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?
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 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
Radiographer, Technologist
Sonographer

Radiologist
+ 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
What is “too reliant”?

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

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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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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Medical Imaging

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Medical Imaging

Appendicitis

Inflamed appendix

McBurney’s Point
2/3 the distance from navel to R. ASIS
Tenderness maximal in cases of acute appendicitis

Symptoms
- Low-grade fever
- Constipation or diarrhea
- Nausea and vomiting

Diagnosis
- Physical exam
  - Rebound tenderness
  - Rovsing’s sign
  - PSAS sign
  - Obturator sign

Lab studies
- WBC count & CRP
- CT scan
- Ultrasound
Medical Imaging

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

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

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

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

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

Appendicectomies are the UK’s most common emergency operation. Photograph: Burgo/Pharile/Rex Features
Unnecessary appendix surgery 'performed on thousands in UK'

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

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- Confirmed appendicitis
- Other appendix pathology
- Histologically normal appendix

993 operations on men

- 84.7%
- 3.2%
- 12.1%
Unnecessary appendix surgery 'performed on thousands in UK'

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993 operations on men
- Confirmed appendicitis: 84.7%
- Other appendix pathology: 3.2%
- Histologically normal appendix: 12.1%

964 operations on women
- Confirmed appendicitis: 64.8%
- Other appendix pathology: 7.0%
- Histologically normal appendix: 28.2%
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.
Radiation dose

**LOW RACE ULTRASOUND or MRI**
Radiation exposure is equivalent to:

- ZERO days of natural radiation
- ZERO hours of flying

**LOW RACE X-RAY**
Radiation exposure is equivalent to:

- 213 days of natural radiation
- 182 hours of flying

**LOW RACE CT SCAN**
Radiation exposure is equivalent to:

- 511 days of natural radiation
- 462 hours of flying
Radiation dose

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1 banana = 0.1 microsieverts (μSv)

800 bananas
Transatlantic flight = 80μSv

27,000 bananas
UK average annual radiation dose = 2,700μSv

50 bananas
Dental x-ray = 5μSv

100 bananas
100g of Brazil nuts = 10μSv

50,000,000 bananas
Lethal radiation dose = 5,000,000μSv
**Radiation in Daily Life**

### Natural Radiation
- **10**: Unusually high natural radiation dose in downtown Guarapari, Brazil.
- **5**: Average annual dose to aircrew flying 800 hours per year.

### Man-Made Radiation
- **20**: Annual dose limit for radiation worker.
- **2.4**: Annual natural background radiation.
- **10**: Average effective dosage from CT scan.
- **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**: Average effective dosage of a Chest X-ray.

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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
Medical Imaging

1. Diagnostic imaging

2. Imaging as part of treatment – biopsy, therapy

3. Follow up imaging / monitoring

4. Screening

5. Incidental findings
Medical Imaging as part of treatment
Scan is part of the operation!
Medical Imaging as part of treatment
Medical Imaging as part of treatment

HIFU: High Intensity Focused Ultrasound
Imaging hearts
Imaging hearts
Imaging hearts

Stent placement

- Artery
- Catheter
- Plaque
- Stent
- Balloon
- Guidewire

Common femoral arteries
Radial artery

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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
Medical Imaging

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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 go on to spread
- Some of these would never cause harm
- Some women live healthy, full lives unharmed by and unaware of these cancers
- If these spread to vital organs, they may cause death

Breast Screening in Women
The Benefits and Harms of Breast Cancer Screening

Of 1,000 women aged 50–70, without any symptoms...

**Without Screening**
- 58 will be diagnosed with breast cancer
- 21 will die of breast cancer
- 37 will be treated and survive their cancer

**With Screening**
- 75 will be diagnosed with breast 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.

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?

Anxiety of further tests

Overdiagnosis

<table>
<thead>
<tr>
<th>Without screening</th>
<th>5 years later</th>
<th>With screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 people with progressive cancer</td>
<td></td>
<td>2000 people with nonprogressive cancer</td>
</tr>
<tr>
<td>5-year survival = ( \frac{400}{1000} = 40% )</td>
<td>400 alive</td>
<td>2000 alive</td>
</tr>
<tr>
<td>600 dead</td>
<td>1000 people with progressive cancer</td>
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</table>
Screening

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

Lung cancer

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

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Incidental findings

Helpful (serendipitous) or unhelpful

Scan finds something unexpected
Incidental findings – what do we do?
Incidental findings – what do we do?
Incidental findings – what do we do?

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?
Incidental findings – what do we do?

New, solid, indeterminate nodule on chest CT imaging, 8 to 30 mm

- Assess surgical risk
  - Low to moderate
    - Assess clinical probability of cancer
      - Very low (< 5%)
      - Low/moderate (5%-65%)
      - High (> 65%)
      - PET to assess nodule
        - Negative or mild uptake
          - CT surveillance
        - Moderate or intense uptake
          - Nonsurgical biopsy
          - Surgical resection
          - SBRT or RFA
      - Standard stage evaluation (± PET)
        - No metastasis
          - + N2,3
            - Chemotherapy or chemoradiation (after biopsy)
        - Malignant
          - Nonsurgical biopsy
          - CT surveillance
          - Specific treatment
    - Non-diagnostic
      - Nonsurgical biopsy
      - CT surveillance
      - Specific treatment
  - High or
    - Nonsurgical biopsy
    - CT surveillance
Incidental findings – what do we do?
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Incidental findings – what do we do?
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

Misdiagnosis claims in NHS hospitals in 2014/15

- **1,136 claims**
  - For failure to diagnose or delay in diagnosis
  - £185 million paid out by the NHS

- **£12 million**
  - For wrong diagnosis
  - 150 claims

#1 Fracture
#2 Cancer
#3 Tendon
#4 Scaphoid
#5 Hip
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
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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

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?

Quality of life losses from a 25 week delay to a hip operation

- Quality of life lost waiting for operation - 80 days in perfect health
- Quality of life lost as a result of delayed operation being less effective - 102 days in perfect health

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

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 ?
Tool to spot breast cancer at home wins UK Dyson award

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.
Can computers help us?
Can computers help us?

Risk Factors
- e.g. BRCA mutations.

Monitoring
- Imaging, symptom tracking, ctDNA, etc.

Early Detection
- Sub-clinical
  - e.g. ctDNA

Treatment
- Surgery, targeted medicines, immunotherapy, radiotherapy, etc.

Early Disease
- first symptoms appear
  - e.g. Assessment of skin lesions

Diagnosis & Prognosis
- Histopathology, radiology, tumour DNA/RNA seq, etc.
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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Fixing the NHS
Why we must stop normalising the unacceptable