Beth Israel Deaconess Medical Center

A teaching hospital of Harvard Medical School

Changing Your Culture

Inspiring Curiosity and Critical Thinking in Teachers and Learners

Richard M. Schwartzstein, MD

Ellen and Melvin Gordon Professor of Medicine and Medical Education

Chief, Division of Pulmonary, Critical Care, and Sleep Medicine

Director, Shapiro Institute for Education and Research

Beth Israel Deaconess Medical Center

Harvard Medical School

Education is at the heart of patient care. ——

CENTER FOR EDUCATION
Shapiro Institute
BETH ISRAEL DEACONESS MEDICAL CENTER
HARVARD MEDICAL SCHOOL

Disclosures

I have no financial disclosures relevant to the content of this presentation.

What direction are we driving?

Sometimes, signs help; other times…

…. signs can be confusing

Today's Objectives: At the end of this session, you should be able to…

- Define the elements of critical thinking and the dual processing model used to describe how we approach problems
- Describe the role of cognitive bias in contributing to clinical errors
- Distinguish hypothetical deductive reasoning, commonly used in practice, from inductive reasoning, which may be less subject to cognitive biases
- Describe the pitfalls of teaching reasoning via illness scripts
- Explain the role of uncertainty and curiosity in clinical reasoning
- Describe strategies for developing (and assessing) critical thinking in learners
- Delineate the limitations of artificial intelligence to do "critical thinking"

Case 1

A 60 year old man presents with a complaint of shortness of breath that has gradually worsened over 2 years. Now can only walk for 50 yards at which time he stops with a sensation of “suffocating” and “urge to breathe.” His wife notes “wheezing” when this happens.

Case 1, cont.

- PH: asthma since childhood, hypertension for 30 years, mild diabetes, 30 pack year smoker
- PE: obese. BP 160/90, HR 92, RR 16

  Mild increase in AP diameter of chest. Lungs with mild decrease in air movement, I/E=1/1.5; JVP=10 cm. +S4. Abdomen benign. No edema.

You walk him in corridor: after 50 yards, patient is wheezing.

Your diagnosis….

Case 1 - Diagnosis

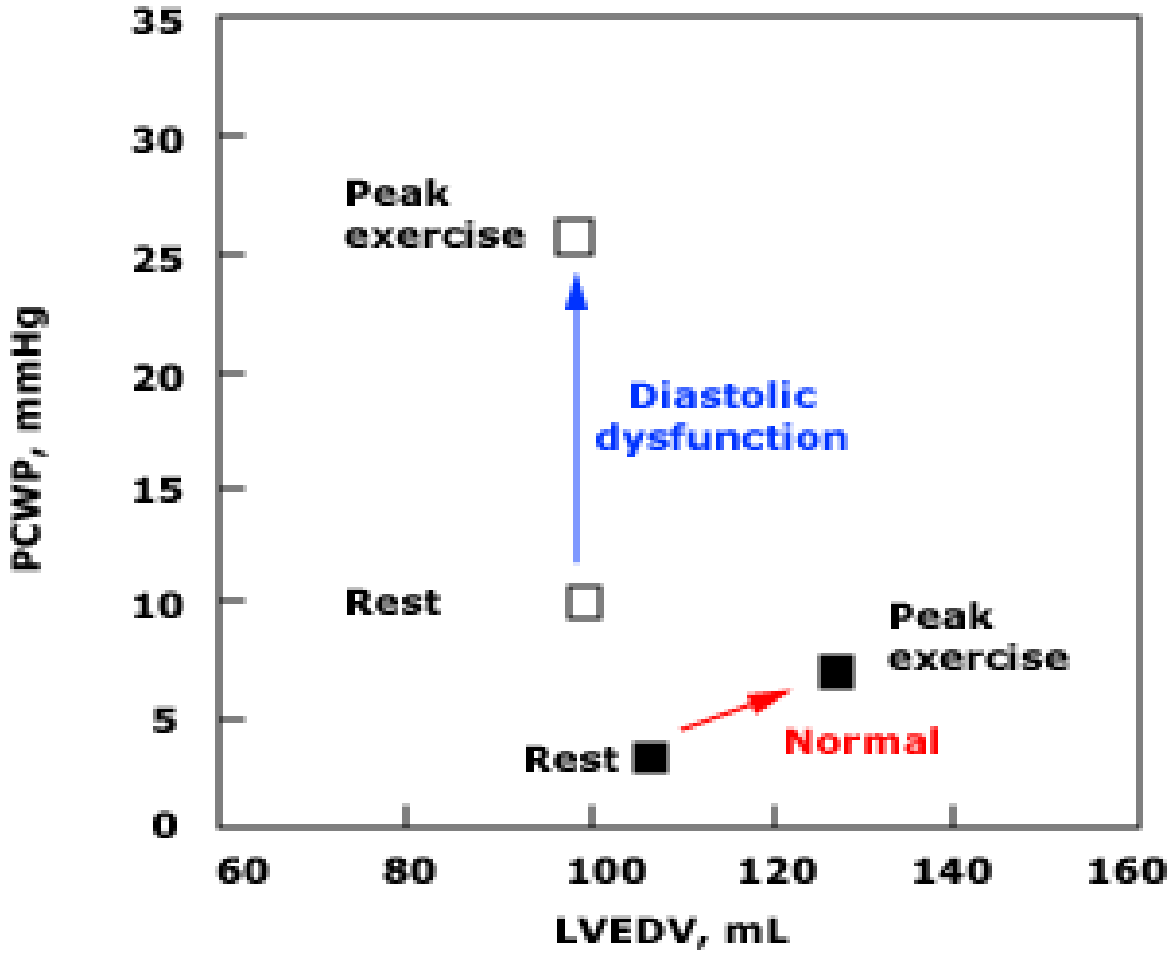
A. Asthma exacerbation
B. COPD exacerbation
C. Heart Failure
D. Recurrent Aspiration
E. Interstitial lung disease
F. Ask ChatGPT

