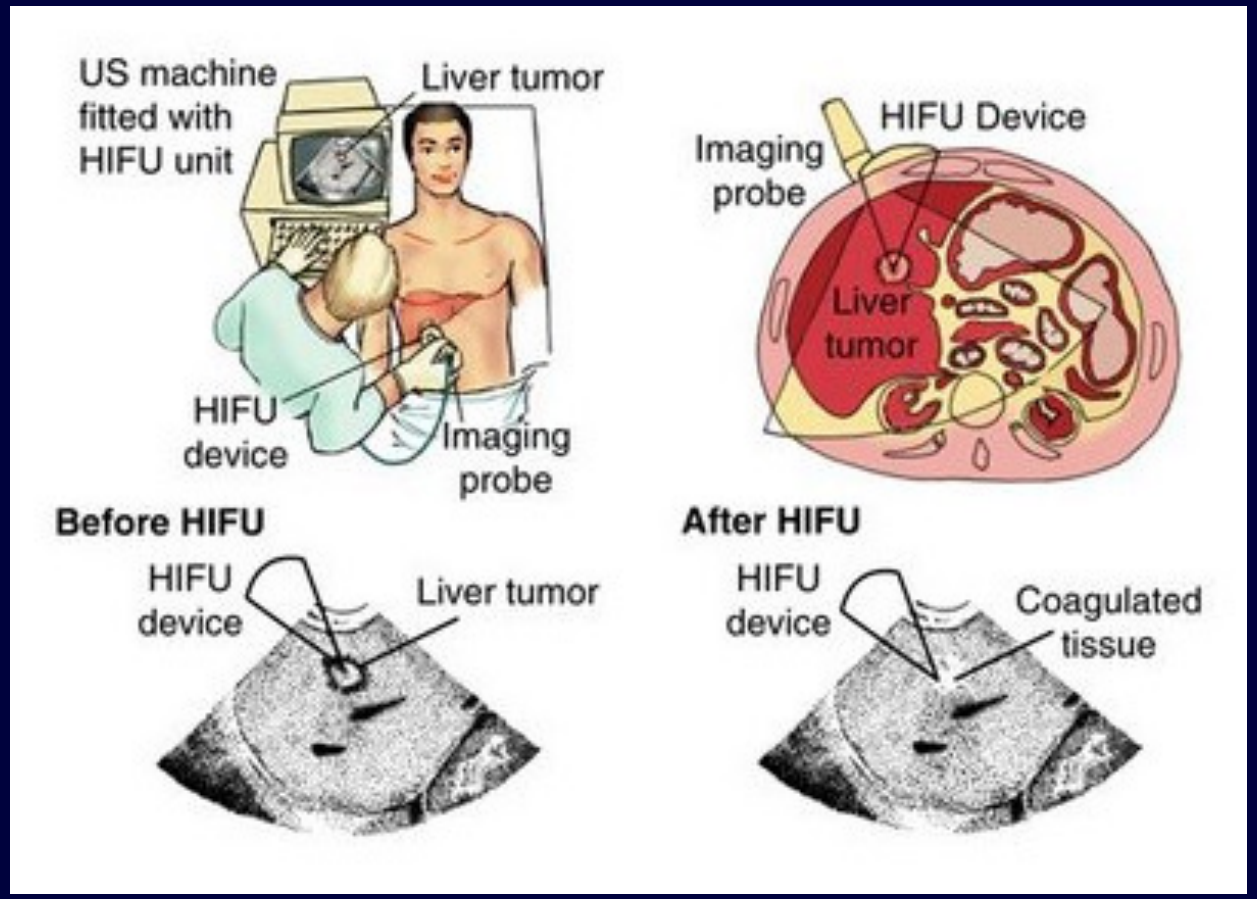
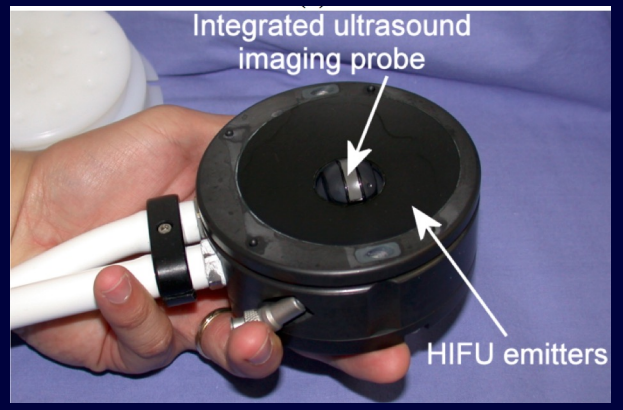
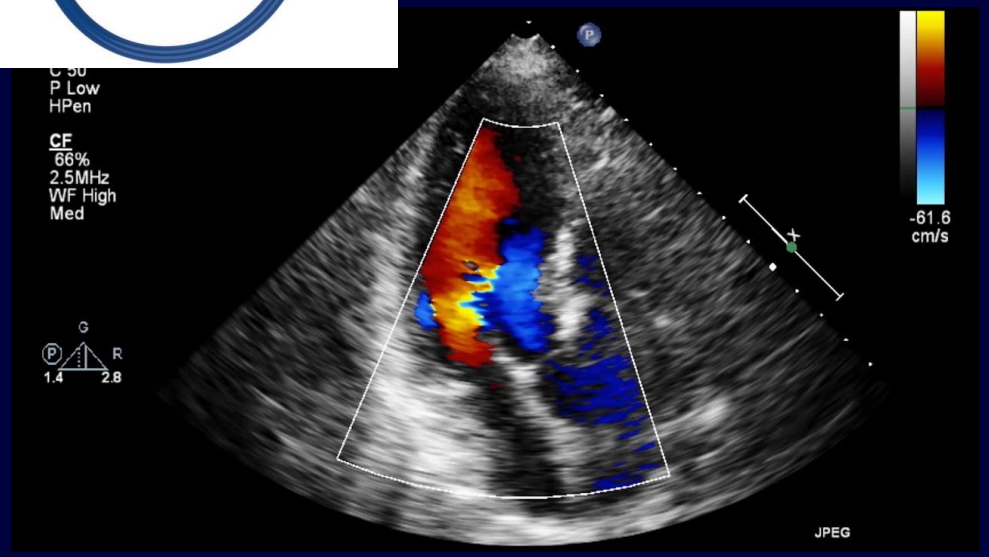




HIFU: High Intensity Focused Ultrasound

Imaging hearts



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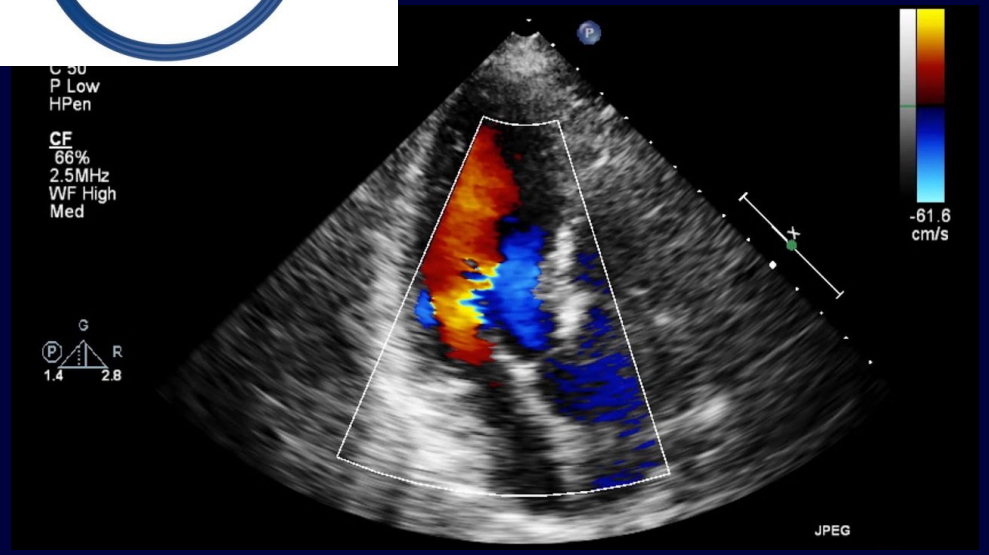

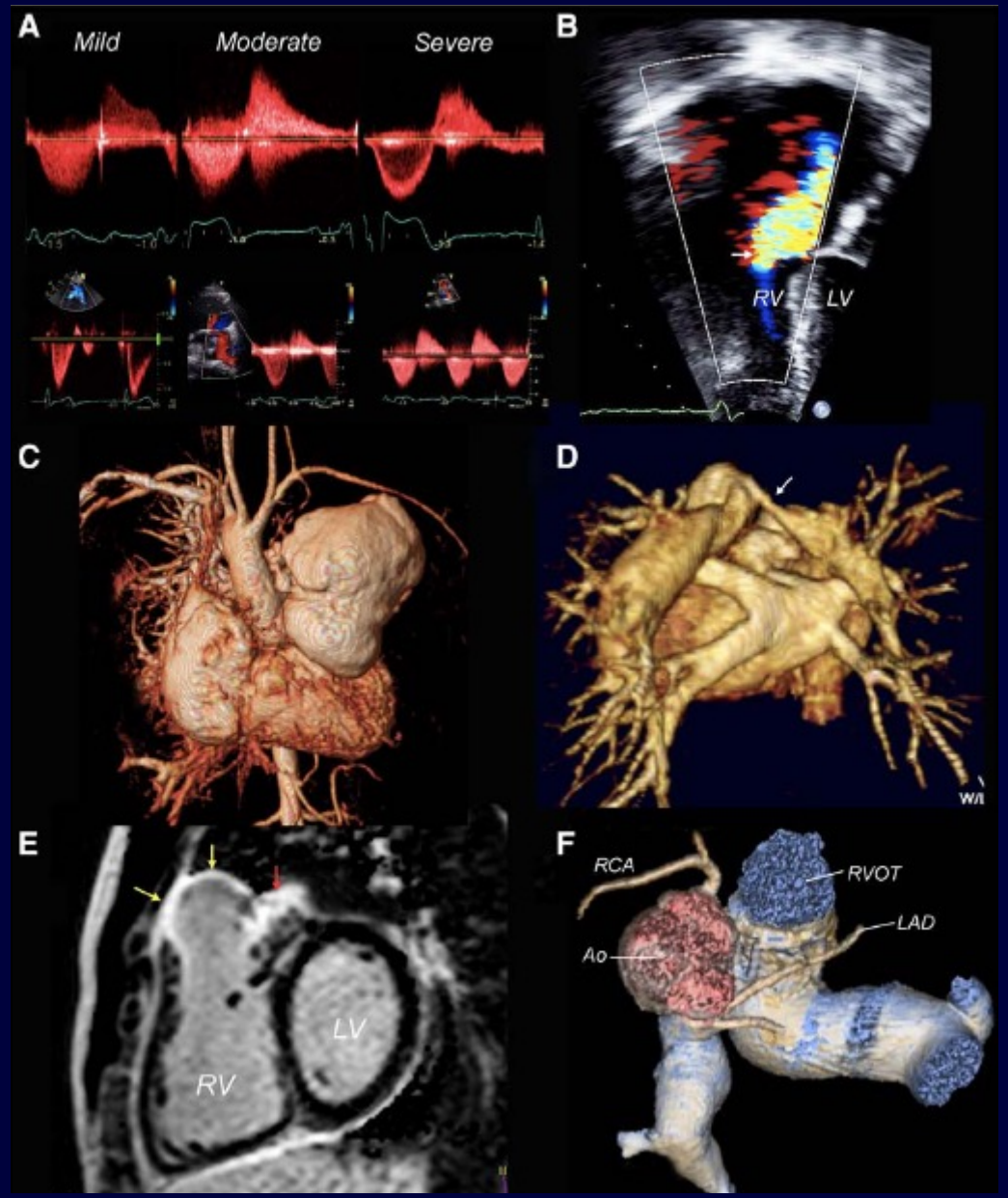

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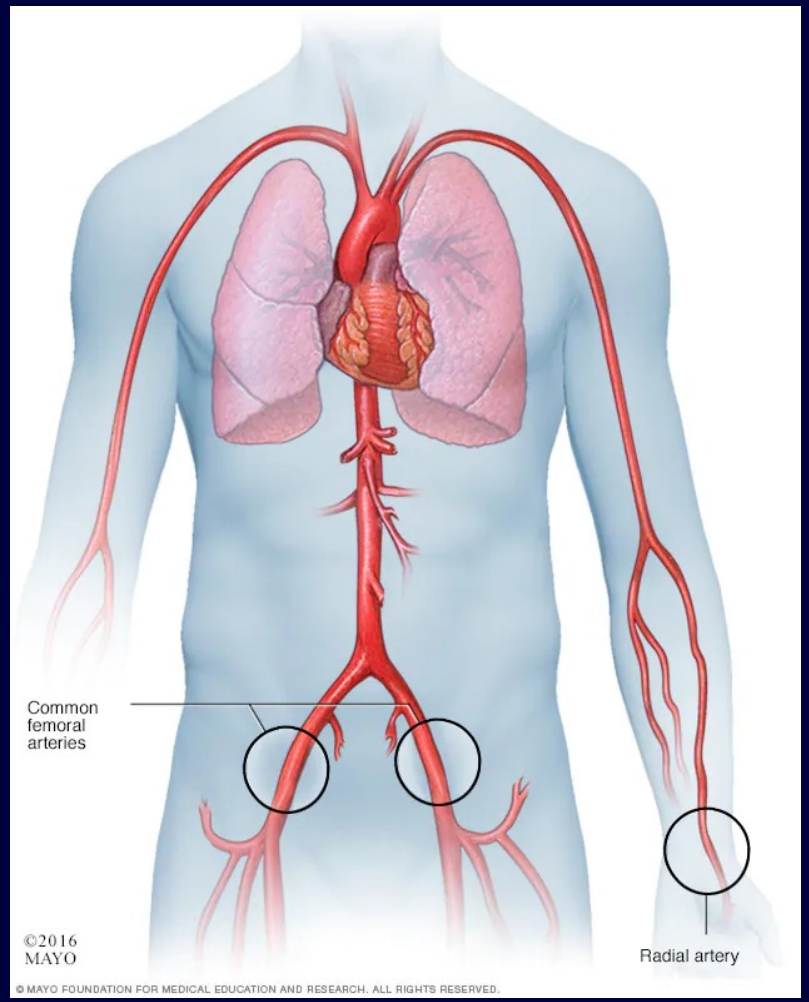
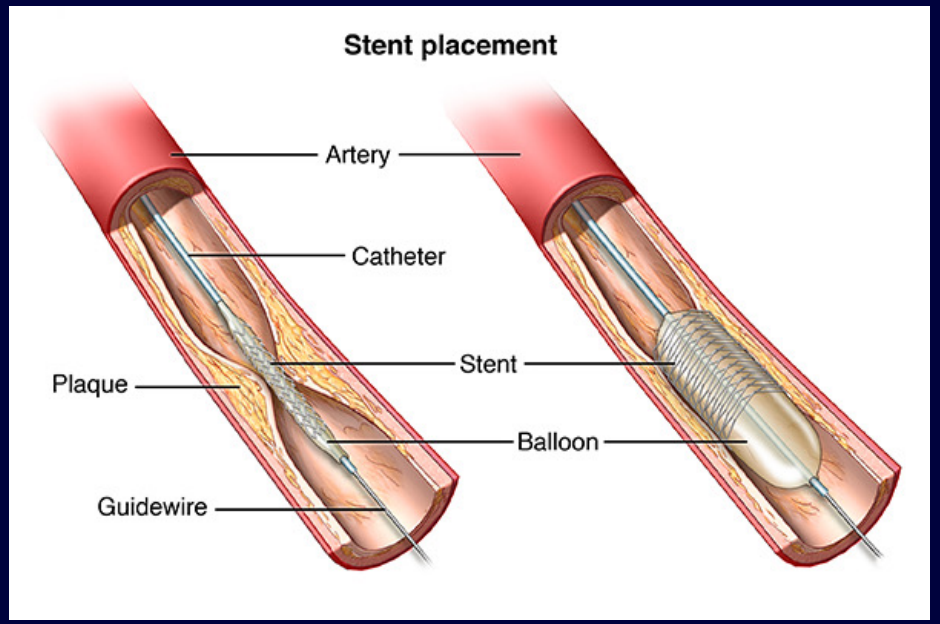
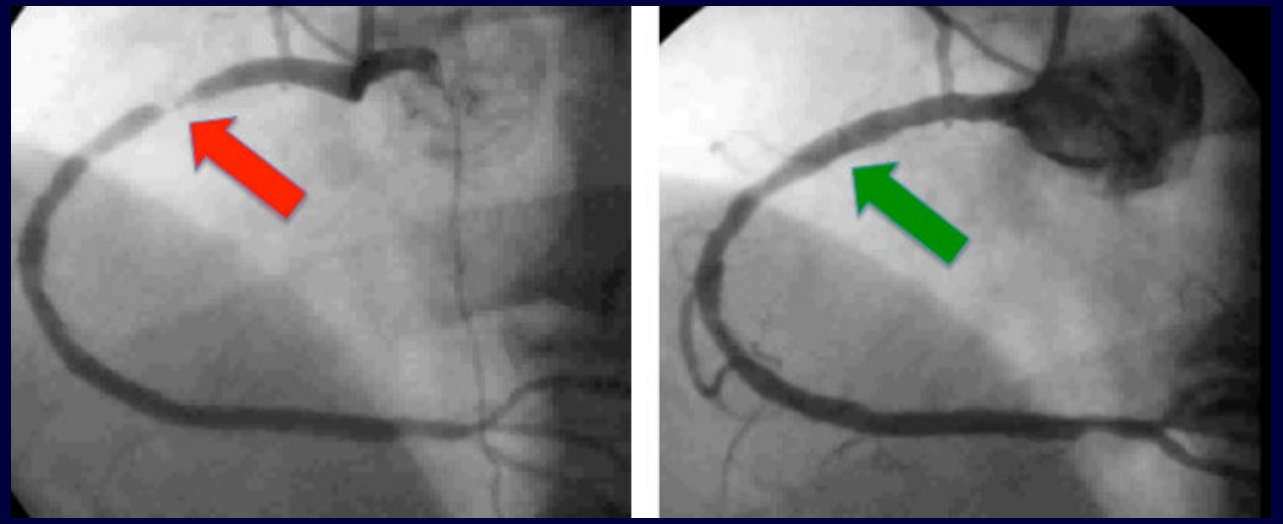
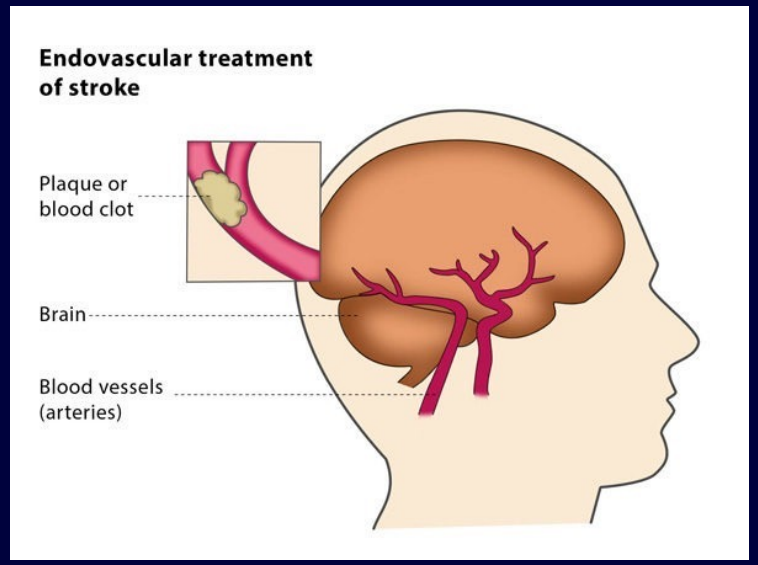
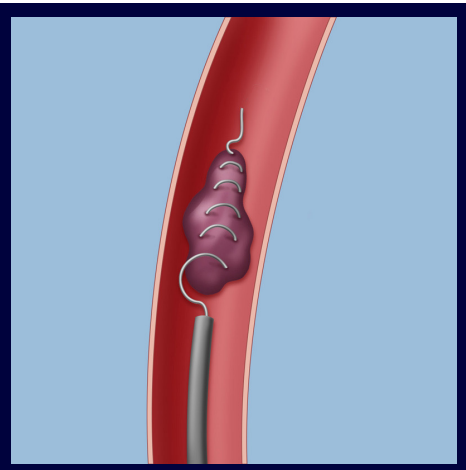






