Clinical Reasoning 1:
Introduction to diagnostic tests

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Consultant Physician & Honorary Clinical Associate Professor
There are two clinical reasoning workshops in the first year.

By the end of this session you should:

• Understand what is meant by ‘clinical reasoning’
• Know the different components of clinical reasoning
• Understand the principles of using and interpreting diagnostic tests
What is meant by ‘clinical reasoning’?
‘A clinician’s ability to make decisions, often with others, based on the available clinical information, which includes history (sometimes from multiple sources), physical examination findings and test results – against a backdrop of uncertainty. [It] also includes choosing appropriate treatments (or no treatment at all) and decision-making with patients and/or their carers.’

In all definitions in the literature, several ‘components’ (i.e. elements of a larger whole) of the clinical reasoning process are described:

- History
- Physical examination
- Use and interpretation of diagnostic tests
- Reasoning/rationality
- Shared decision making (with patients, carers, teams, guidelines etc.)
- Formal and experiential knowledge of medicine
Clinical reasoning describes the thinking and decision-making processes associated with clinical practice.

Clinical reasoning is not the same as ‘critical thinking’ … critical thinking is a component of rationality – one’s ability to reason based on facts – and rationality is only one component of clinical reasoning.
Why does clinical reasoning matter?
• 1 in 10 diagnoses are incorrect
• Diagnostic error causes significant harm
• Diagnostic error accounts for 40,000 – 80,000 deaths annually in the US, somewhere between breast cancer and diabetes
• Chances are, we will all experience a diagnostic error in our lifetime

Results -

‘System-related factors contributed to diagnostic error in 65% of the cases and cognitive factors in 74% ... the most common cognitive factors involved faulty synthesis.’
'The prevailing opinion that diagnostic error is a cognitive processing error ... is incorrect. This perspective presupposes that all of the available knowledge is present ... In contrast, a diagnostic error may reflect not a processing error, but an incomplete knowledge base or inadequate experience.'

The components of clinical reasoning

- Basic science & clinical medicine
- Evidence-based physical examination
- Evidence-based history
- Use and interpretation of diagnostic tests
- Reasoning/rationality
- Shared decision-making*

Clinical Reasoning
What do we mean by ‘knowledge’?

<table>
<thead>
<tr>
<th>Knowledge dimension</th>
<th>Description</th>
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</table>
| A. Factual knowledge | The basic elements that students must know to be acquainted with a discipline or solve problems in it  
• Terminology  
• Specific details and elements |
| B. Conceptual knowledge | The inter-relationships among the basic elements within a larger structure that enable them to function together  
• Classifications and categories  
• Principles and generalisations  
• Theories, models and structures |
| C. Procedural knowledge | How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques and methods  
• Subject-specific skills and algorithms  
• Subject-specific techniques and methods  
• Criteria for determining when to use appropriate procedures |
| D. Metacognitive knowledge | Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition  
• Strategic knowledge  
• Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge  
• Self-knowledge |

Using and interpreting diagnostic tests
In a 60-year old heavy smoker who presents with persistent breathlessness on exertion and wheeze, what is the probability of him having emphysema with a normal* spirometry result?

*FEV1/FVC ratio >70%: GOLD Guide 2017
Tests lie! – tests give us test probabilities not real probabilities

All test results are affected by the following:

• How ‘normal’ is defined
• Factors other than disease that influence test results
• Operating characteristics
• Sensitivity and specificity
• Prevalence of disease in the population
Sensitivity and specificity

- Sensitivity is the ability to detect true positives
- Specificity is the ability to detect true negatives
- No test has 100% sensitivity and specificity

<table>
<thead>
<tr>
<th></th>
<th>Disease</th>
<th>No disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive test</td>
<td>A (True pos)</td>
<td>B (False pos)</td>
</tr>
<tr>
<td>Negative test</td>
<td>C (False neg)</td>
<td>D (True neg)</td>
</tr>
</tbody>
</table>

Sensitivity = \( \frac{A}{A+C} \times 100 \)

Specificity = \( \frac{D}{D+B} \times 100 \)
The probability of a disease depends on the clinical (pre-test) probability plus the sensitivity and specificity of the test
An elderly lady is admitted following a fall. She had hurt her left hip and was unable to weight bear. On examination, the left hip was extremely painful to move.

Her X-ray (shown) is normal. 
Is there a fracture?
The most fundamental principle in clinical decision making is that the interpretation of new information depends on what you believed* beforehand

In a 60-year old heavy smoker who presents with persistent breathlessness on exertion and wheeze, what is the probability of him having emphysema with a normal* spirometry result?

*FEV1/FVC ratio >70%: GOLD Guide 2017
Probability of having a disease

http://vassarstats.net/clin2.html
Probability of having a disease

http://vassarstats.net/clin2.html
\[ P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)} \]
Figure 3 Non-proportional Venn diagram: the presence of emphysema on CT \( n = 36 \), a decreased KNO \( n = 94 \) and \( \text{FEV1/FVC} < 70\% \) \( n = 95 \) are partially overlapping entities.

If a test to detect a disease whose prevalence is 1:1000 has a false positive rate of 5%, what is the chance that a person found to have a positive result actually has the disease, assuming you know nothing about the person’s symptoms and signs?

