Diagnostic Reasoning and Diagnostic Error Across the Curriculum:

When to teach/learn it?
Where to teach/learn it?
How to teach it?

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Objectives:

- List the common models of Diagnostic Reasoning
- Identify the common patterns of diagnostic error
- Identify methods and places to teach/learn Dx reasoning and error across the curriculum
- Improve your auto repair skills
So you went out to your car this morning and it didn’t start.

What's wrong?
Questions
Context, Knowledge and Experience all Matter

- Old or new?
- Who’s been driving?
- This ever happen before?
Three Brothers Work at the Local Garage

• Tim (Old and experienced)
• Pat (Middle-career and smart with lots of knowledge from school)
• Brendan (Just getting started)

The Context:
Matthew, my college student son, is home from school and was using my new car last night. It didn’t start this morning....
• Matt – “Tim, the car won’t start.”
• Tim – “Matt, does your father know?”

• Matt – “No, Tom, I didn’t want to tell him and get in trouble”
• Tim – “You ran out of gas, again?”
• Matt – “I didn’t look at the gas gauge, I’ll be right back…”
• Matt – “Uhh… it’s on empty.”
• Tim – “I’ll be right over with a gallon.”
• Matt – “Don’t tell my dad.”
• Matt – “Pat, the car won’t start.”
• Pat – “Matt, when you turn the key, does it crank or make no noise?

• Matt – “Pat, why did you ask me that?”
• Pat – “It’s simple, if it cranks it’s a fuel or air problem, and if it doesn’t it’s an electrical problem.”

• Matt – “It cranks when I turn the key.”
• Pat – “Then it must be your out of gas, the fuel line is blocked, or the air intake is blocked. A few simple tests will solve the problem.”
• Matt – “Brendan, the car won’t start.”
• Brendan – “O boy, it could be a lot of things including:
  • No gas
  • Too much gas
  • Bad gas
  • Blocked gas
  • Blocked air intake
  • Dead battery
  • Disconnected battery
  • Shorted ignition system
  • Failed spark plugs
  • Failed compression
  • Starter isn’t grounded
  • Solenoid
  • Broken engine wires
  • A short in the wires
• Matt – “Boy, this sounds expensive.”
• Brendan – “Don’t worry, Matt, it’s complicated but it might not be expensive.”
• Matt – “Can you fix it before my dad gets home?”
• Brendan – “I’ll send someone over with a tow truck and we’ll run a bunch of tests and figure it out.”
• Matt – “Thanks, Brendan. Call me as soon as you know”
Models for Problem Solving

• Tim
  – Two seconds to solve problem and $6.50 for a can of gas

• Pat
  – Two minutes to solve problem and $65.00 for time and effort

• Brendan
  – Two hours to solve problem and $200.00 for the tow, $200.00 for labor, and $6.50 for gas
Role Play Patients: presenting with acute onset chest pain

- Joe Six Pack is 53, overweight, couch potato, smokes and loves to watch baseball - just came in by ambulance at 6pm
Also presenting with acute chest pain

• Lean Larry is 28 and runs 5 miles per day, balanced diet, just walked over from the gym after lifting this am.
What is clinical judgment?

• “The exercise of reasoning under *uncertainty* when caring for patients.”

• It combines scientific theory, personal experience, patient perspectives, and other factors. (context)

• It is *NOT* based solely on evidence and it is not just arbitrary
Cognitive Psychology

• This is the basic science that examines how people…
  – Reason
  – Make decisions
  – Make errors

• … in predictable and repeated patterns.
Models for Clinical Problem Solving

- Hypothesis/Deductive reasoning
  - Epidemiology
  - Anatomy
  - Pathophysiology
  - “Badness”

- Heuristics (short cuts)
  - Pattern recognition
  - Algorithmic thinking
Models for Clinical Problem Solving

• Hypothesis/deductive reasoning
  – Generate an organized list of possible causes for a problem
  – Common things occur commonly
  – Simple, single explanations are usually right (Ockham’s Razor)
  – Hypothesis should come from the data, not from what you think the data should be
  – Hypothesis should be consistent with known pathophysiology
  – Never fall in love with a hypothesis
Hypothesis/deductive Reasoning Model

- Try to use the common list to start
- Try not to leave out the things you NEVER want to miss (treatable diseases with bad consequences if you don’t Dx them)
- Common/bad/everything
## Everything Differential for Neonatal Seizures