Medical Imaging as part of treatment





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Follow up imaging

Surveillance – illness treated but might recur

e.g. cancer, multiple sclerosis

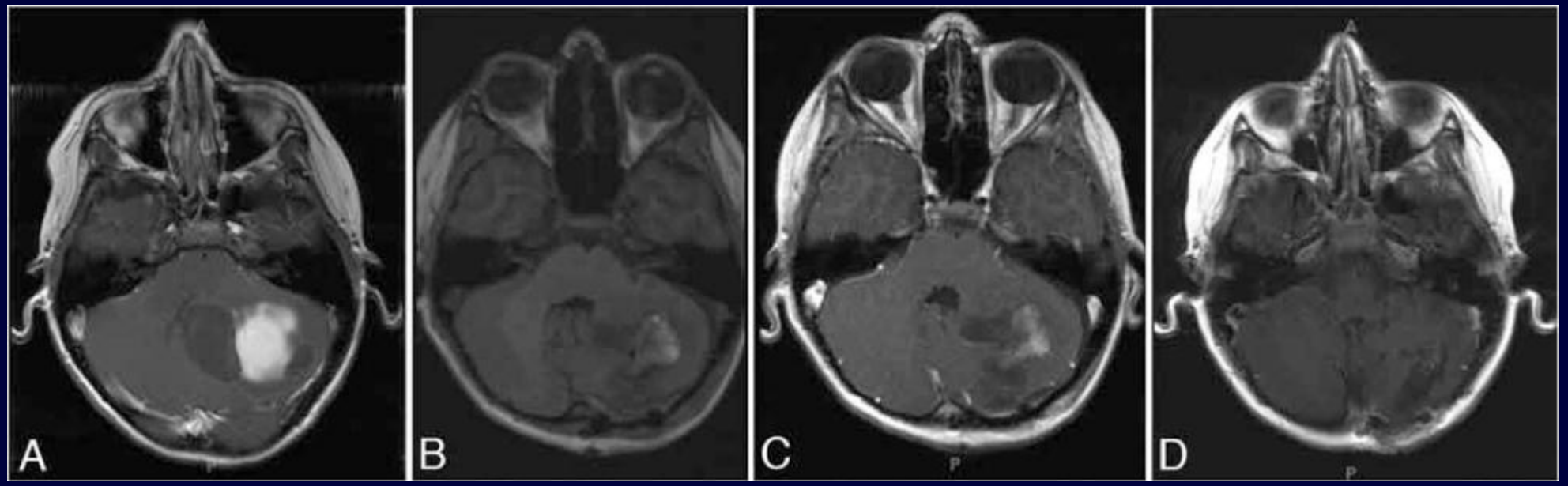
Monitoring – what happens to a known diagnosis

e.g. small possible cancer

High risk population (screening)

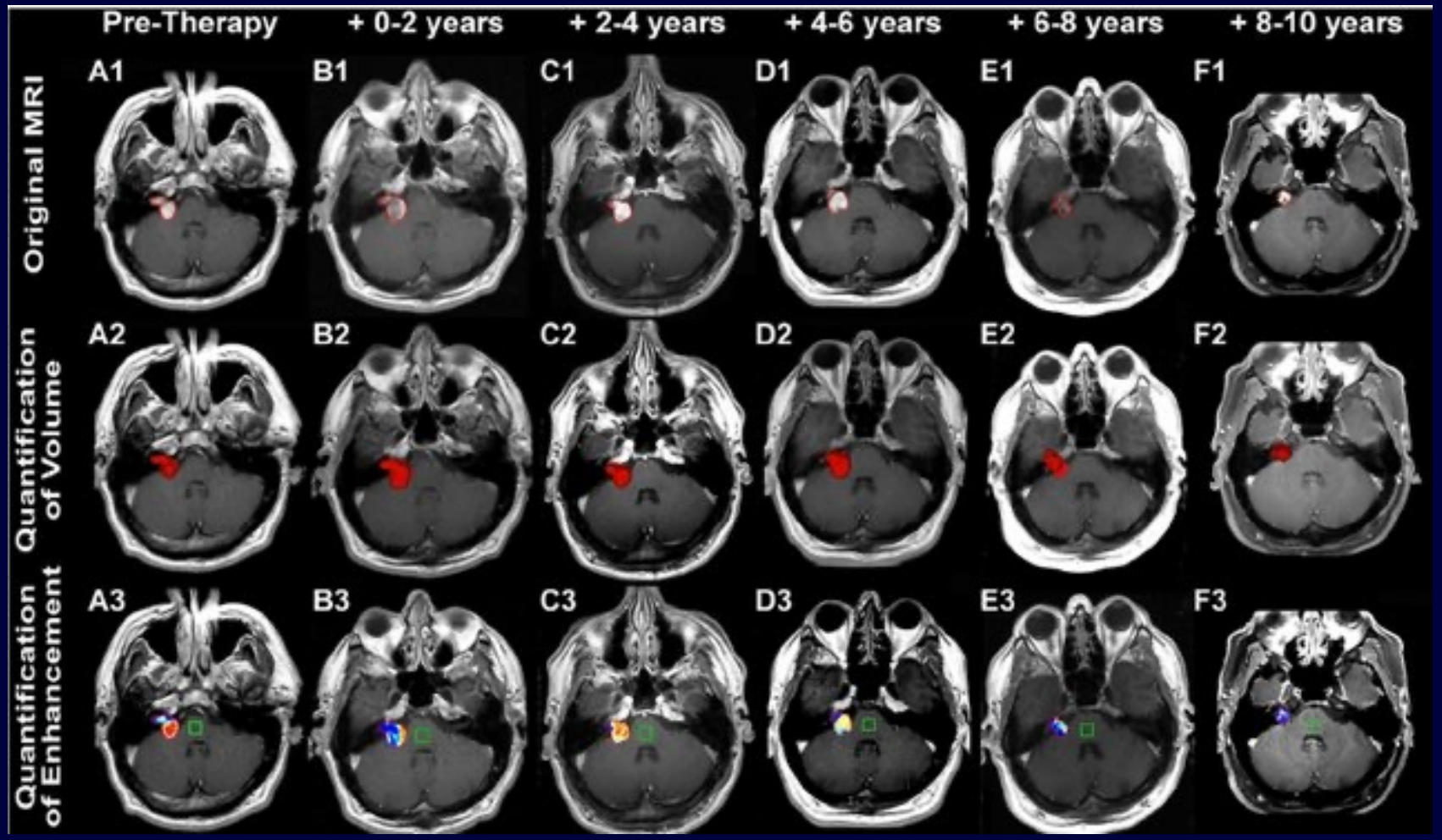
e.g. cystic fibrosis

Monitoring - post op



Scan to confirm surgical success

Surveillance / follow up imaging



Scan to assess progression

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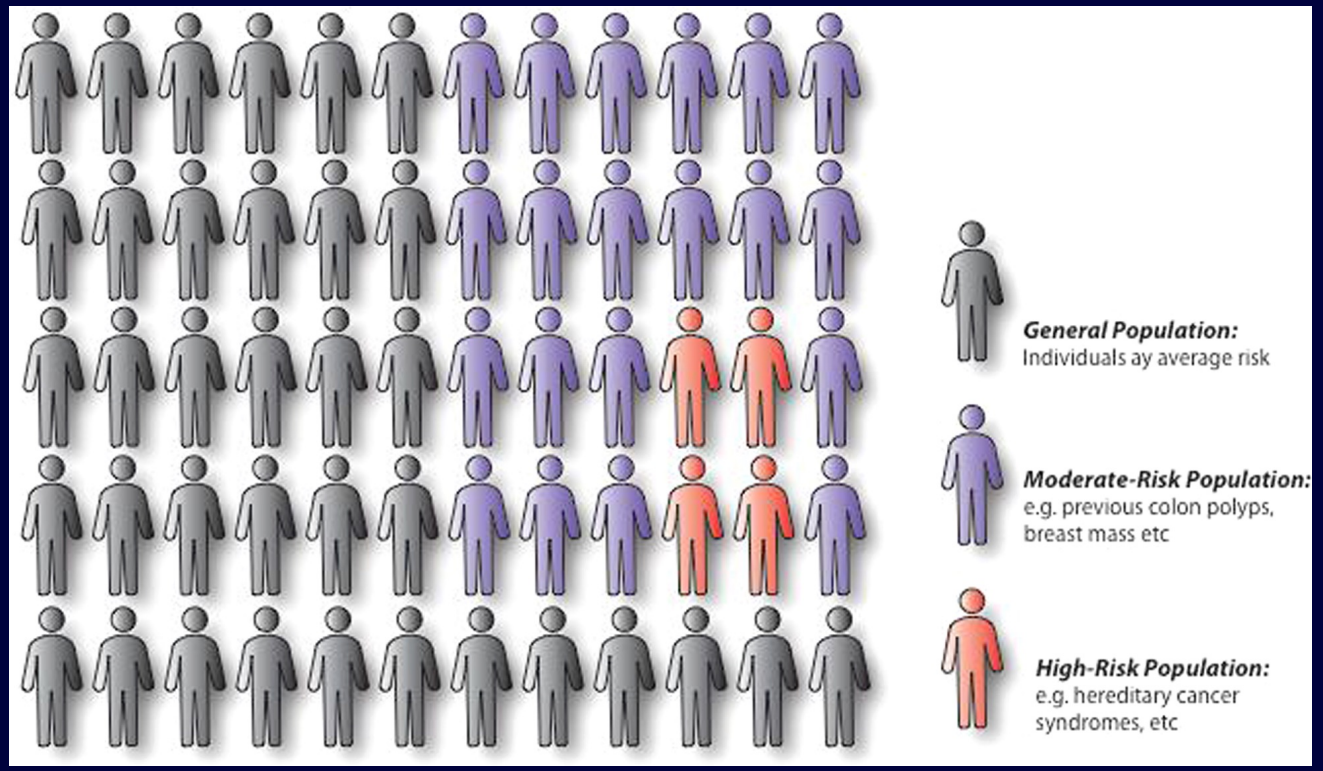
Screening

Investigating Asymptomatic people for potential disease

Screening

Investigating Asymptomatic people for potential disease



Scan to find "hidden" important disease

Screening

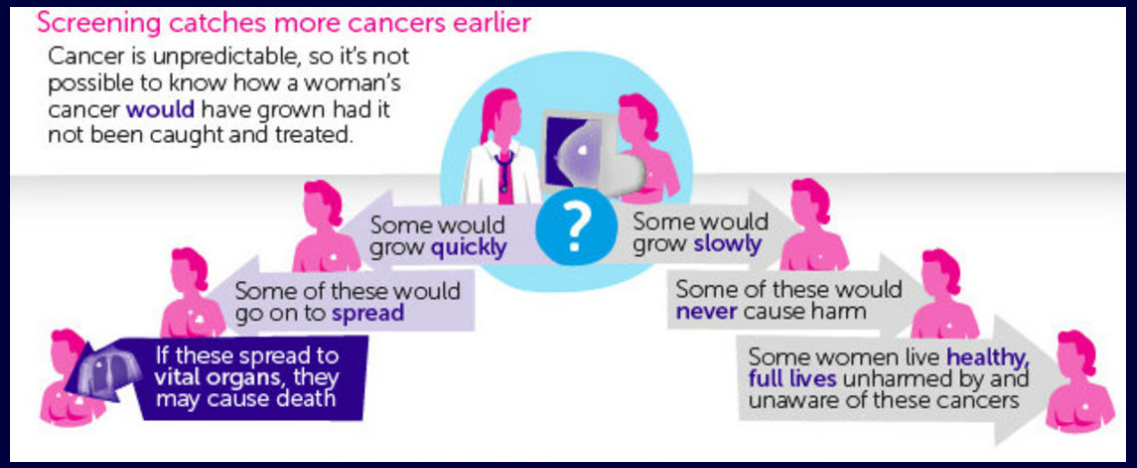
Investigating Asymptomatic people for potential disease

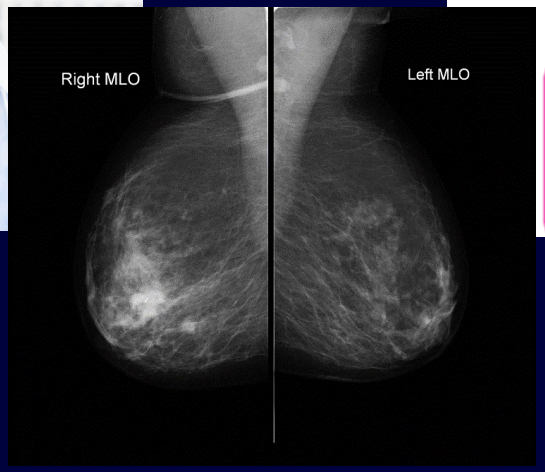
Breast cancer screening
Cervical cancer screening
Bowel cancer screening

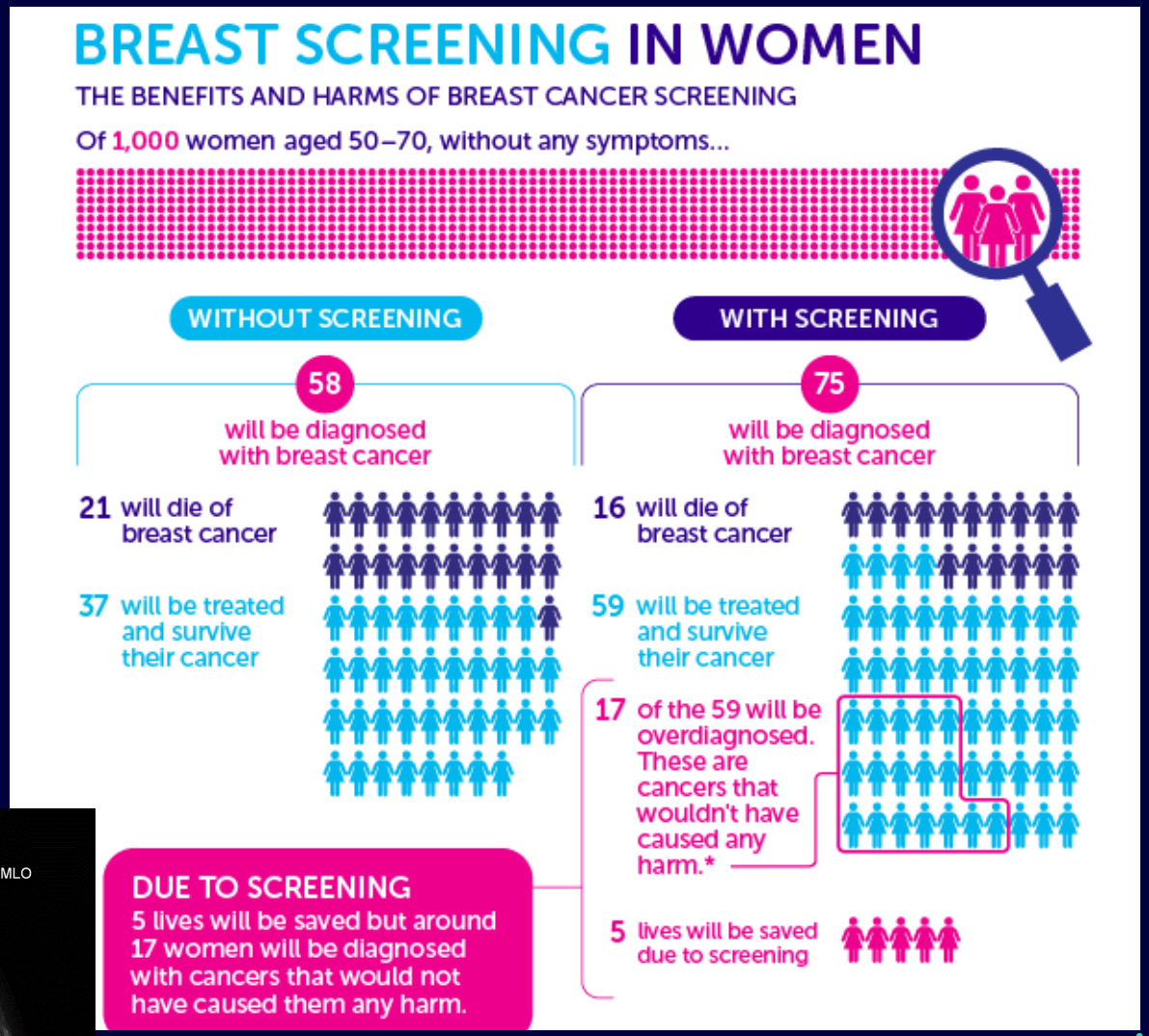
} save 10,000 lives / year

Benefits for individual patient vs population risk

Should we do more, or less ?