ChatGPT

- ***Based on the patient's history, physical examination, and symptoms, the most likely diagnosis is chronic obstructive pulmonary disease (COPD) with possible exacerbation***. The patient's long-term history of smoking, asthma, and gradual onset of shortness of breath over 2 years, as well as his wheezing and decreased air movement on lung examination, suggest COPD. The sensation of "suffocating" and "urge to breathe" could be due to hypoxia and hypercapnia, which are common in patients with COPD. The mild increase in the AP diameter of the chest could also be due to hyperinflation of the lungs, which is a characteristic finding in COPD. The patient's obesity, hypertension, and mild diabetes may be comorbidities that can worsen his COPD. ***The S4 heart sound and JVP elevation suggest possible right-sided heart failure due to pulmonary hypertension, which can occur in severe COPD.*** Further testing, such as pulmonary function tests and imaging, may be necessary to confirm the diagnosis and assess the severity of the disease.
- **Wrong answer!! And wrong reasoning!! Are you *curious* about "why now?" for the symptoms?**

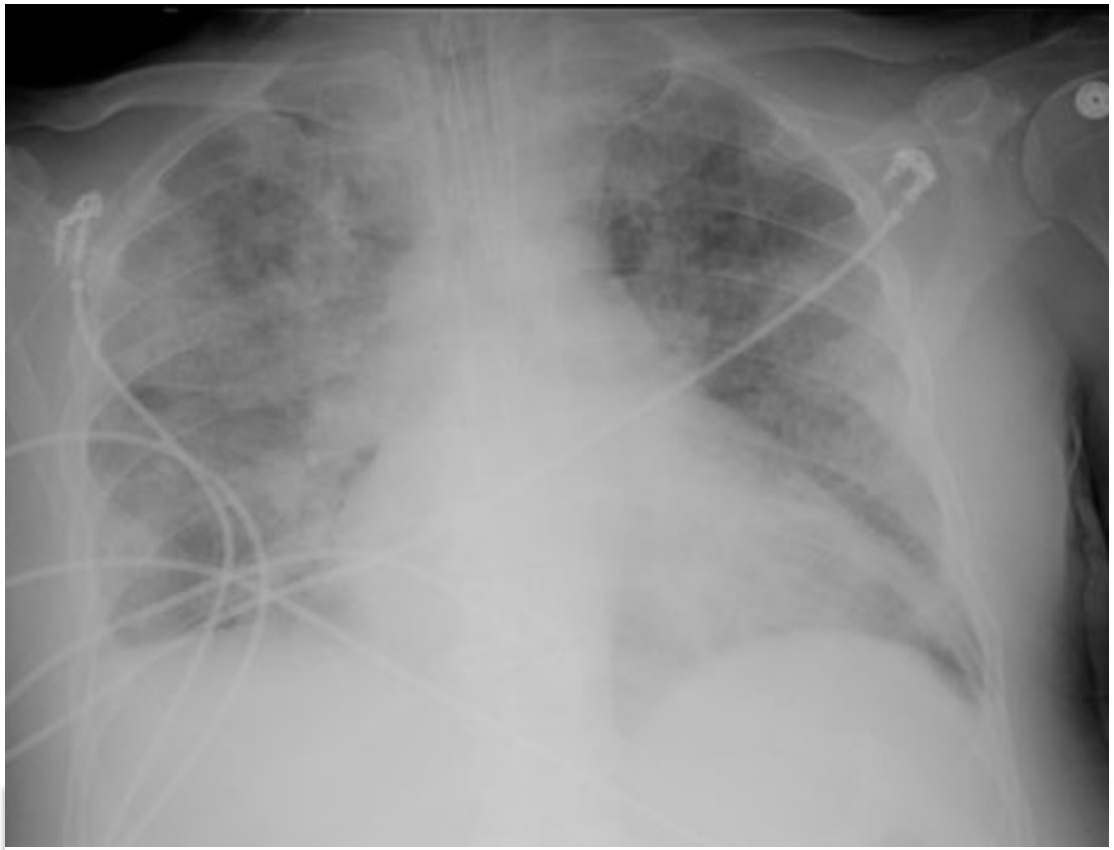
Diastolic Dysfunction

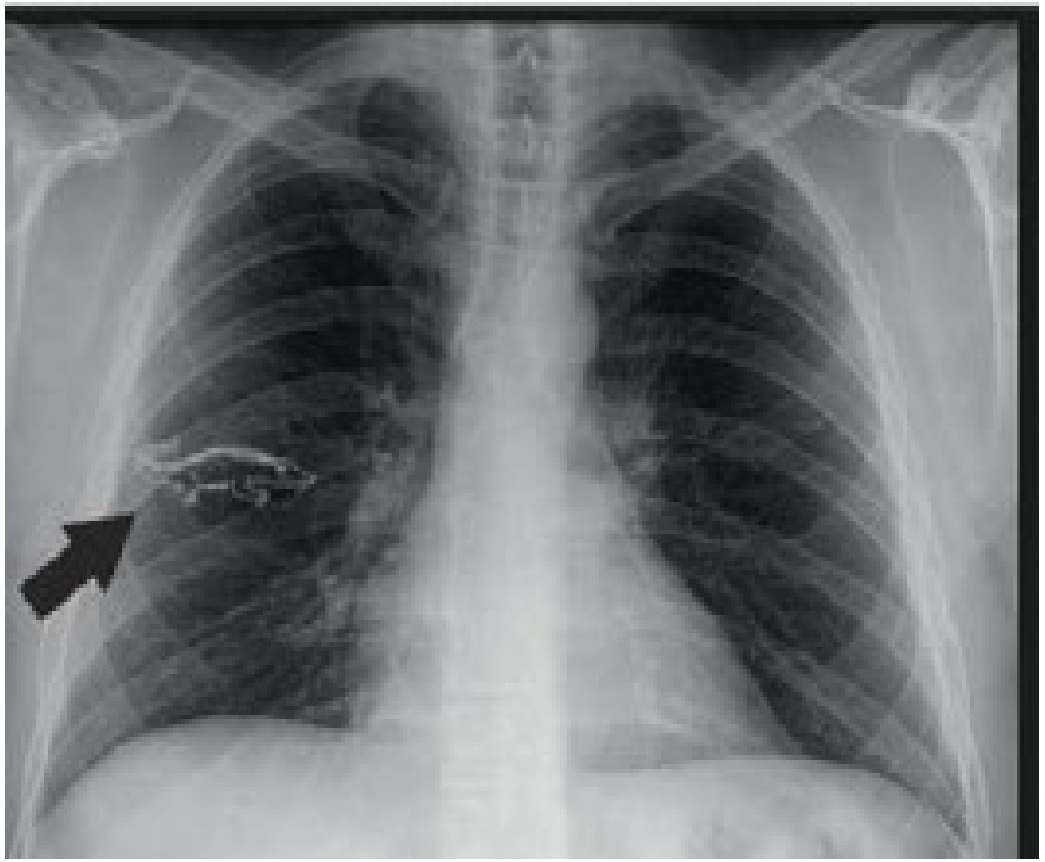
- 1/3 of cases of CHF are due primarily to diastolic dysfunction
- Failure of LV to accommodate increased volume load (often in setting of LVH from systemic hypertension)
- Symptoms often isolated to exercise



What is critical thinking?
Work the problem!

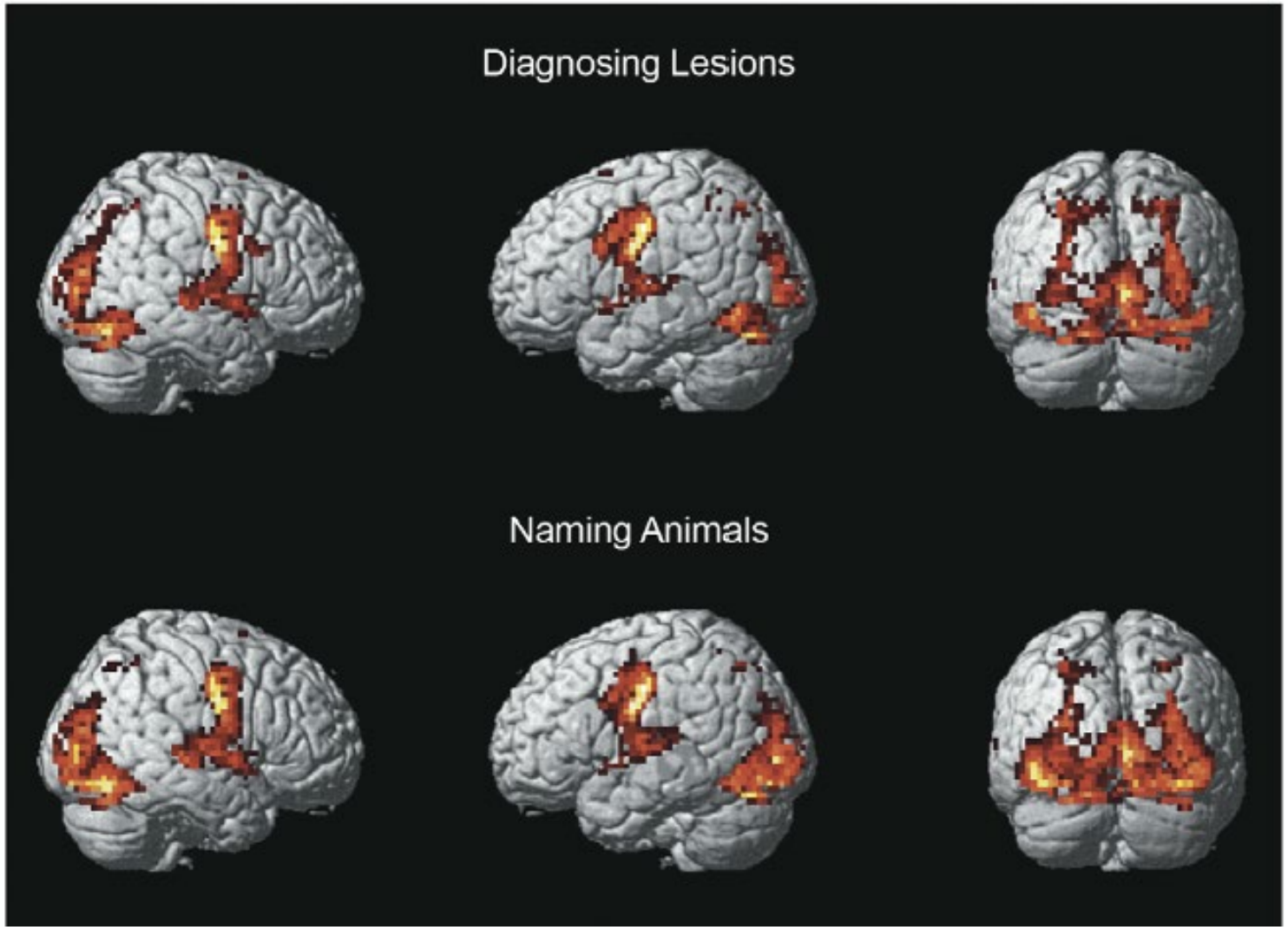
What is the diagnosis?