<table>
<thead>
<tr>
<th>Metabolic</th>
<th>Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxic-ischemia</td>
<td>Bacterial meningitis</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>Viral-induced encephalitis</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Congenital infections</td>
</tr>
<tr>
<td>Hypocalcemia</td>
<td>Herpes</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>Cytomegalovirus</td>
</tr>
<tr>
<td>Intrauterine growth retardation</td>
<td>Toxoplasmosis</td>
</tr>
<tr>
<td>Infant of a diabetic mother</td>
<td>Syphilis</td>
</tr>
<tr>
<td>Glycogen storage disease</td>
<td>Coxsackie meningoencephalitis</td>
</tr>
<tr>
<td>Galactosemia</td>
<td>Acquired immune deficiency syndrome (AIDS)</td>
</tr>
<tr>
<td>Idiopathic</td>
<td>Brain Abscess</td>
</tr>
<tr>
<td>Hypocalcemia</td>
<td>Brain Anomalies</td>
</tr>
<tr>
<td>Hypomagnesemia</td>
<td>Drug Withdrawal or Toxins</td>
</tr>
<tr>
<td>Infant of a diabetic mother</td>
<td>Prenatal substance: methadone, heroin,</td>
</tr>
<tr>
<td>Neonatal hypoparathyroidism</td>
<td>barbiturate, cocaine, etc</td>
</tr>
<tr>
<td>Maternal hypoparathyroidism</td>
<td>Prescribed medications: propoxyphene, isoniazid</td>
</tr>
<tr>
<td>High phosphate load</td>
<td>Local anesthetics</td>
</tr>
<tr>
<td>Other electrolyte imbalances</td>
<td>Bilirubin</td>
</tr>
<tr>
<td>Hypernatremia</td>
<td>Hypertensive Encephalopathy</td>
</tr>
<tr>
<td>Hyponatremia</td>
<td>Amino-acid Metabolism</td>
</tr>
<tr>
<td>Cerebrovascular Lesions</td>
<td>Branched-chain amino acidopathies</td>
</tr>
<tr>
<td>Cerebral infarction</td>
<td>Urea-cycle abnormalities</td>
</tr>
<tr>
<td>Ischemic versus hemorrhagic</td>
<td>Nonketotic hyperglycinemia</td>
</tr>
<tr>
<td>Cortical vein thrombosis</td>
<td>Ketotic hyperglycinemia</td>
</tr>
<tr>
<td>Trauma</td>
<td>Familial Seizures</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>Neurocutaneous syndromes</td>
</tr>
<tr>
<td>Intracranial hemorrhage</td>
<td>Tuberous sclerosis</td>
</tr>
<tr>
<td>Subdural/epidural hematoma</td>
<td>Incontinentia pigmenti</td>
</tr>
<tr>
<td>Intraventricular hemorrhage</td>
<td>Autosomal dominant neonatal seizures</td>
</tr>
<tr>
<td></td>
<td>Selected Genetic Syndrome</td>
</tr>
<tr>
<td></td>
<td>Zellweger’s syndrome</td>
</tr>
<tr>
<td></td>
<td>Neonatal adrenal leukodystrophy</td>
</tr>
<tr>
<td></td>
<td>Smith-Lemli-Opitz syndrome</td>
</tr>
</tbody>
</table>
Common Diff Dx for Neonatal Seizures

- Hypoxic Ischemic injury
- Hypoglycemia (SGA, LGA)
- Trauma
- Drug withdrawal

Bad but rare:
- meningitis
- bleeding
Models for Clinical Problem Solving

• **Heuristics**
  – Shortcuts used by or created by experts to speed up the problem solving process
  – Two common types of heuristics include
    • *Pattern recognition*
    • *Algorithmic thinking*
What do you see?
Happy Newborn in well baby with Petechiae:
Algorithmic Thinking

Neonatal Thrombocytopenia

- Maternal Plts normal
  - Alloimmune thrombocytopenia

- Maternal plts very low
  - Immune thrombocytopenia

- Maternal plts moderately low
  - Gestational thrombocytopenia
Heuristics

- Shortcuts often used by experts
- Faster and easier
- Prone to error when used by the inexperienced and sometimes the experienced
- VERY context specific
Heuristics Used By Experts

• “One becomes an expert by making routine many aspects of a problem which require creative problem solving by a novice” ~Anderson JR