Screening catches more cancers earlier
Cancer is unpredictable, so it's not possible to know how a woman's cancer would have grown had it not been caught and treated.
Some would grow quickly
Some would grow slowly
Some of these would go on to spread
Some of these would never cause harm
If these spread to vital organs, they may cause death
Some women live healthy, full lives unharmed by and unaware of these cancers

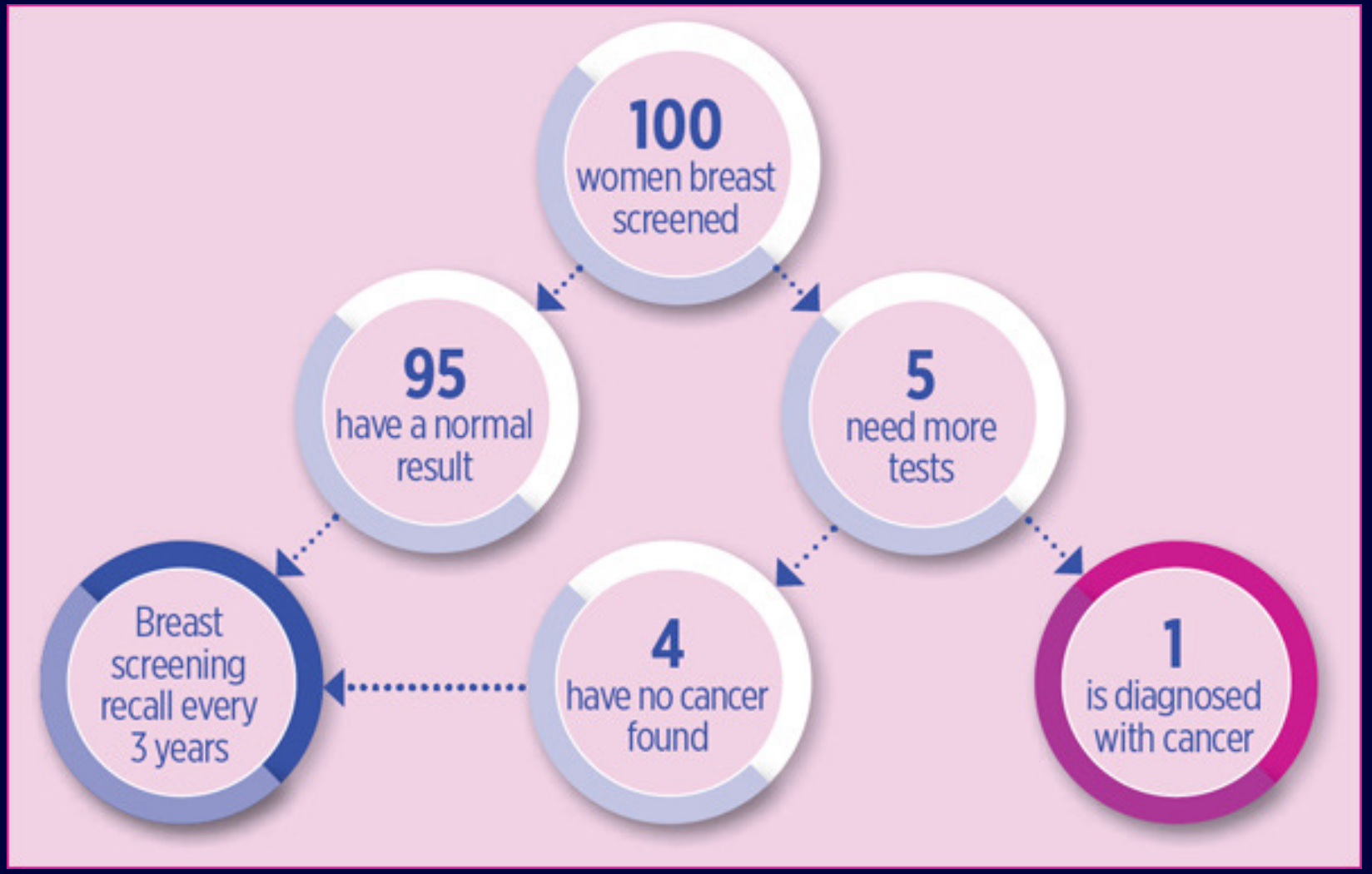

Right MLO
Left MLO


BREAST SCREENING IN WOMEN
THE BENEFITS AND HARMS OF BREAST CANCER SCREENING
Of 1,000 women aged 50–70, without any symptoms...
WITHOUT SCREENING
WITH SCREENING
58
will be diagnosed with breast cancer
75
will be diagnosed with breast cancer
21 will die of breast cancer
37 will be treated and survive their cancer
16 will die of breast cancer
59 will be treated and survive their cancer
17 of the 59 will be overdiagnosed. These are cancers that wouldn't have caused any harm.*
5 lives will be saved due to screening
DUE TO SCREENING
5 lives will be saved but around 17 women will be diagnosed with cancers that would not have caused them any harm.

Screening – can it do harm?

Anxiety of further tests

Overdiagnosis



Screening – can it do harm?

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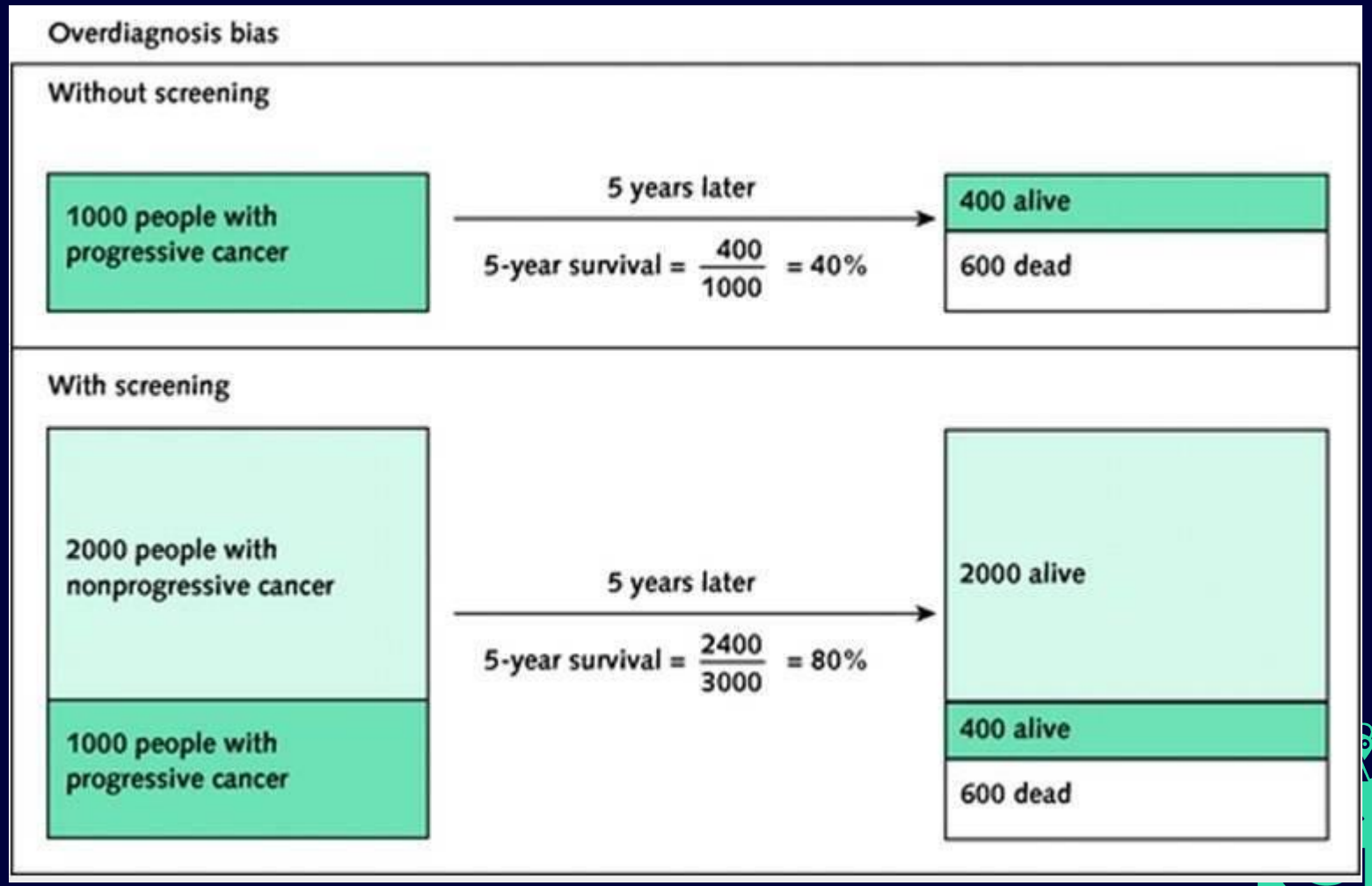
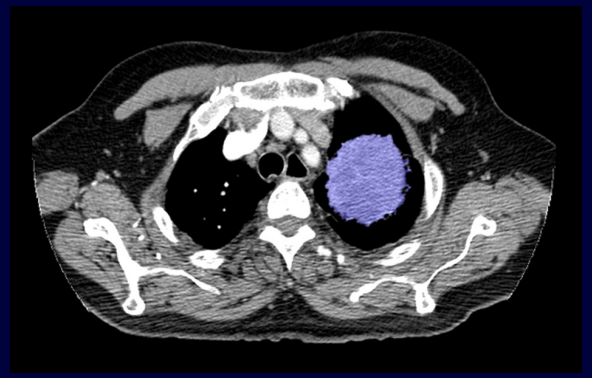


Screening



ORIGINAL ARTICLE

Reduced Lung-Cancer Mortality with Volume CT Screening in a Randomized Trial

Harry J. de Koning, M.D., Ph.D., Carlijn M. van der Aalst, Ph.D., Pim A. de Jong, M.D., Ph.D., Ernst T. Scholten, M.D., Ph.D., Kristiaan Nackaerts, M.D., Ph.D., Marjolein A. Heuvelmans, M.D., Ph.D., Jan-Willem J. Lammers, M.D., Ph.D., Carla Weenink, M.D., Uraujh Yousaf-Khan, M.D., Ph.D., Nanda Horeweg, M.D., Ph.D., Susan van 't Westeinde, M.D., Ph.D., Mathias Prokop, M.D., Ph.D., et al.

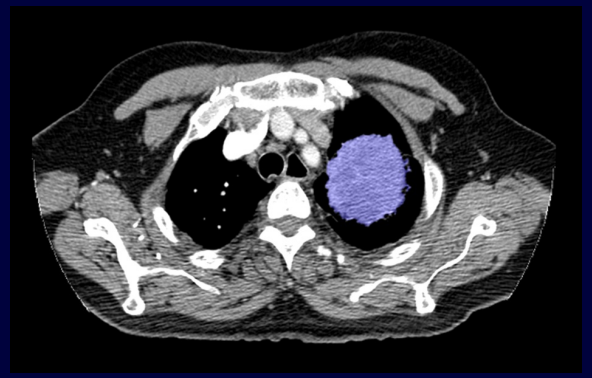
February 6, 2020
N Engl J Med 2020; 382:503-513
DOI: 10.1056/NEJMoa1911793

Lung cancer
70% have advanced disease at diagnosis, 15% survive 5 years

NELSON trial, Netherlands
High risk, former or current smokers (16,000 people)
Offered CT screening at 2 yearly intervals (2005 – 2015)

After 10 years
Screening group – 160 cancers, mainly early stage (20% reduction)
Control group – 210 cancers, mainly late stage

Screening



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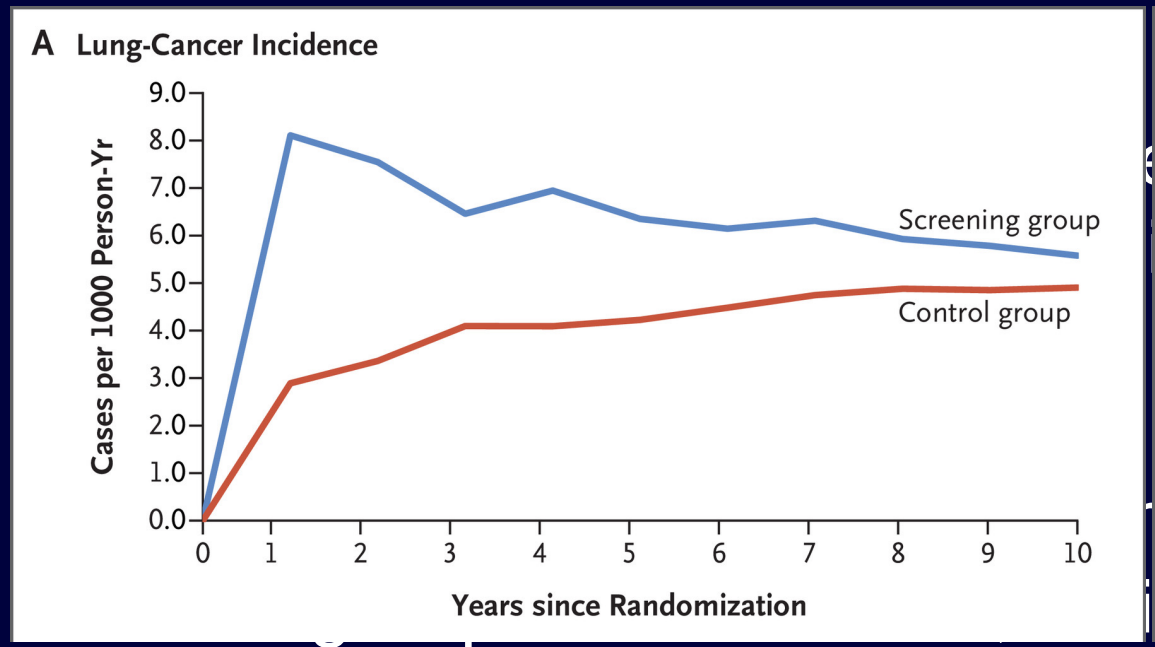
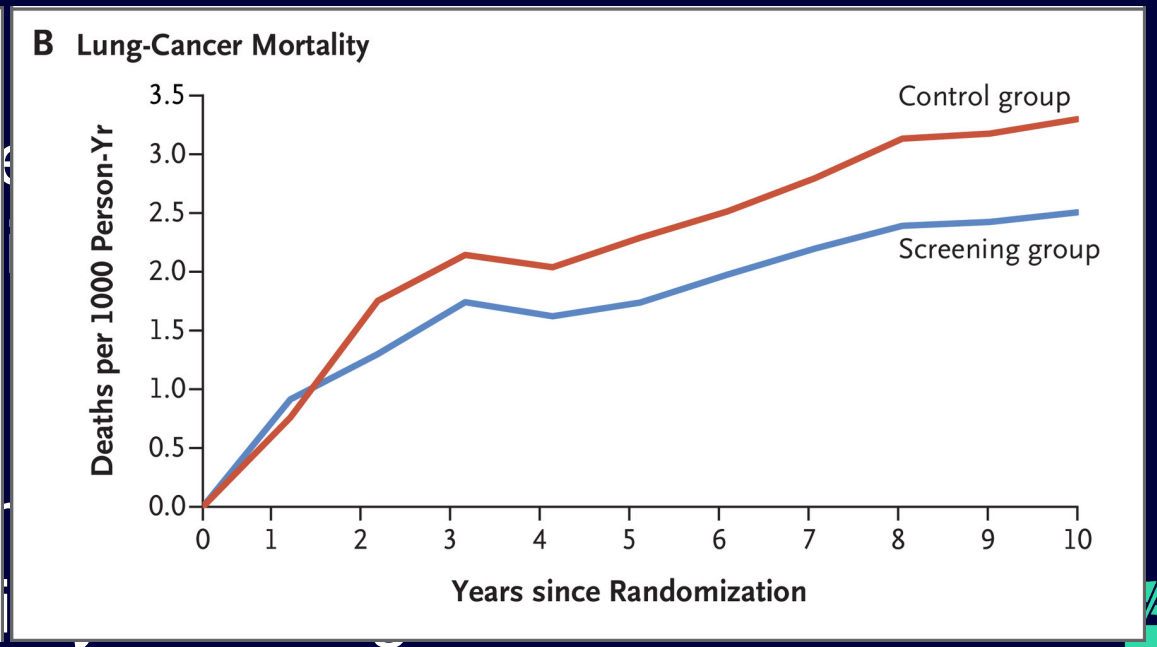




Screening …

Cancer scan at the supermarket: NHS rolls out screening trucks in Tesco and Asda car parks in bid to improve detection rates of the disease

- Scheme is being expanded after trial led to four-fold increase in detection rate
- At risk patients aged 55 to 75 were sent letters urging them to get a scan done
- They were then directed to mobile scanners in Tesco and Asda car parks
- Just one in ten lung cancer patients is alive five years after diagnosis, largely because the disease has spread to other organs before it is detected

Mail online, Nov 2017

Medical Imaging

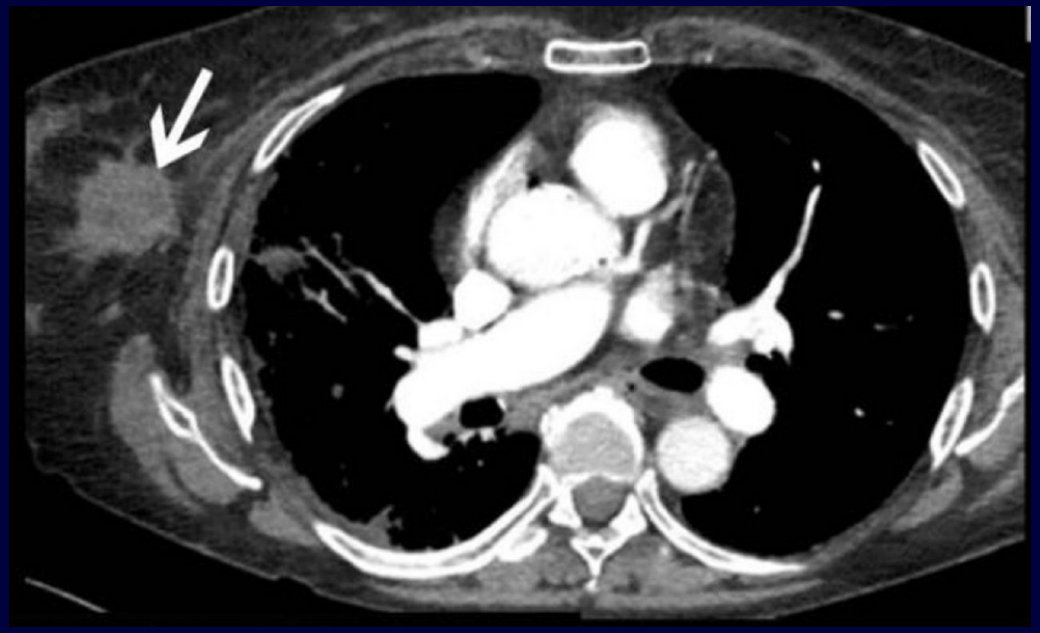
1. Diagnostic imaging
2. Imaging as part of treatment – biopsy, therapy
3. Follow up imaging / monitoring
4. Screening
5. Incidental findings