Neural Activation of Pattern Recognition

Melo M, et al., PLoS ONE 6(12):e28752, 2011



Students' Experience of Medical School

Teacher's Goal:
How can you solve the problem? Why did this happen? How do I explain this? Wow, that's puzzling???

Focus of Education Changed
Even Before AI

Education in universities in the future "will be more about how to process and use information and less about imparting it. …in a world where the entire Library of Congress will soon be accessible on a mobile device…factual mastery will become less and less important."

Larry Summers, NY Times, Jan 22, 2012

Thinking!

upthebarconsulting.com

Uncertainty

"As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality."
---Albert Einstein

"All understanding is provisional and subject to continual adjustment."

--- Atul Gawande

Acknowledging uncertainty is part of metacognition; may protect against cognitive biases. AND it goes hand-in-hand with curiosity

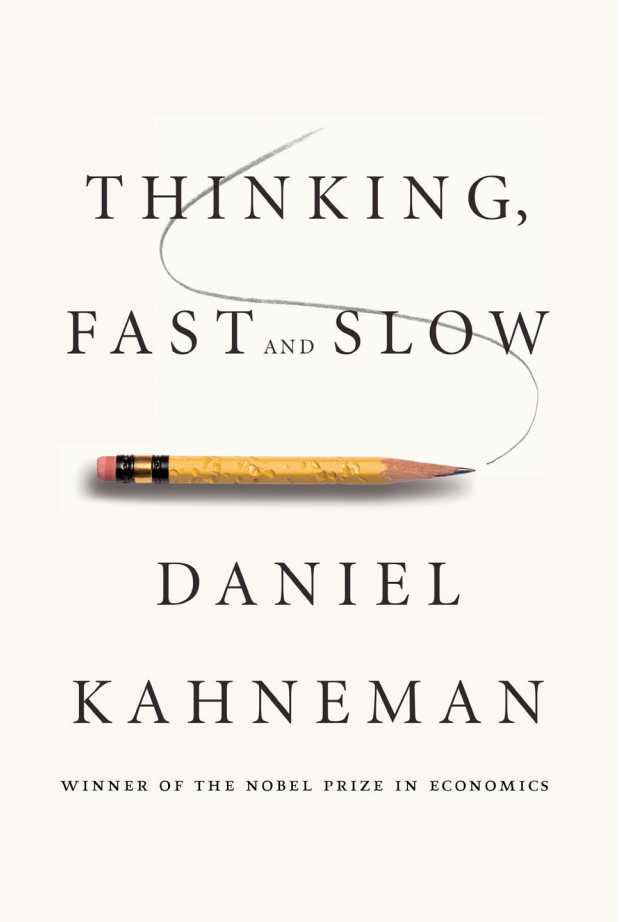
How we think…Dual Processing

- Conscious thought
- Unconscious thought
  - Cognitive Biases

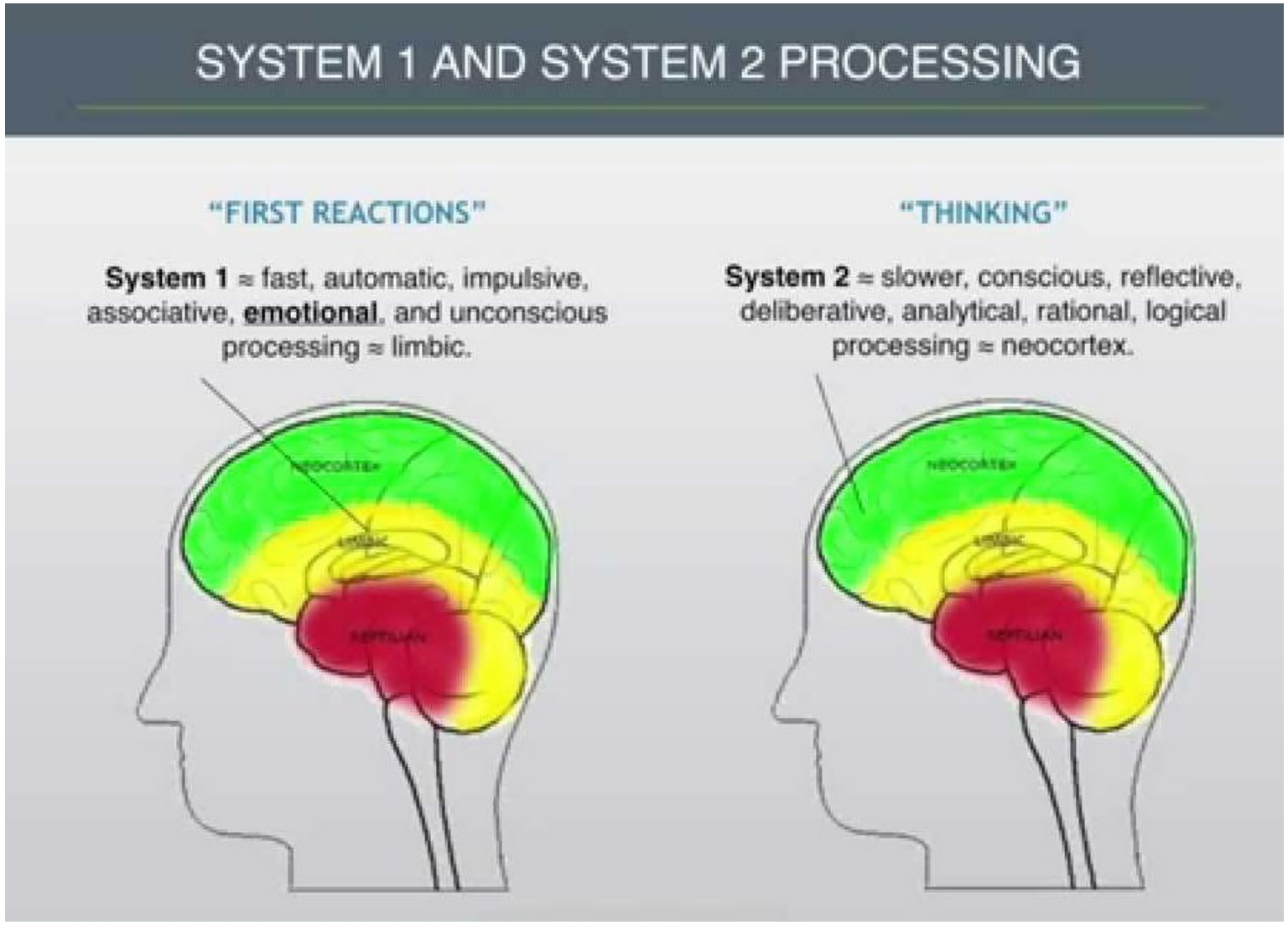
Judgment Under Uncertainty

Tversky and Kahneman, Science, 1974

"…people rely on a limited number of heuristic principles which reduce the number of complex tasks of assessing probabilities…to simpler judgmental operations" which can "lead to severe and systemic errors."