• “An expert is not solving problems, but remembering solutions” ~Norman GR
## System 1 and System 2 Model

<table>
<thead>
<tr>
<th>System 1</th>
<th>System 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intuitive</td>
<td>analytic</td>
</tr>
<tr>
<td>Fast</td>
<td>slow</td>
</tr>
<tr>
<td>Heuristic</td>
<td>Systematic</td>
</tr>
<tr>
<td>Automatic</td>
<td>Conscious</td>
</tr>
<tr>
<td>High error</td>
<td>Lower error</td>
</tr>
<tr>
<td>Low EBM</td>
<td>Higher EBM</td>
</tr>
<tr>
<td>Low EBM</td>
<td></td>
</tr>
</tbody>
</table>
Evaluation of Knowledge Structures and Problem Solving Style

- Reduced
- Dispersed
- Elaborated causal
- Scheme
- Scripted
- Guess
- Hypothetical/deductive
- Hypothetical/deductive
- Scheme inductive reasoning
- Pattern recognition
Scuba Diving Story:
Easy to learn, easy to die
Diagnostic Error in Medicine

• Delayed, incorrect or missed diagnosis which affects patient outcome or leads to additional complications/procedures
Literature on Diagnostic Error Suggests…

- ER literature notes 25% of patients affected by a “diagnostic error”

- Autopsy studies over the past 30 years reveal a constant 10% rate of significant “surprises”
Sources of Individual Diagnostic Error

• Intellectual factors
  – Lack of knowledge
  – Overconfidence in knowledge
  – Bias

• Failure to check for errors
  – Reluctance to change initial opinion
  – Lack of detailed follow up
  – Inadequate peer review with propagation or errors
Sources of Team/System Diagnostic Error

• **Systems based errors**
  – Complex care settings
  – Many steps in patient care
  – Many healthcare providers
  – Many systems interacting to deliver care
Why did I miss the diagnosis?

- It never crossed my mind
- I paid too much attention to one finding, especially a lab result
- I didn’t listen enough to the patients story
- I was in too much of a hurry
- I didn’t know enough about the disease

I AM SORRY
I AM NOT LISTENING TO YOU
Why did I miss the diagnosis?

- I let the consultant convince me
- I didn’t reassess the situation
- The patient had too many problems at once
- I was influenced by a similar case
- I failed to convince the patient to investigate further
- I was in denial of an upsetting diagnosis

Error Analysis

- Didn’t consider the diagnostic entity - 26%
- Premature closure on the wrong dx – 24%
- Misinterpretation of a diagnostic test – 20%
100 Cases of Diagnostic Error in Internal Medicine

- No fault - 7%

- Systems related - 65% (teamwork and communication)

- Cognitive - 74% (faulty synthesis, premature closure)

- Average case had 5.9 errors

Cognitive Errors in Diagnosis: Crookery Classification

- Cognitive Dispositions to Respond (CDR’s) which result from:
  - failure in perception
  - failed heuristics
  - biases
Cognitive Dispositions to Respond (CDR)

- **Aggregate bias** - group data doesn’t apply to MY patient, they are special
- **Anchoring** - locking on to a salient feature of the patient’s initial presentation too early
- **Ascertainment bias** - thinking is shaped by prior experience. (stereotyping Lean Larry)
- **Availability** - what comes to mind is most likely (everybody has mitochondrial disease)
CDRs…continued

- **Base-rate neglect**- ignoring the TRUE prevalence of a disease
- **Confirmation bias**- once you “have” the diagnosis you look for confirming evidence rather than look for disconfirming evidence
- **Diagnosis momentum**- labels tend to stick you asthmatic you
- **Fundamental attribution error**- the tendency to blame the patient for their illness (Joe six-pack)
CDRs

- **Overconfidence bias** - we think we know more than we do and so we tend to act on incomplete information and we of course “know” we are right.

- **Premature closure** - tendency to stop the diagnostic process early, and accepting a Dx before it has been “fully” verified.

- **Representative error** - if it looks like a duck, walks and quacks like one then IT is one. Beware of the wolves in duck clothing.