Incidental findings

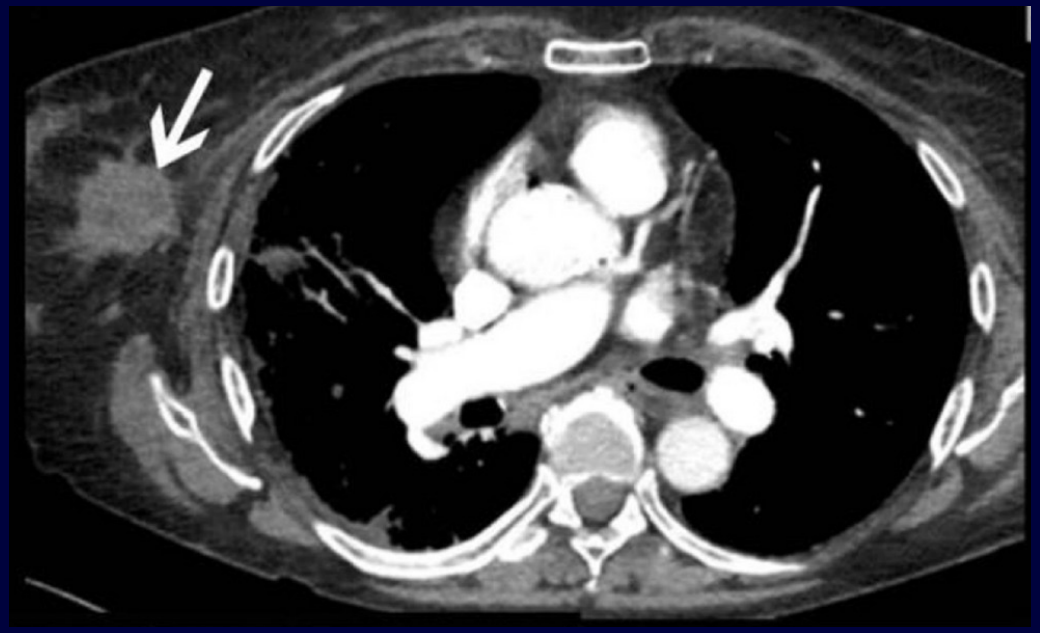
Helpful (serendipitous) or unhelpful

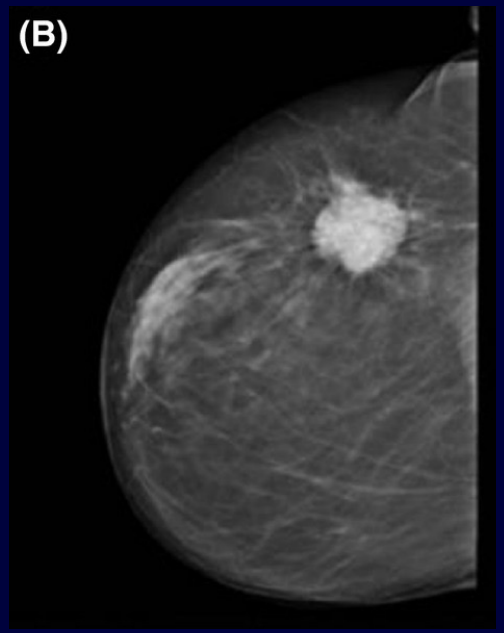
Scan finds something unexpected

Incidental findings – what do we do ?



Incidental findings – what do we do ?





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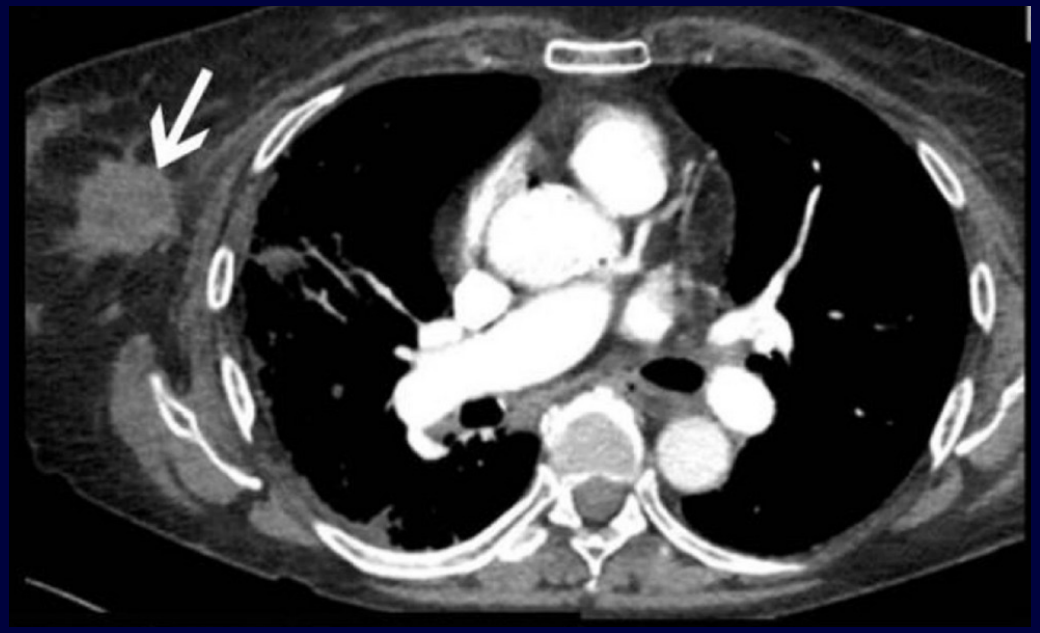
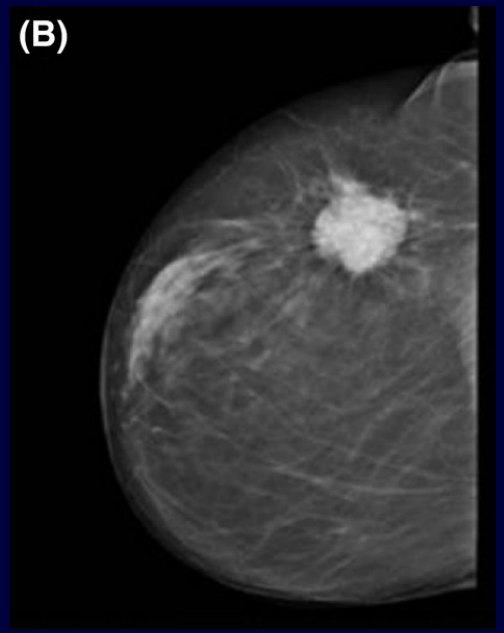
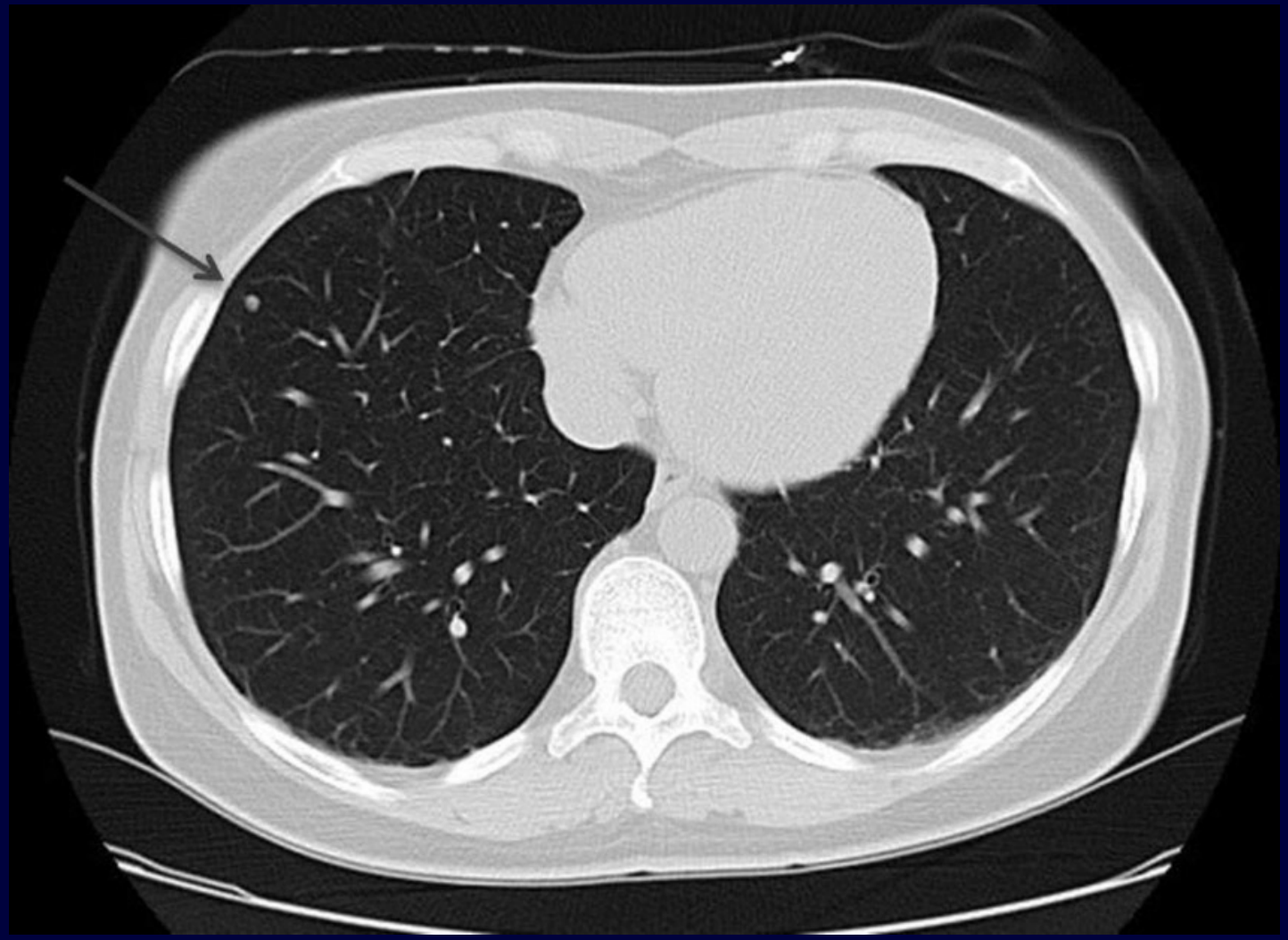




35,000 CT chest scans - 27 breast lesions identified, 23 malignant (4 metastases)
= 0.07%, i.e. 1 in 1300

Georgieva et al., 2021

Incidental findings – what do we do ?



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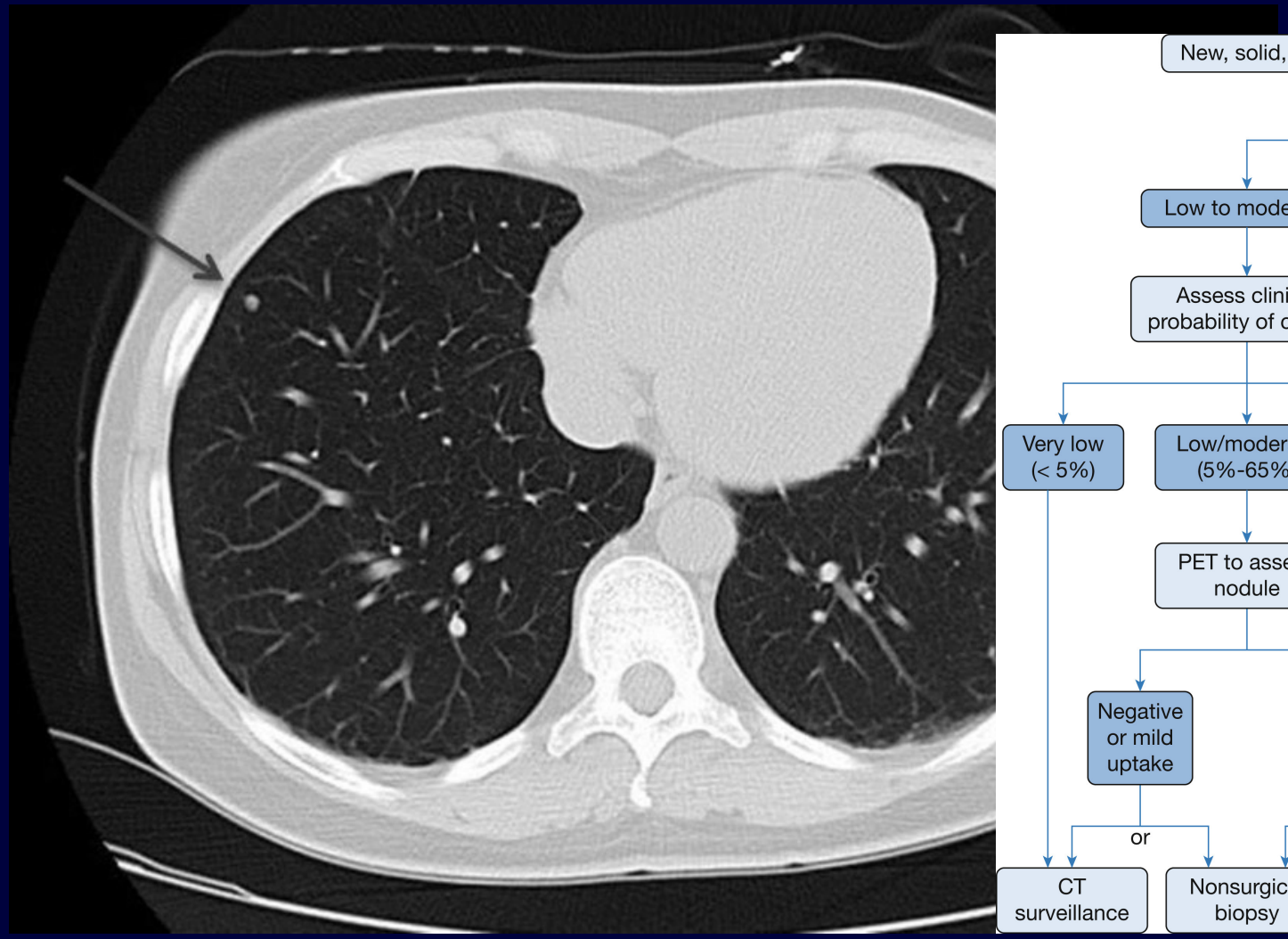

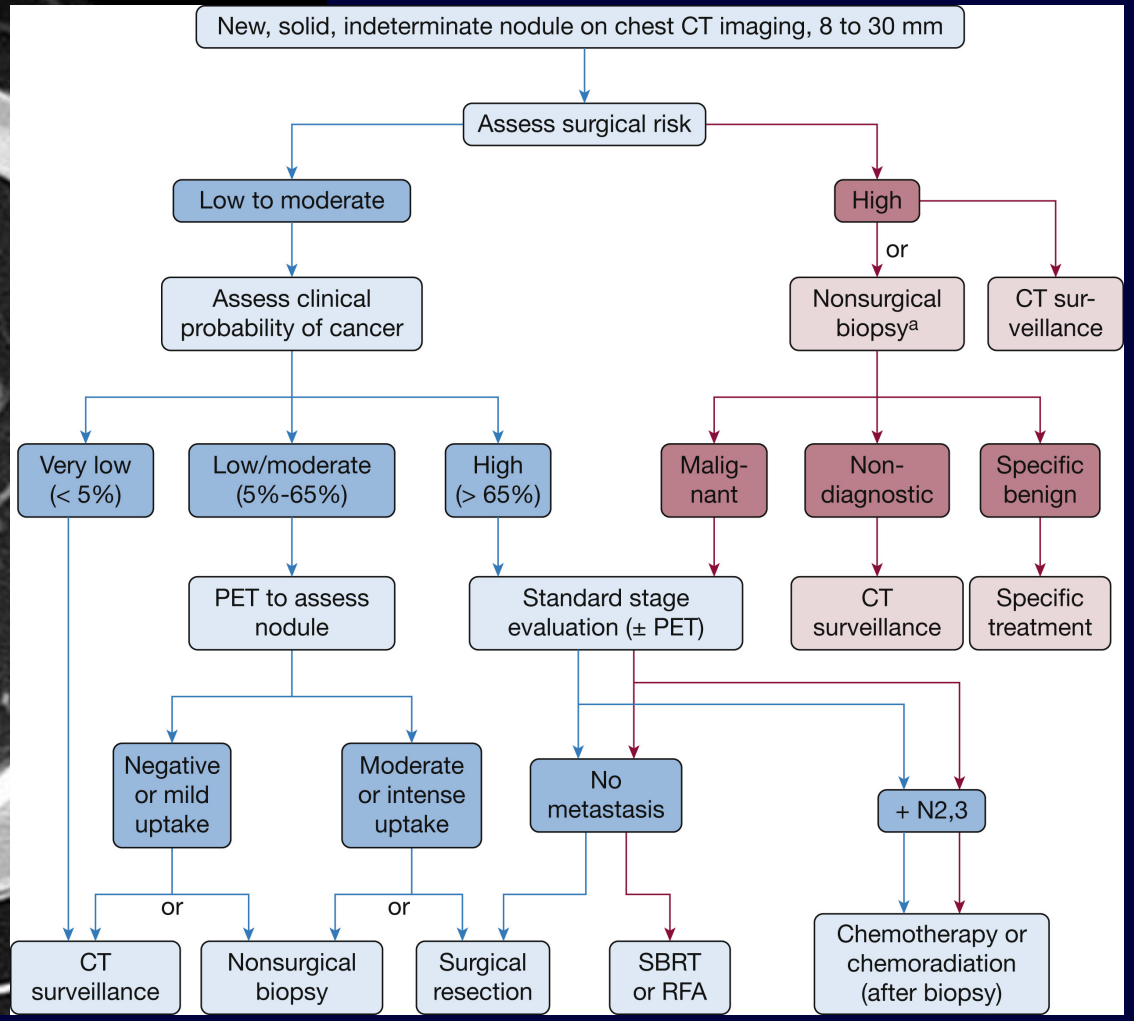

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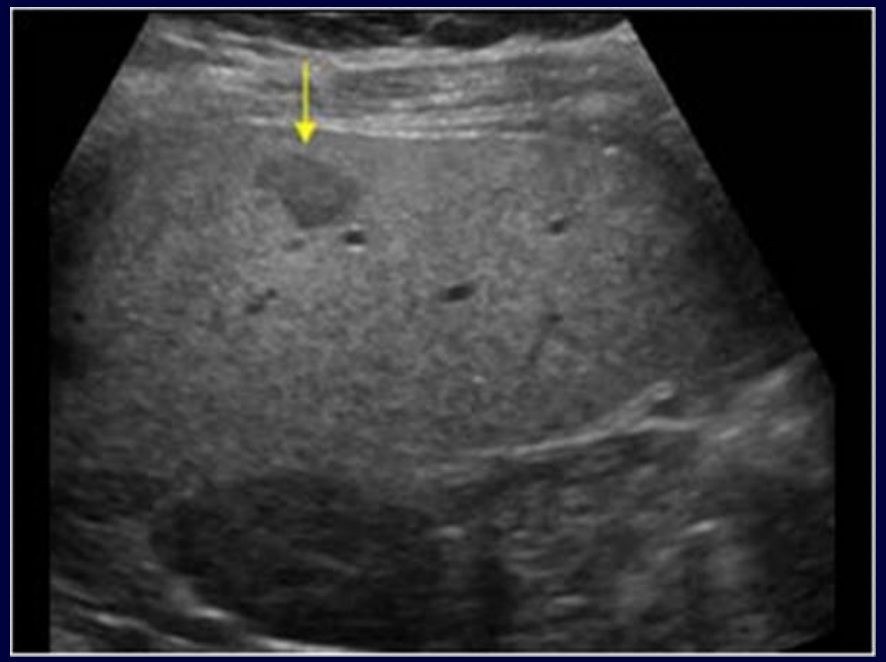