Dual Process Model for Thinking



Inductive vs Deductive Reasoning

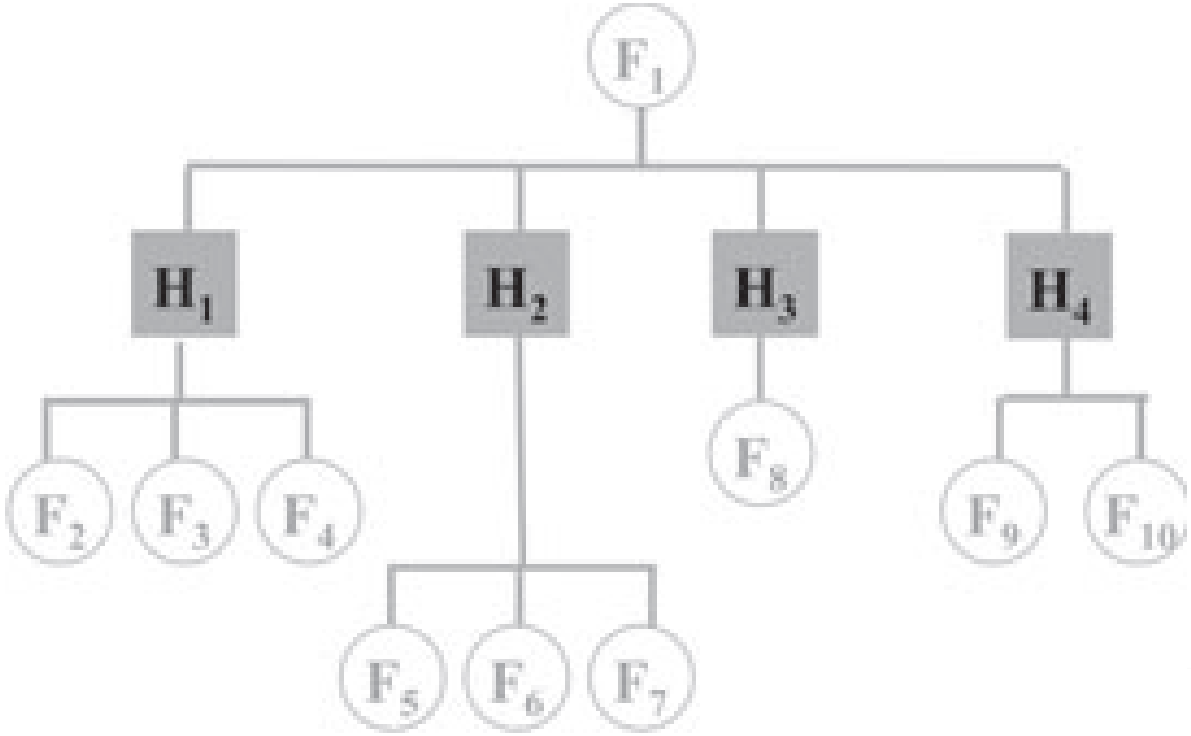
Inductive vs. deductive reasoning

- Most doctors learn the hypothetico-deductive approach to patient care -- clinical reasoning
  - With a few “facts” create a differential dx
  - State what you know about those diagnoses and see how well the data fit.
- Inductive approach (taught to engineers) – critical thinking
  - Create “basic” or mechanistic hypotheses before creating ddx