- **Search satisfying** - you call off the search once something is found.
Note to Medical Educators from Pat Croskerry

1. Appreciate the full impact of diagnostic errors in medicine and the contribution of cognitive errors

2. Refute the inevitability of cognitive errors

3. Dismiss the pessimism that surrounds approaches for lessening cognitive bias
Where Does This Fit Across the Curriculum?
Diagnostic Reasoning and Diagnostic Error Across the Curriculum

- **When to teach/learn it?** Early and often

- **Where to teach/learn it?** In any setting where clinical cases are involved

- **How to teach it?** Intro early in 1st year with workshop and in all PBL, CBL and clinical teaching using modeling and reflection
Cognitive Debiasing Strategies

• Develop insight/awareness of CDRs

• Develop the “What else might this be?” habit

• Metacognition-think about thinking

• Decrease reliance on memory (Isabel, clinical practice guidelines, algorithms)

• Simulation

• Make task easier-more information and time
Cognitive Debiasing Strategies

• Cognitive forcing strategies in specific settings to avoid predicted bias

• Accountability

• Feedback so errors are appreciated, understood and corrected
Simple Questions in Preventing Diagnostic Error? Groopman Rx

• What else could it be? Stops premature closure

• Is there anything that doesn’t fit? Mitigates confirmation bias

• Is it possible there is more than one problem? Search satisfaction never sets in
Educational Strategies to Promote Clinical Diagnostic Reasoning

• Early clinical experience
• Data acquisition and reporting-focused?
• Articulating problem representations-
• Generation of hypothesis-developing illness script
• Cognitive feedback

How Do You Become a Better Clinical Problem Solver?

• Errors are common, don’t hide from them, learn from them
• Ambiguity and uncertainty are unavoidable, get used to it
• Always ask “How is this test going to change the post test probability of the diagnosis?”
Errors are common, don’t hide from them

Learn from them
Pitfalls to Avoid

- Hypothesis/deductive reasoning
  - Generate an organized list of possible causes for a problem (anchoring error)
  - Common things occur commonly (availability error)
  - Simple, single explanations are usually right or Ockham’s Razor (search satisfaction)
  - Hypothesis should come from the data, not from what you think the data should be (confirmation bias)
  - Hypothesis should be consistent with known pathophysiology
  - Never fall in love with a hypothesis (premature closure)
Specific Ideas to Help You Become Better Problem Solvers

• Keep an open mind (i.e. don’t fix on one possibility)
• Listen to the patient. Did you hear what I said? Listen to the patient. They usually have the answer.
• Utilize “pocket brains” to help in the construction of differentials (common, bad)
• Slow down, this isn’t a race
Specific Ideas to Help You Become Better Problem Solvers

• Stay stupid- always question your tentative diagnosis
• Heuristics are useful but dangerous, use with caution (representative error)
The Medical Culture surrounding Error?

- Hide and forget
We Need a culture that Stops and Smells the Errors
If We Don’t Measure It How Will We Know We Improved It?

Assessing Critical Thinking Skills will be critical as an outcome measure:
When to measure?
How to measure?

Watson-Glaser Critical Thinking Appraisal
California Critical Thinking Skills Test
Watson-Glaser Critical Thinking Appraisal (WGCTA-FS)

- 40 item test that looks at 5 subscales
- Inference
- Recognition of Assumptions
- Deduction
- Interpretation
- Evaluation of Arguments
California Critical Thinking Disposition Inventory (willing) Health Sciences Reasoning Test (able)

- Commercial tests used in nursing and now in ~20 medical schools
- Tests willingness to think critically
- And ability to think critically
- Has been used to measure improvement in reasoning after workshops
- Has shown PBL is better than lecture for improving critical thinking
Critical Thinking and Clinical Reasoning in the Health Sciences: An International Multidisciplinary Teaching Anthology

Cognitive Skills Habits of Mind
The Ten Commandments for minimizing ERROR

Not yet approved by the Supreme Court for use in public…
Ten Commandments for Minimizing Error:

1. I shall not believe everything I hear from the Doctor
2. I shall first listen to the patient
3. I shall not fall in love with my first Dx
4. I shall not believe everything I hear about test results
5. I shall explain my thinking to everyone
Ten Commandments…

6. I shall **involve** the patient in everything
7. I shall **communicate** with peers precisely
8. I shall take **personal responsibility** for the patients clinical problem
9. I shall **not believe everything** the consults say.
10. I shall say “**I DON’T KNOW**” regularly and go get the answer
Acknowledgments

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• Geoffrey Norman
• Pat Croskerry
References


References


• Croskerry P. The Importance of Cognitive Errors in Diagnosis and Strategies to Minimize Them. Acad Med. 2003;78:775-780.