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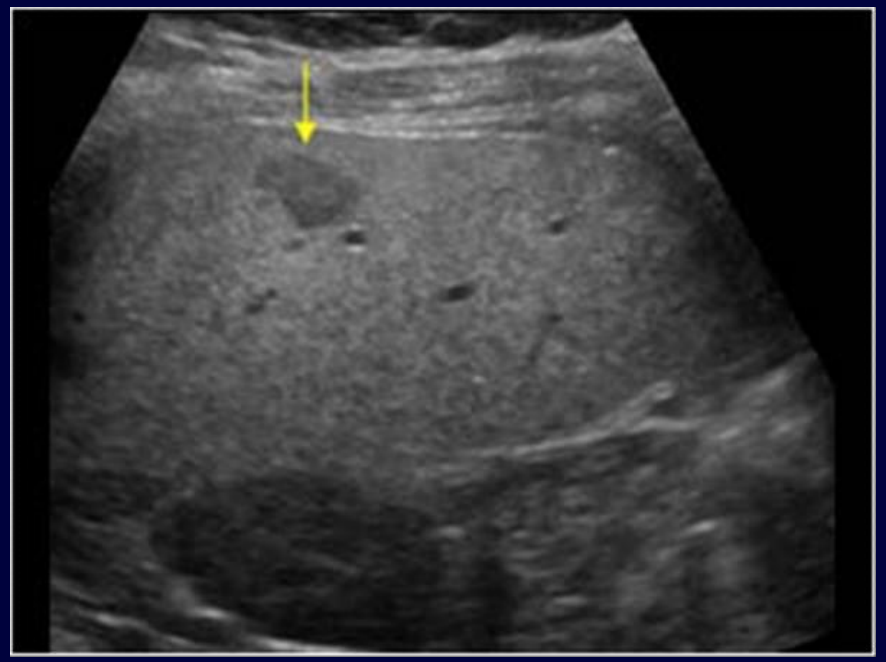
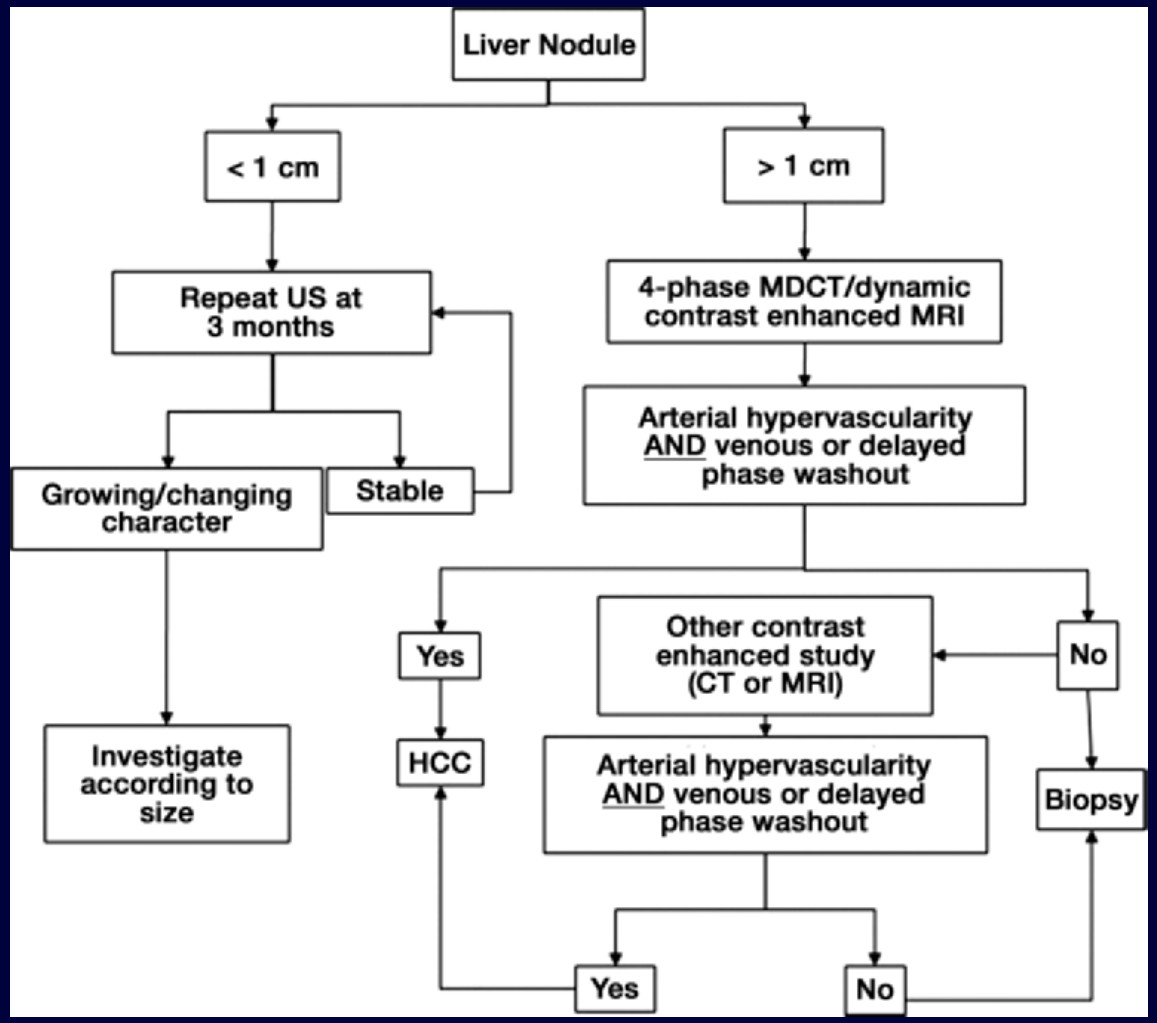
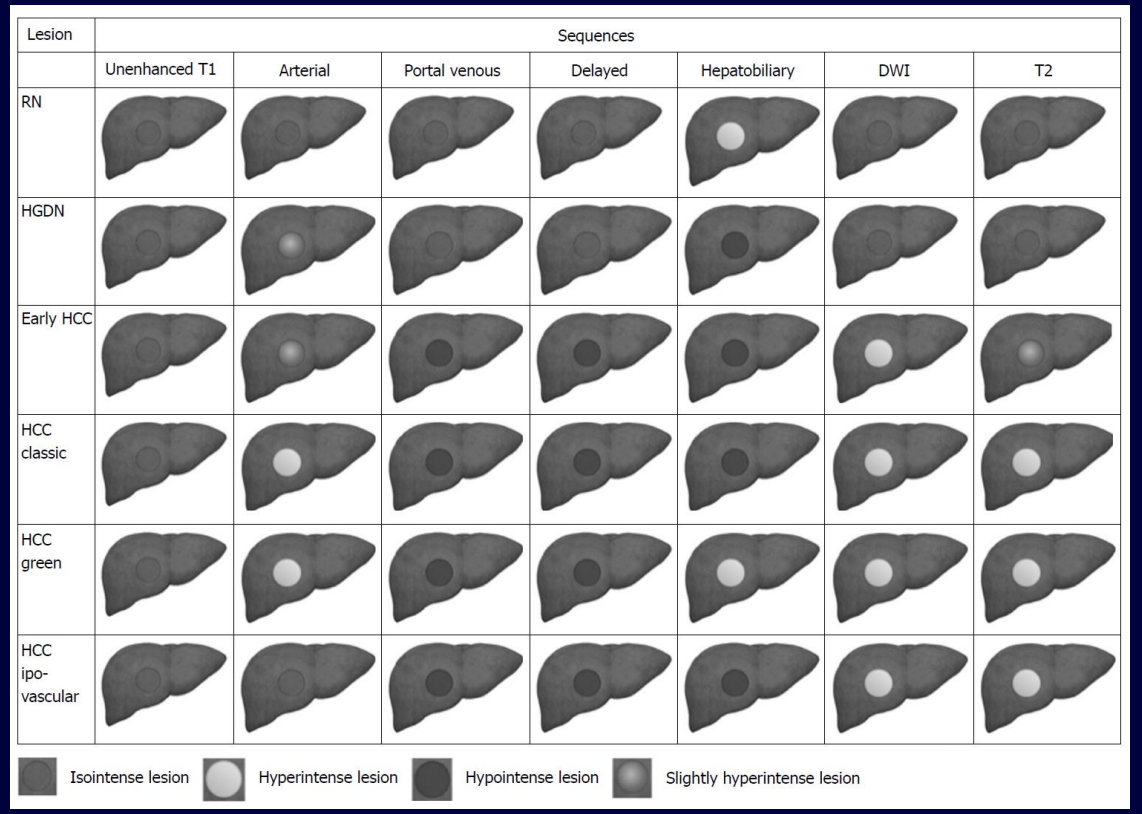


Lesion	Sequences						
	Unenhanced T1	Arterial	Portal venous	Delayed	Hepatobiliary	DWI	T2
RN							
HGDN							
Early HCC							
HCC classic							
HCC green							
HCC ipo-vascular							

Isointense lesion Hyperintense lesion Hypointense lesion Slightly hyperintense lesion

Incidental findings – what do we do ?





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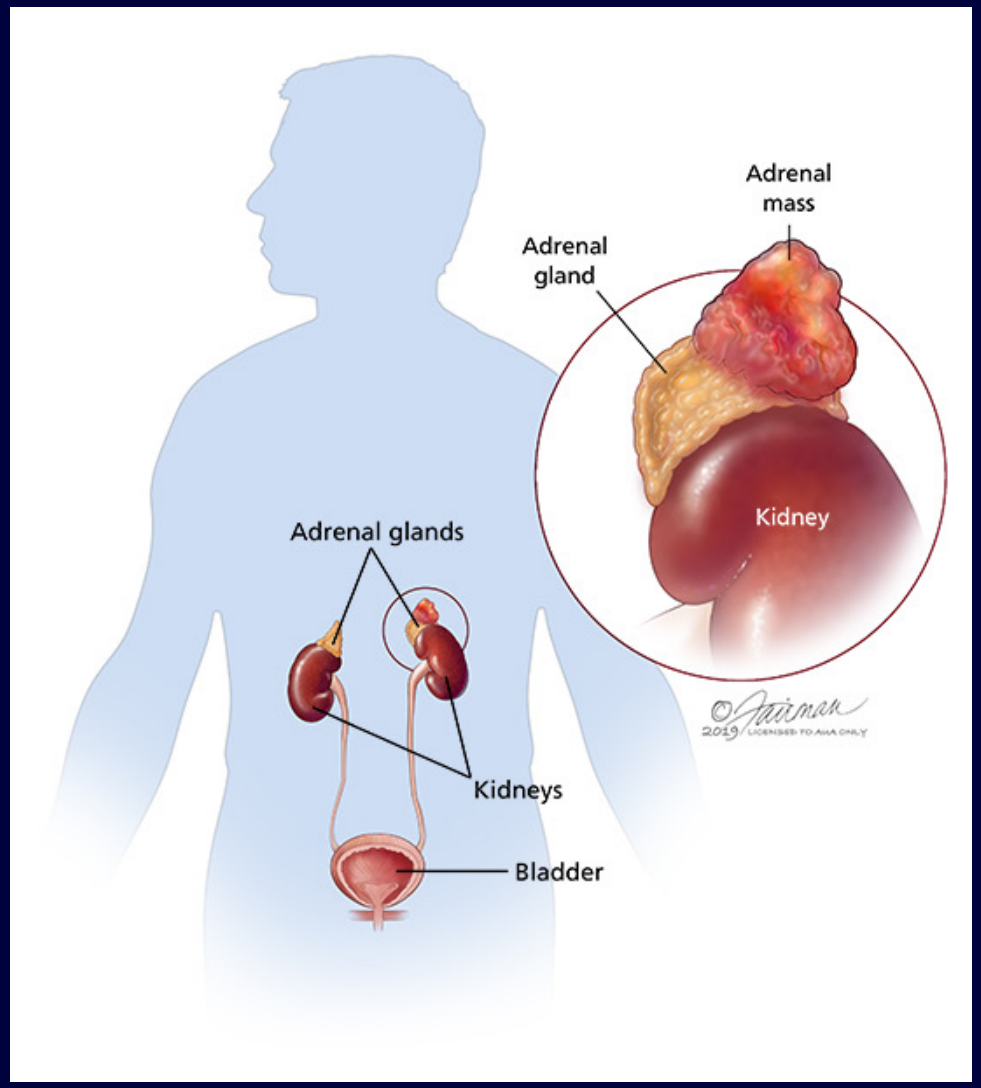
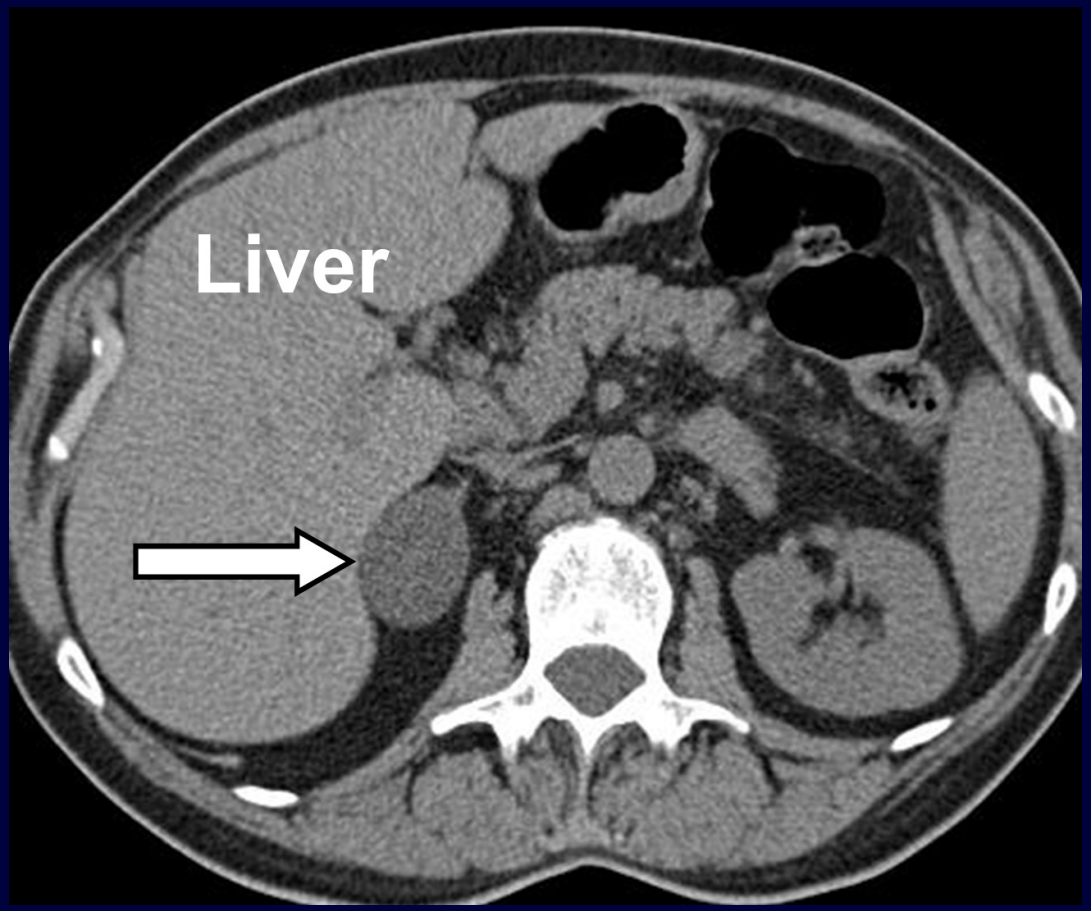




Adrenal “incidentalomas”

10% people have asymptomatic, inactive adrenal adenomas
(autopsy data 1945 – 1985)