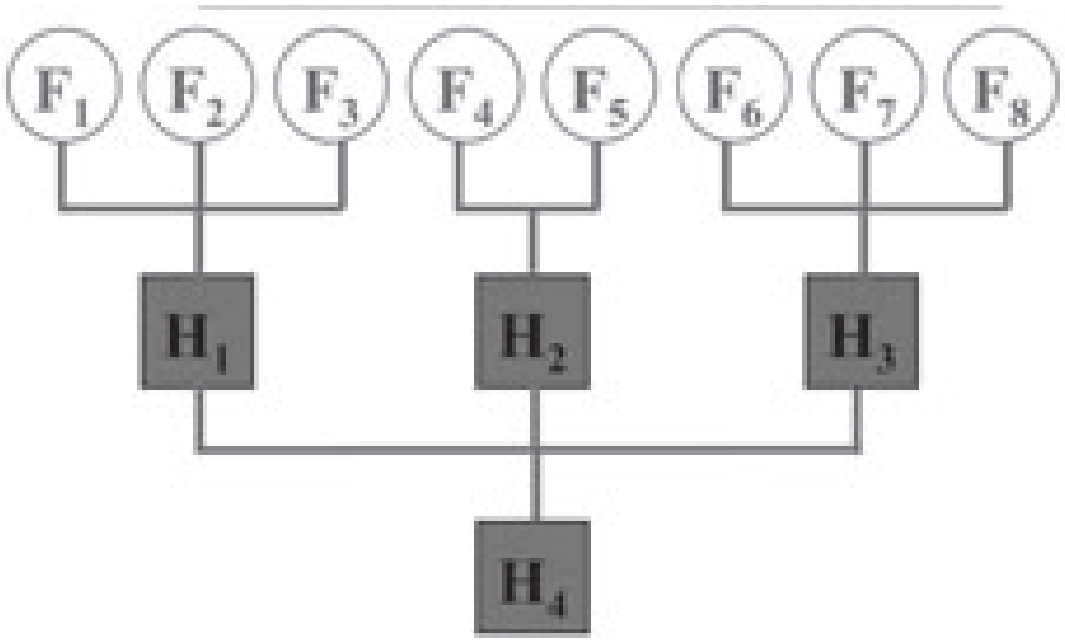
Contrasting Thinking Approaches

Modified from Pottier et al. Med Ed 2010

Deductive Reasoning



Inductive Reasoning

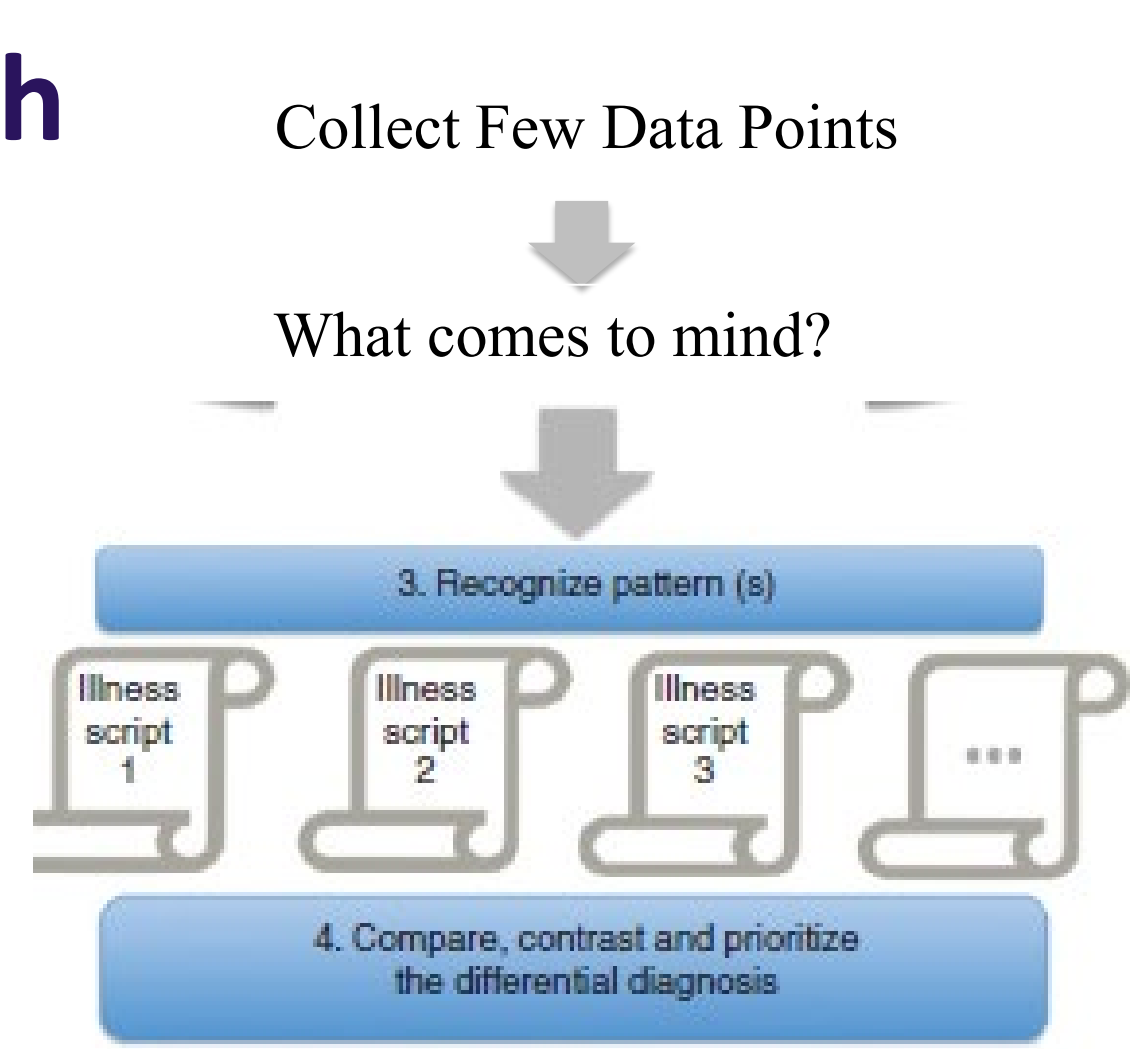


Conventional Approach to Clinical Reasoning

Illness Scripts: An illness script is **an organized mental summary of a provider's knowledge of a