(45% of Harvard doctors said 95%)

False positives 50/1000
True positives 1/1000
Means the chance of a positive result with disease = 1 out of 51 or 2%

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual disease</td>
<td>1</td>
<td>999</td>
<td>1000</td>
</tr>
<tr>
<td>Test +</td>
<td>1</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td>Test -</td>
<td>0</td>
<td>949</td>
<td>949</td>
</tr>
</tbody>
</table>

The importance of understanding prevalence
Predictive values are the combination of sensitivity, specificity and prevalence.

Sensitivity and specificity are characteristics of the test – the population does not change this.

But we are interested in the Q, ‘What are the chances that a person with a positive test result truly has a disease?’ – the positive predictive value of a test.

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Positive PV = A/(A+B) x 100

Negative PV = D/(D+C) x 100
A cab was involved in a hit-and-run at night. Two cab companies operate in the city, the Green and the Blue. 85% of the cabs in the city are Green and 15% are Blue. A witness identified the cab as Blue. The Court tested the witness under the circumstances that existed on the night of the accident and concluded that the witness correctly identified the colour 80% of the time.

What is the probability that the cab was actually Blue?

(The most common answer is 80%)

Answer

<table>
<thead>
<tr>
<th></th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>Witness +</td>
<td>68 (80% of 85)</td>
<td>12 (80% of 15)</td>
</tr>
<tr>
<td>Witness -</td>
<td>17</td>
<td>3</td>
</tr>
</tbody>
</table>

- 12/100 times the witness will correctly identify a Blue cab as Blue
- 17/100 times the witness will incorrectly identify a Green cab as Blue
- There is therefore a 12+17=29% chance the witness will identify the cab as Blue
- This results in a 12/29 or 41% chance that the cab identified as Blue is actually Blue.

Base rate neglect (prevalence neglect)
A 30-year old woman complained of a dull left-sided headache
On examination she was tender over her left temple
A junior doctor remembered learning about temporal arteritis and requested an ESR (a test for temporal arteritis) which was abnormal
The junior doctor diagnosed temporal arteritis

Temporal arteritis does not exist in people aged <50
You see two patients with chest pain and decide to send them both for an imaging stress test to see whether they have angina (see WORKSHEET).

Stress testing has a sensitivity of 90% and specificity of 85%.

We know the actual prevalence of IHD in the population based on angiography and PM studies.

What is the chance of a positive stress test being correct in each of your two patients?

(The answer is not 90%)
65 year old man with typical angina history: results

<table>
<thead>
<tr>
<th></th>
<th>IHD</th>
<th>No IHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>94</td>
<td>6</td>
</tr>
<tr>
<td>Pos ST</td>
<td>84.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Neg ST</td>
<td>9.4</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Sensitivity = true pos
Specificity = true neg

The above are the actual results you would get.

PPV = true pos/(true pos + false pos) x 100
     = 84.6/(84.6 + 0.9) x 100 = 99%
35 year old woman with atypical chest pain history: results

<table>
<thead>
<tr>
<th></th>
<th>IHD</th>
<th>No IHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>Pos ST</td>
<td>0.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Neg ST</td>
<td>0.1</td>
<td>84.1</td>
</tr>
</tbody>
</table>

The above are the actual results you would get.

\[
PPV = \frac{\text{true pos}}{\text{true pos} + \text{false pos}} \times 100
\]

\[
= \frac{0.9}{0.9 + 14.9} \times 100 = 5.7\%
\]
A test result by itself is not the answer

• Tests must be interpreted in the light of CLINICAL PROBABILITY
• You must also know something about the CHARACTERISTICS of the test in question
• And if the PREVALENCE of the disease is very high or very low in the patient’s group – this affects the predictive value of the test
Conclusions: ‘Commonly used measures of test accuracy are poorly understood by health professionals’
Therapeutic threshold

• It is not necessary to know the true state of the patient before deciding whether to act.

• The therapeutic threshold combines factors such as test characteristics, risks of the test, and the risks and benefits of treatment.

• The point at which all factors are evenly weighed is the threshold.

• If a test or treatment is effective and low risk we would have a lower threshold for going ahead ...
Learning objectives

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• Next time – reasoning/rationality!
1. Go to the web address below:
   https://bluecastle.nottingham.ac.uk

   Or if you have a QR code scanner, scan in the code on the right

2. Enter your University username and password.
3. Click on ‘My Survey’.
4. Click on the Complete Survey button.
5. Complete the SET survey.
6. Click on the Submit button.
Further resources
<table>
<thead>
<tr>
<th>Age</th>
<th>Non-anginal CP</th>
<th>Atypical angina</th>
<th>Typical angina</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>30-39</td>
<td>5.2</td>
<td>0.8</td>
<td>21.8</td>
</tr>
<tr>
<td>40-49</td>
<td>14.1</td>
<td>2.8</td>
<td>46.1</td>
</tr>
<tr>
<td>50-59</td>
<td>21.4</td>
<td>8.4</td>
<td>58.9</td>
</tr>
<tr>
<td>60-69</td>
<td>28.1</td>
<td>18.6</td>
<td>67.1</td>
</tr>
</tbody>
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