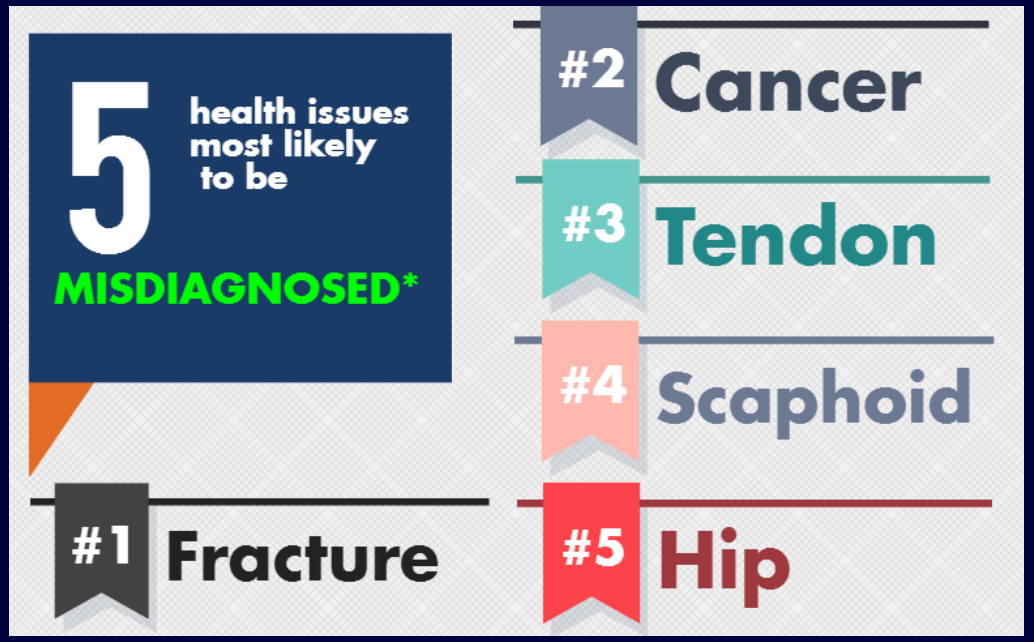
Rarely malignant (1 / million people)

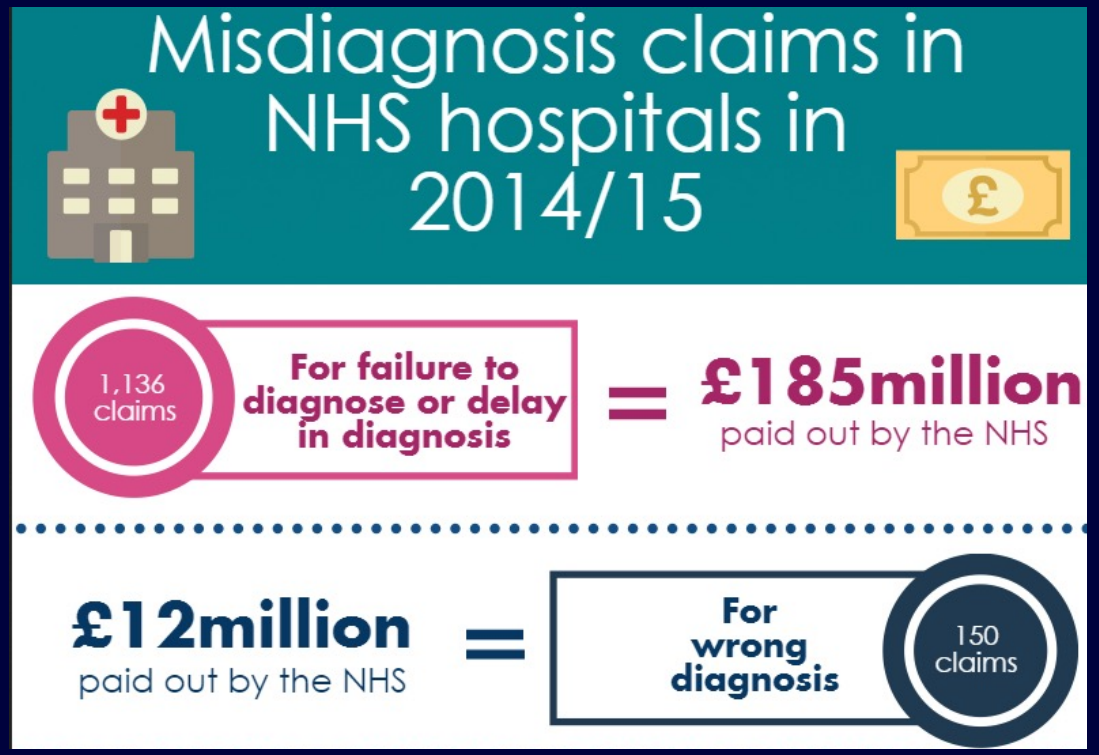
Scan – identify – biopsy ?
Measure hormones ?
Follow up (imaging) ?

Afraid of doing the wrong thing

Afraid of doing the wrong thing

Wrong diagnosis
Missed diagnosis
Late diagnosis





Afraid of doing the wrong thing

Failure or delay to send for a scan
Failure to detect the abnormality
Failure to follow up correctly

Afraid of doing the wrong thing

Failure or delay to send for a scan
Failure to detect the abnormality
Failure to follow up correctly

Unnecessary scan better than an unnecessary operation?

Afraid of doing the wrong thing

Failure or delay to send for a scan
Failure to detect the abnormality
Failure to follow up correctly

Unnecessary scan better than an unnecessary operation?

Unnecessary scan better than an unnecessary lawsuit ?

Medical Imaging

Essential ?
Or just “Nice to have”?

Path of least resistance?

Depends on availability !

Scan “just in case”

Quandary

Lots of people need imaging

Insufficient resources to meet demand

Quandary

Lots of people need imaging

Insufficient resources to meet demand

Can we test the system ?

COVID-19

COVID-19

Elective imaging stopped overnight
Emergency – either emergency surgery
- or COVID-19 related

+ social distancing
+ infection control
+ deep cleaning
+ imaging staff redeployed

Main issues

Who didn't get scanned during COVID ?

"Pandemic effect on patients WITHOUT Covid"

Main issues

Who didn't get scanned during COVID ?

"Pandemic effect on patients WITHOUT Covid"

Diagnostic imaging – continued, reduced
Treatment - reduced

Screening - reduced
Surveillance - stopped

Main issues

Who didn't get scanned during COVID ?

"Pandemic effect on patients WITHOUT Covid"

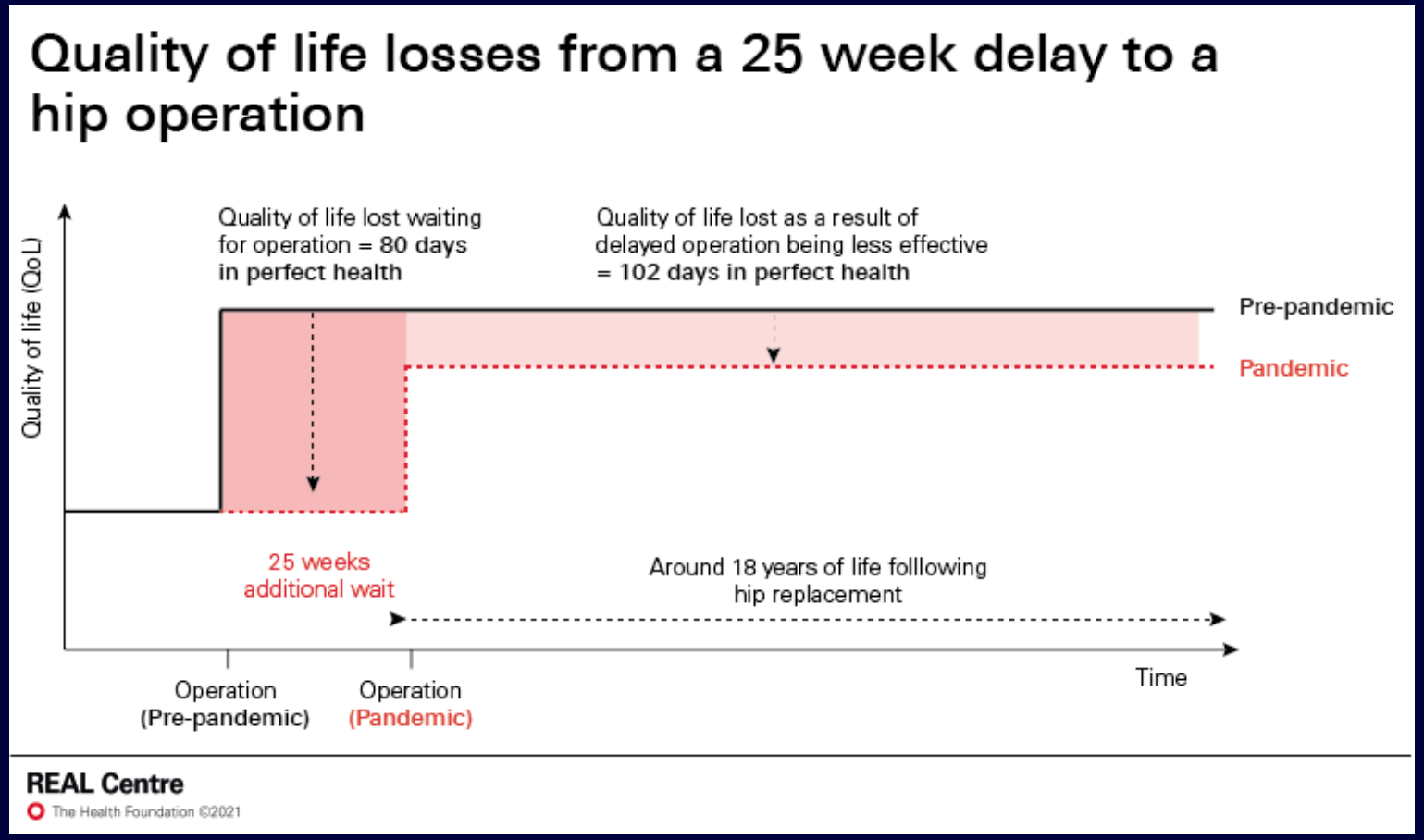
Reduced screening for cancers

- 65% reduction in new breast cancer diagnoses

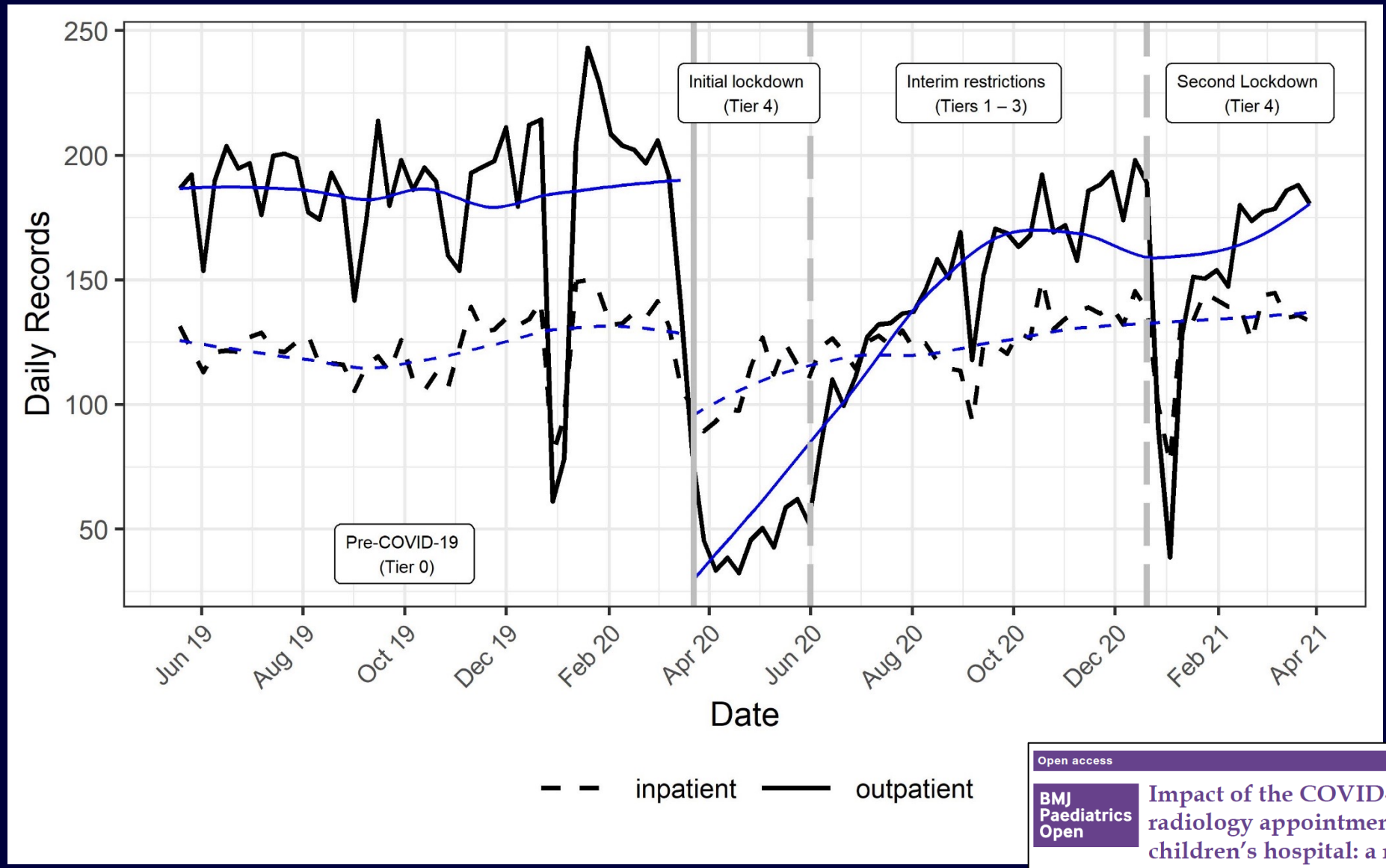
Postponed surgery

- reduced heart operations e.g. bypass, valve replacements
- reduced bowel cancer operations

Effect?



330 hip replacements per DAY in NHS
58,000 people waited 25 additional weeks for hip replacement (Jan 21)



Open access Original research letter

BMJ Paediatrics Open

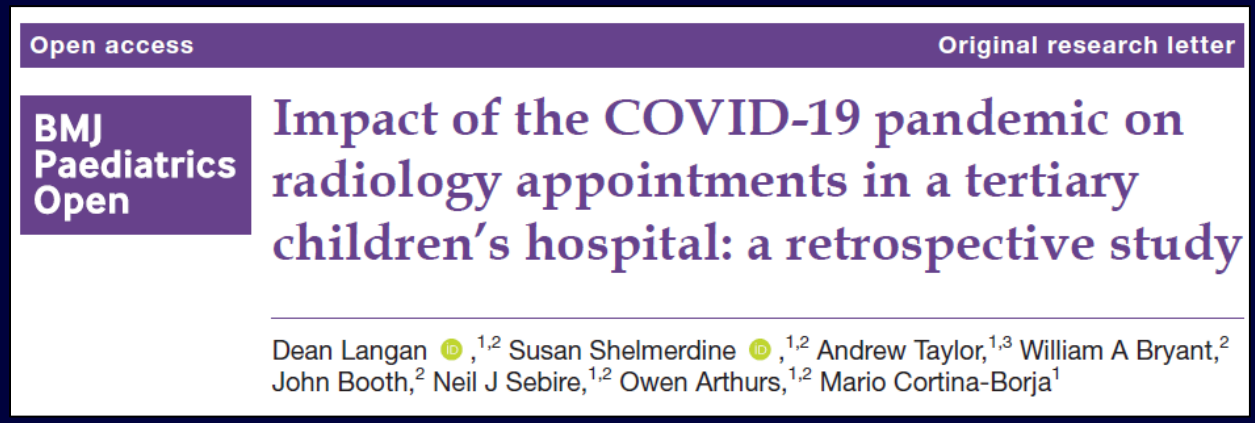
Impact of the COVID-19 pandemic on radiology appointments in a tertiary children's hospital: a retrospective study

Dean Langan ,[1,2] Susan Shelmerdine ,[1,2] Andrew Taylor,[1,3] William A Bryant,[2] John Booth,[2] Neil J Sebire,[1,2] Owen Arthurs,[1,2] Mario Cortina-Borja[1]

COVID-19 impact at GOSH

May 2019 – May 2021
27% reduction in outpatient weekday activity
40% reduction during Tier 4 lockdown

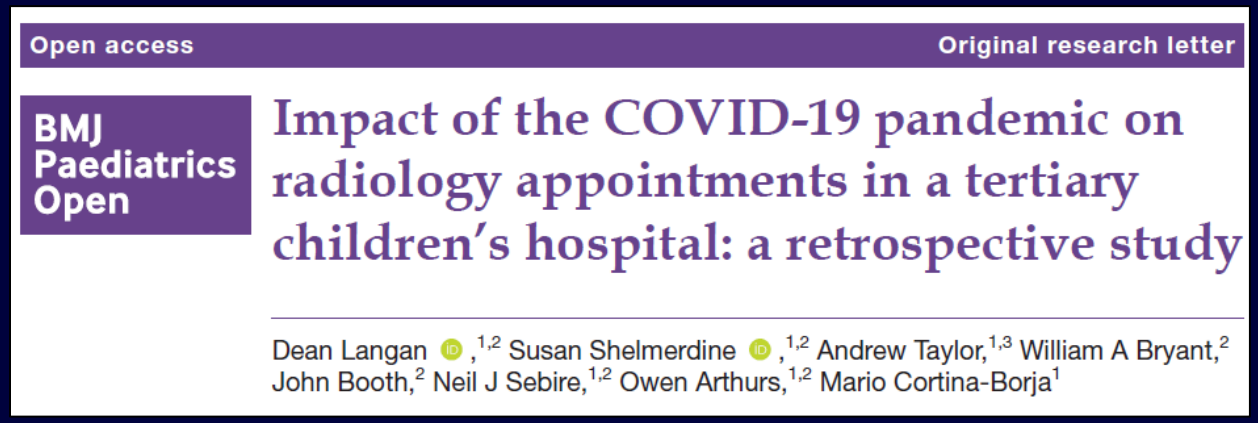
67 800 patients per year = normal
49 250 patients in year after COVID
18 000 “missed” outpatient visits



COVID-19 impact at GOSH

Assuming 10% increased in working activity
720 weekdays (2.5 years) to “catch up” on all this activity

How do we recover this activity ?
Do we need to ?