disease**. Usually as short as a 3x5 pocket card although some would postulate it could be as long as a book chapter.

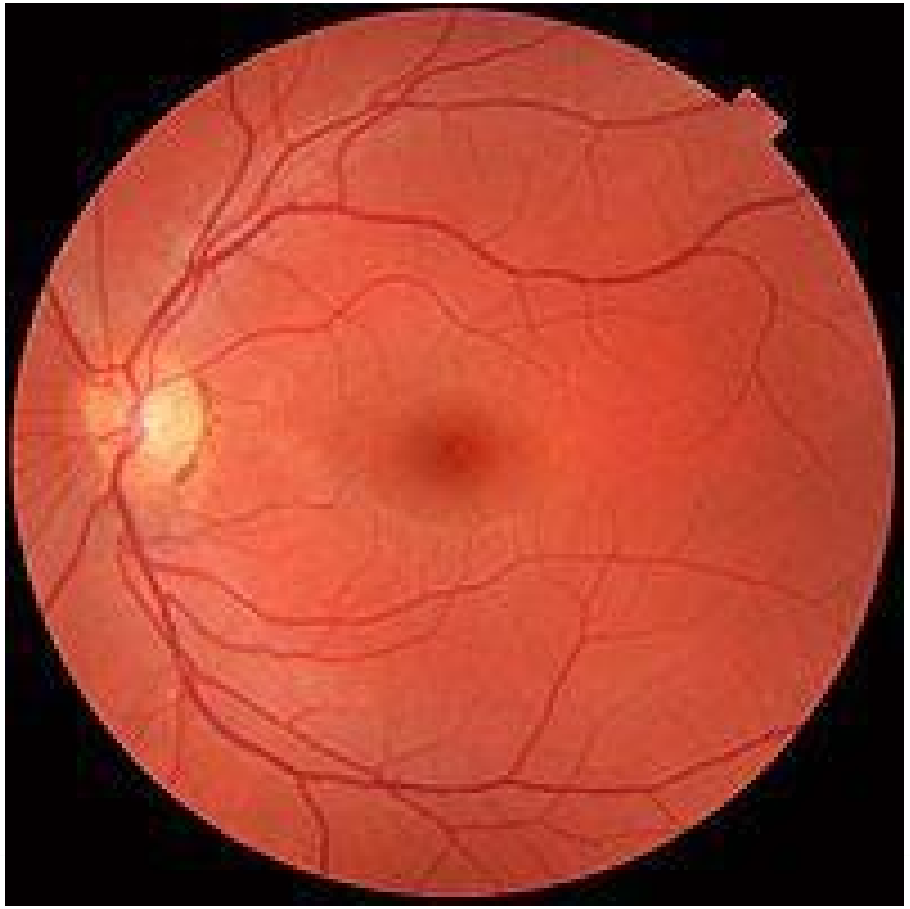
Typically constitutes a "pattern":

- Acute vs chronic
- Few pieces of classic hx and PE
- Possibly a key lab/radiograph



Thammasitboon et al. Diagnosis 2018;5:197-203

Artificial “intelligence” ??