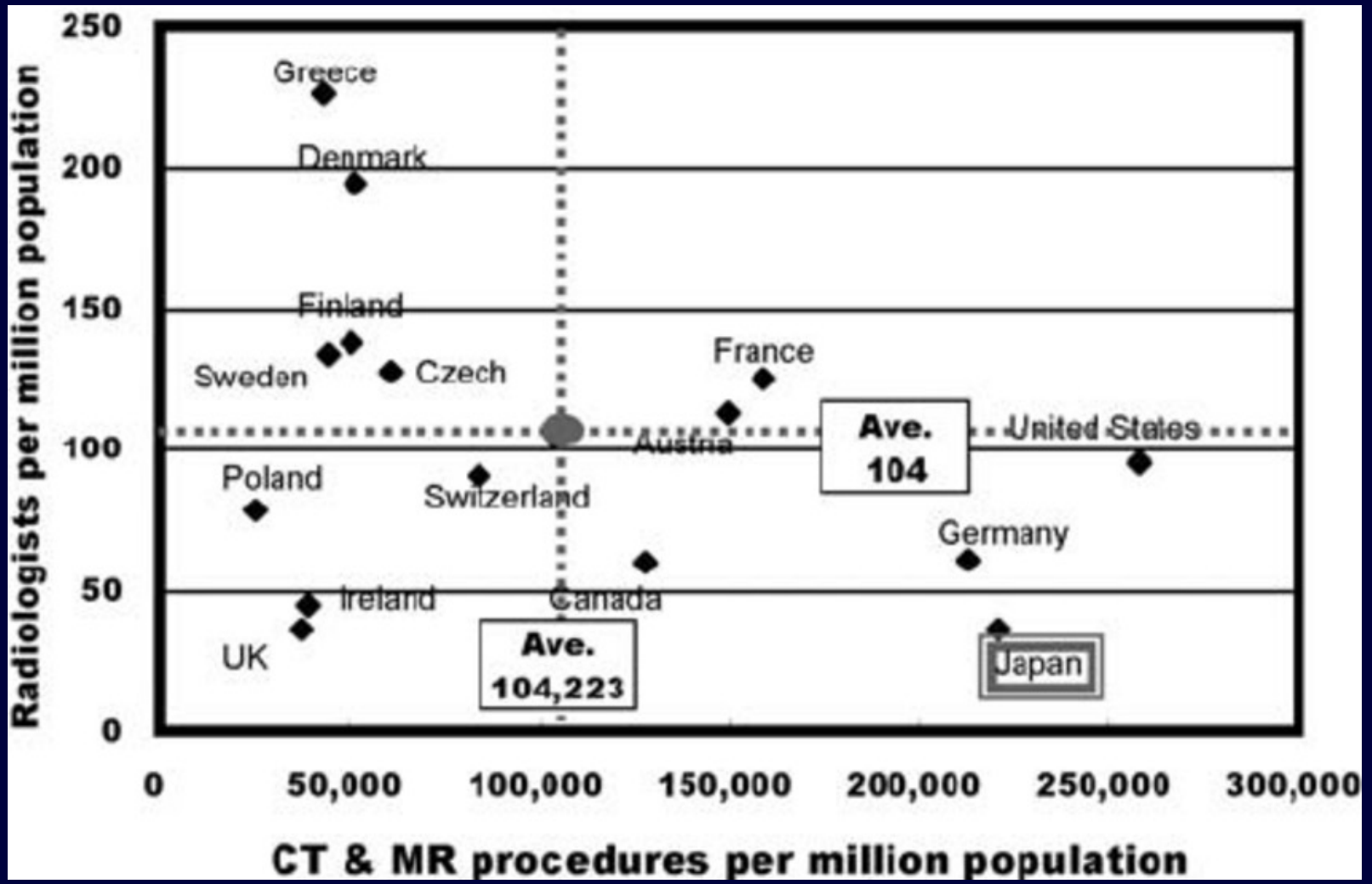


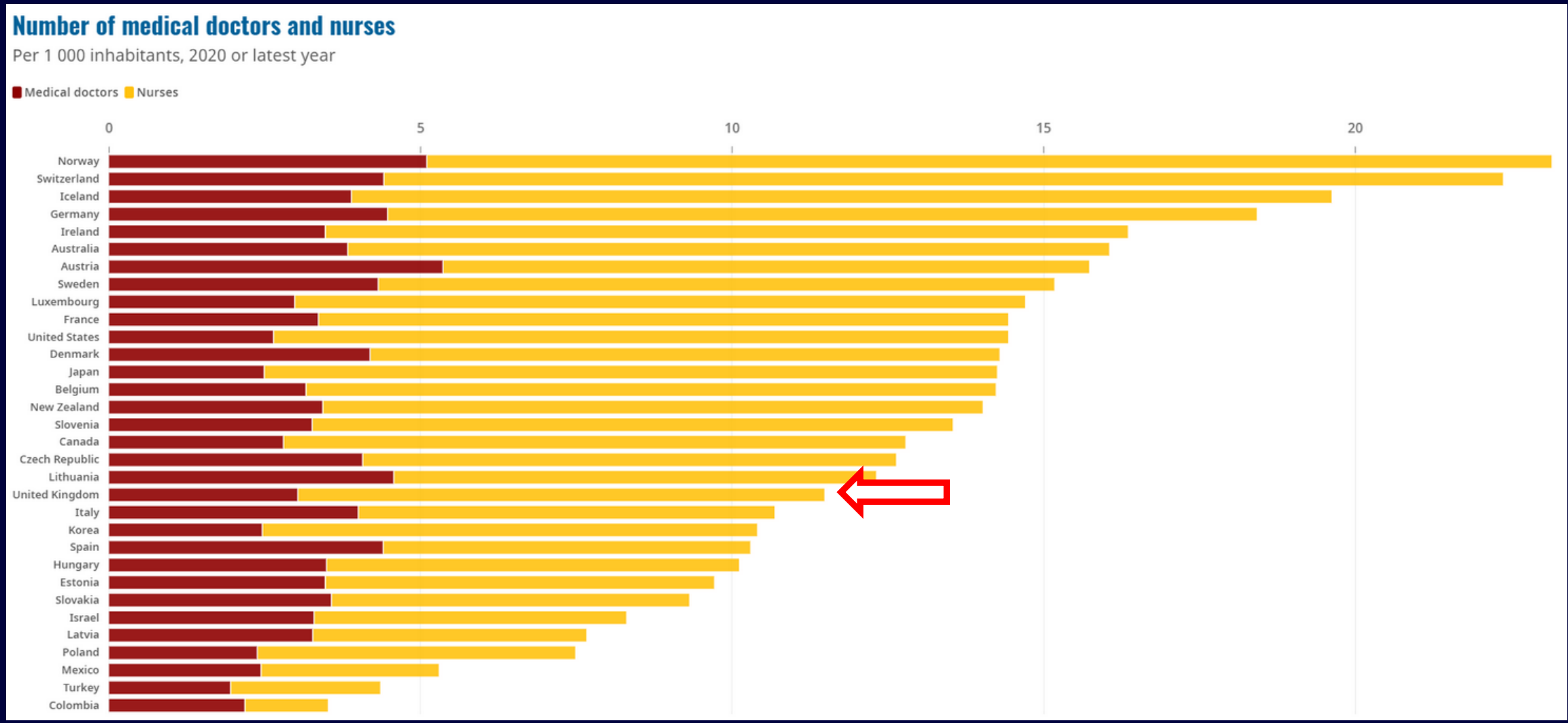
NHS waiting lists

April 2012	2.5 million waiting for routine hospital treatment
Feb 2020	4.6 million
Sept 2022	6.7 million

April 2012	0.6 million patients waiting for MRI or CT scans
Feb 2020	1 million
Sept 2022	1.6 million

Shortage


Radiologists per million population
250
200
150
100
50
0
Greece
Denmark
Finland
Sweden
Czech
France
Austria
Ave.
104
United States
Poland
Switzerland
Germany
Ireland
Canada
UK
Ave.
104,223
Japan
0
50,000
100,000
150,000
200,000
250,000
300,000
CT & MR procedures per million population


Number of medical doctors and nurses
Per 1 000 inhabitants, 2020 or latest year
Medical doctors
Nurses
0
5
10
15
20
Norway
Switzerland
Iceland
Germany
Ireland
Australia
Austria
Sweden
Luxembourg
France
United States
Denmark
Japan
Belgium
New Zealand
Slovenia
Canada
Czech Republic
Lithuania
United Kingdom
Italy
Korea
Spain
Hungary
Estonia
Slovakia
Israel
Latvia
Poland
Mexico
Turkey
Colombia

Shortage

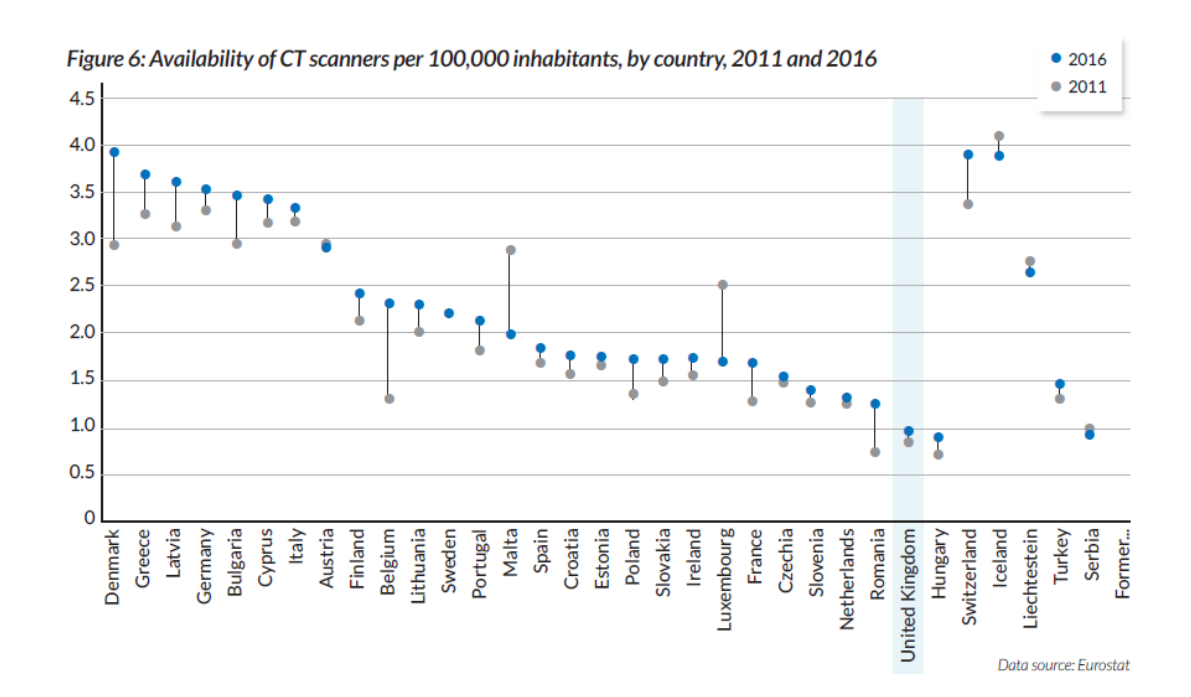


Figure 6: Availability of CT scanners per 100,000 inhabitants, by country, 2011 and 2016
2016
2011
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Denmark
Greece
Latvia
Germany
Bulgaria
Cyprus
Italy
Austria
Finland
Belgium
Lithuania
Sweden
Portugal
Malta
Spain
Croatia
Estonia
Poland
Slovakia
Ireland
Luxembourg
France
Czechia
Slovenia
Netherlands
Romania
United Kingdom
Hungary
Switzerland
Iceland
Liechtestein
Turkey
Serbia
Former...
Data source: Eurostat

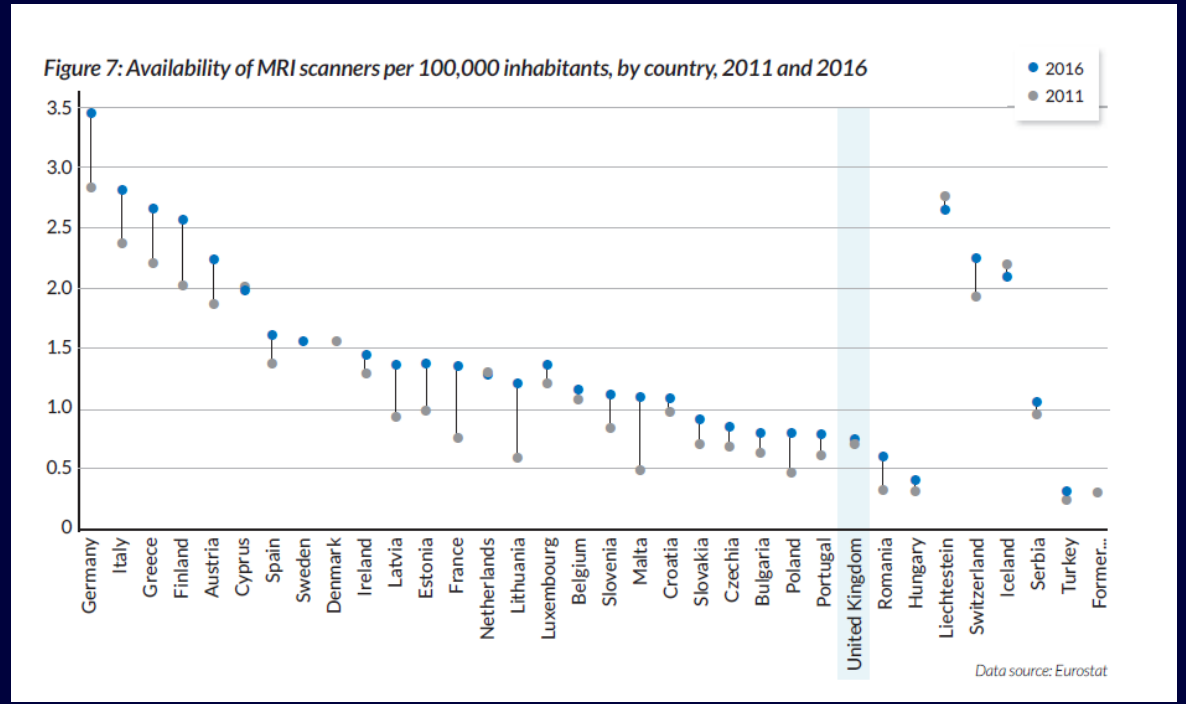


Figure 7: Availability of MRI scanners per 100,000 inhabitants, by country, 2011 and 2016
2016
2011
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Germany
Italy
Greece
Finland
Austria
Cyprus
Spain
Sweden
Denmark
Ireland
Latvia
Estonia
France
Netherlands
Lithuania
Luxembourg
Belgium
Slovenia
Malta
Croatia
Slovakia
Czechia
Bulgaria
Poland
Portugal
United Kingdom
Romania
Hungary
Liechtestein
Switzerland
Iceland
Serbia
Turkey
Former...
Data source: Eurostat

Quandary

HEALTH

Forget the pandemic, 'NHS decline is to blame' for record waiting lists

Lots of people need imaging
Backlog due to chronic shortage + COVID
Insufficient resources to meet demand

Quandary

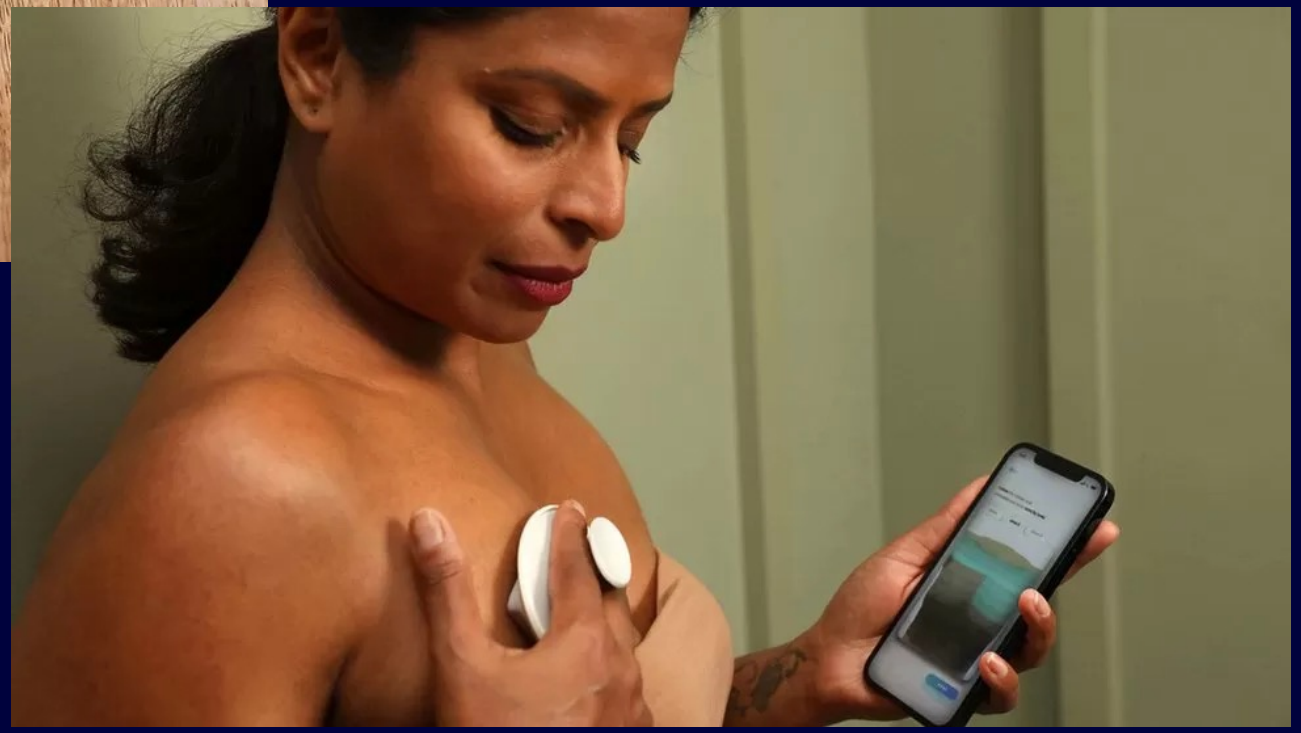
Lots of people need imaging
Backlog due to chronic shortage + COVID
Insufficient resources to meet demand

Solutions
- more trained staff / machines
- imaging hub, improved access
- home imaging ?!
- artificial intelligence
- investment ?

GIRFT
GETTING IT RIGHT FIRST TIME

Tool to spot breast cancer at home wins UK Dyson award

THE JAMES DYSON AWARD 2022



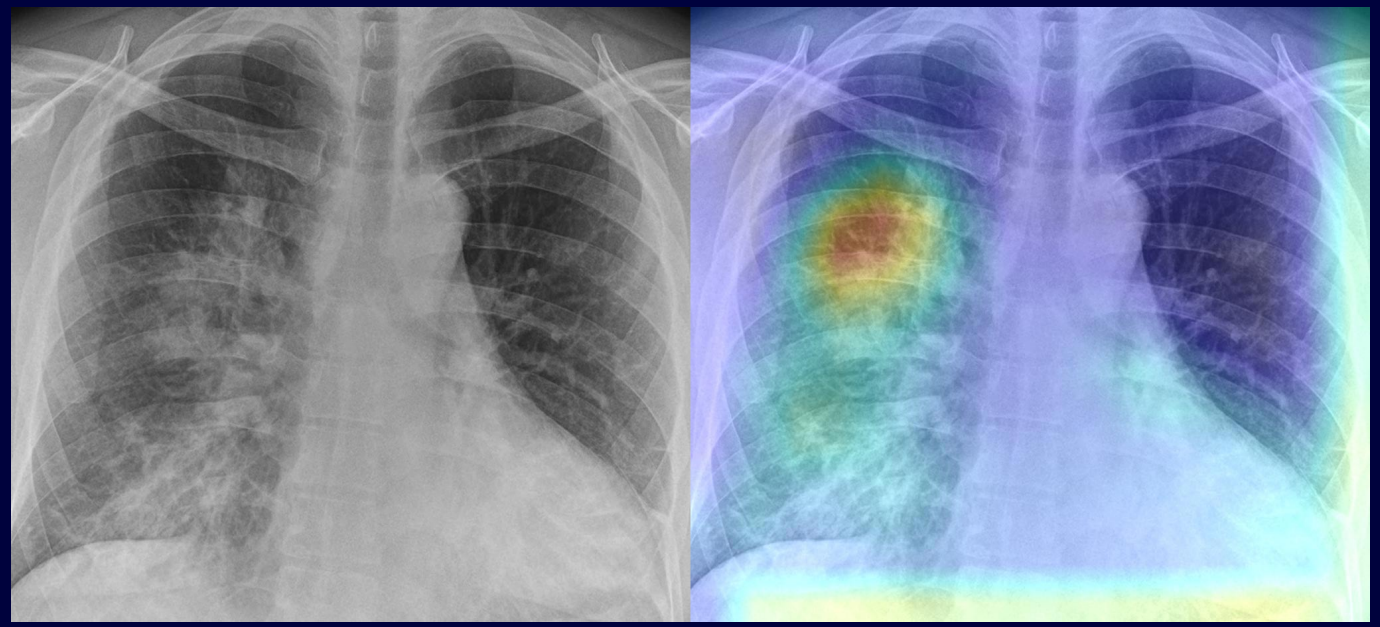
Dotplot
Imperial College / RCA

Stop training Radiologists

“It is just completely obvious that within 5 years, Deep learning will do better than radiologists”

AI pioneer Geoffrey Hinton, 2016

Can computers help us ?

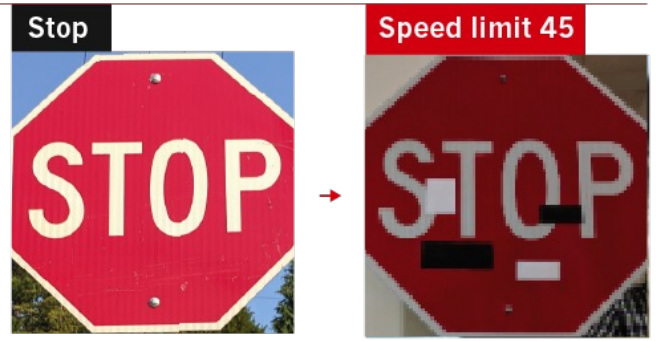


Can computers help us ?

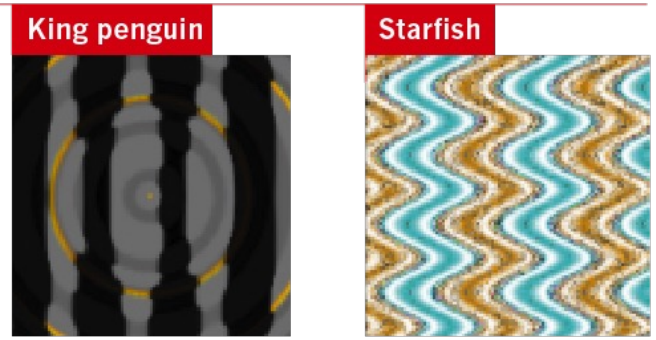
FOOLING THE AI

Deep neural networks (DNNs) are brilliant at image recognition — but they can be easily hacked.

These stickers made an artificial-intelligence system read this stop sign as ‘speed limit 45’.

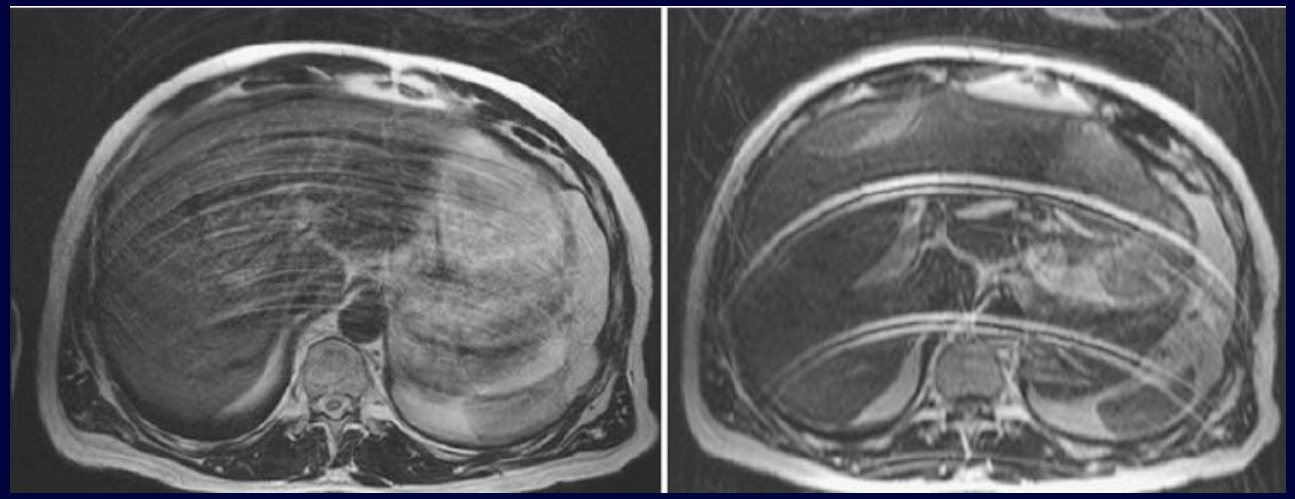


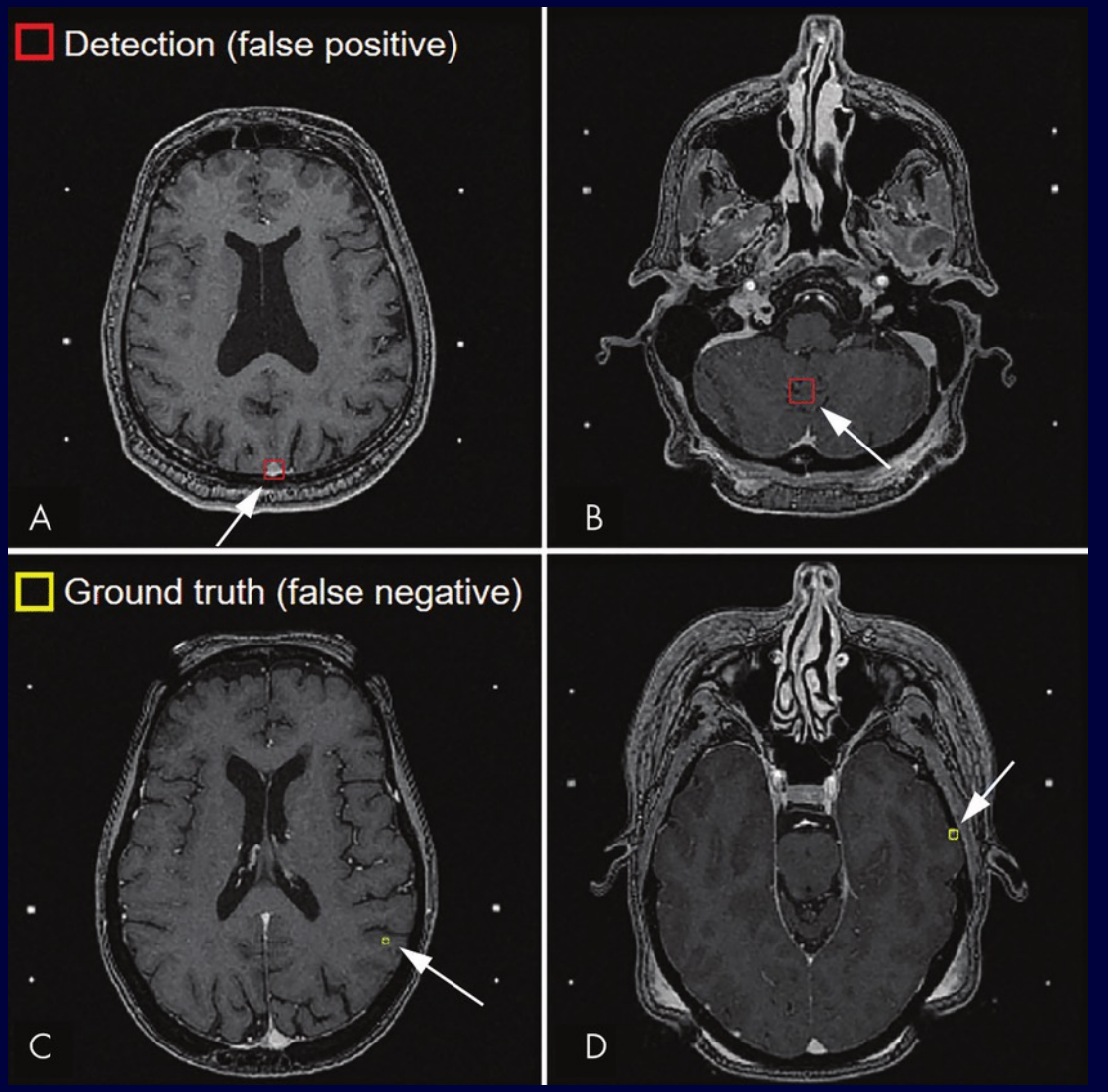
Scientists have evolved images that look like abstract patterns — but which DNNs see as familiar objects.



©nature

Can computers help us ?





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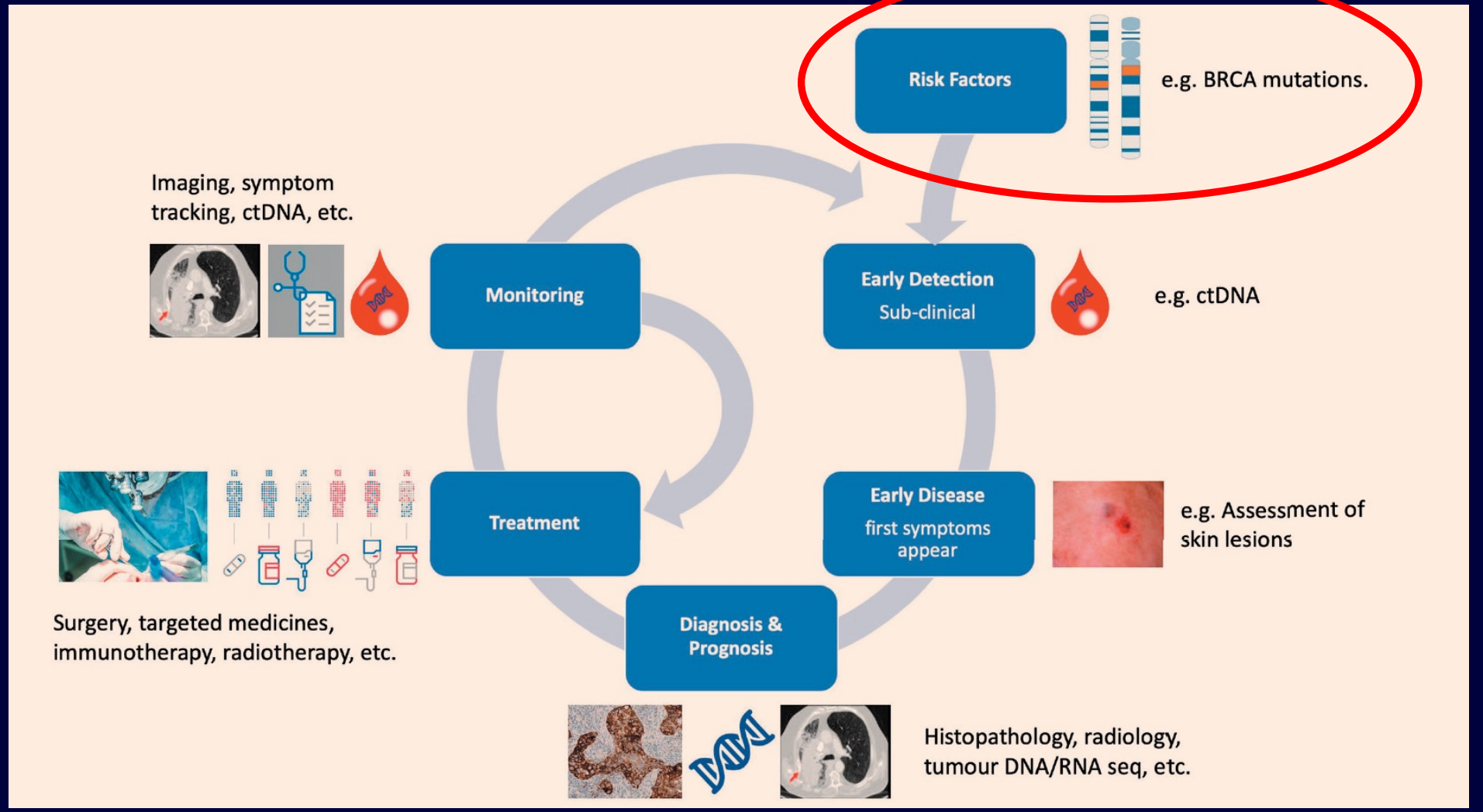
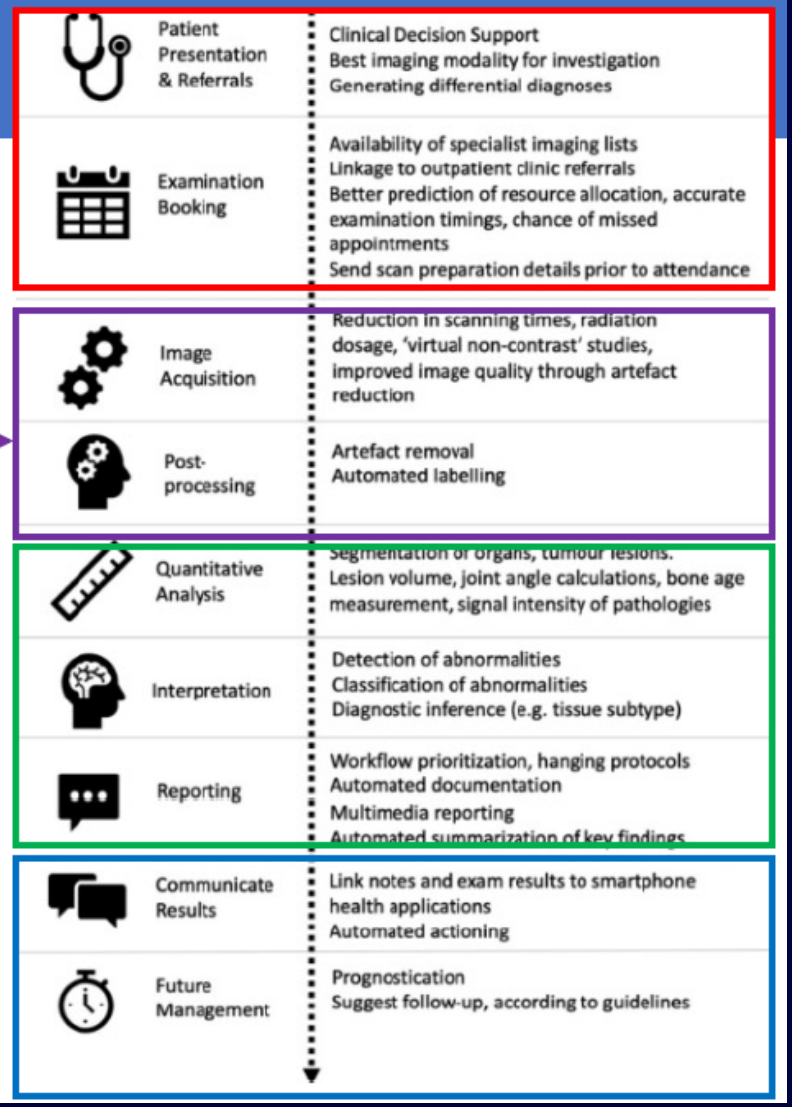


Can computers help us ?

How can AI help?

1. A more efficient workflow
2. Improved image acquisition/processing
3. Improved accuracy & reading time
4. Personalised diagnostics/prognostics



Davendralingham N et al. BJR 2021 Jan 1;94(1117):20200975. Artificial intelligence in paediatric radiology: Future opportunities

Van Leeuwen KG et al. Pediatric Radiology 2021. How does artificial intelligence in radiology improve efficiency and health outcomes?

Are we too reliant on Medical Imaging?

Balance risk of over- vs under-scanning

Limited resource in ailing population

No quick fix

Aim for the right test, right person, right time

Are we too reliant on Medical Imaging?

Who does not need to be in the queue?

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Academy of Medical Royal Colleges

Fixing the NHS

Why we must stop normalising the unacceptable