Int J Acad Health Med Res 2022;6:57-63

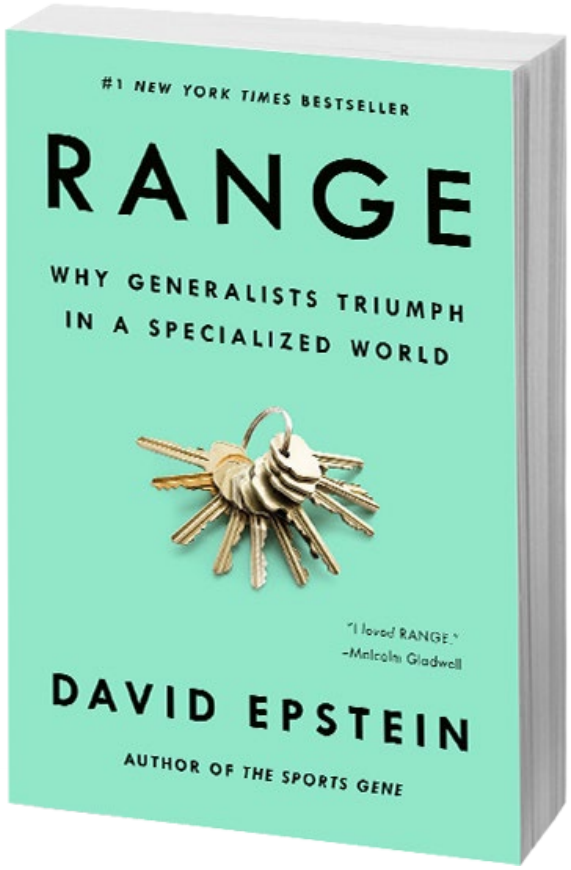
- Computers have been able to detect sex from retinal images
- AI → pattern recognition on steroids? Is that what we mean by “thinking”? Intelligence?
- Greater use of APPs whose training has less time devoted to pathophysiology; may be more reliant on patterns.
- What is the role of the doctor?

ChatGPT
Is Artificial Intelligence "intelligent"?

- Reportedly could answer questions from Step 1 board review books
- Are review books focused on knowledge, not thinking?
- What do doctors need for future?
- Are we teaching thinking skills?

- Question from Homeostasis case session given to ChatGPT
- Why would a person breathing through a 2-foot long snorkel get short of breath?
- ChatGPT→ problem with snorkel; individual out of shape –Wrong answer!! nothing about resistance or dead space associated with tube

Effortful Learning Yields Better Outcomes in "Wicked" Environments



- Counters "guided mastery" of Anders Ericsson; chess is a "kind" learning environment – patterns repeat over and over; feedback accurate and repetitive
- Medicine is a ***"wicked" environment***. The rules of the game are often unclear or incomplete; may not be repetitive patterns; feedback may be delayed and inaccurate; demands cognitive flexibility
- Students (and teachers) try to turn conceptual problems into procedural ones (algorithm)

Diagnosis vs. Hypothesis

- ***Diagnosis***: "the act of identifying a disease from its signs and symptoms"
- ***Hypothesis***: "a tentative assumption made in order to draw out and test its logical or empirical consequences"

Merriam-Webster dictionary

Implications? ⟶ ***Note: LCME 7.3: Students must be trained in the Scientific Method***

All doctors should think like scientists! And scientists start with "I wonder why…."

A phone call at night….

Patient with hx of heart failure admitted 2 days ago with bleeding ulcer. Endoscopy showed large ulcer in fundus with visible vessel but no active bleeding. Within last 15 minutes, patient lightheaded. BP falls from 110/80 to 60 systolic. Extremities cool; poor capillary refill. Hct stable.

Norepi started. HR 110 → 140. No change in BP. Phenylephrine is added. ECG: sinus tachy; chronic ST-T wave changes; more prominent ST depression.

I think the patient is in cardiogenic shock and needs urgent cath or an intra-aortic balloon pump.

Your Response…

1. Sure, go ahead and call me after you speak to cardiology.
2. Get an echocardiogram instead.
3. How do you think about hypotension?
4. Why are you calling me?
5. Ask ChatGPT….

Resident's Thinking

- The patient has a history of heart failure and ischemic heart disease.
- ECG shows ST depressions
- Exam suggests high SVR, consistent with low cardiac output.
- He must be having acute MI and going into cardiogenic shock.

What next??

Get the resident to “work the problem”

- Go the bedside with the resident. Ask the “how” and “why” questions. “I wonder….”
- How does the body generate blood pressure? Does that approach provide more hypotheses to consider?
- How would you distinguish between preload problems vs. contractility problem?
- If the problem was reduced preload, what would you predict the response would be to an inotrope?
- How do we interpret the Hct in this case?

Chat GPT response

- “Based on the information provided, the diagnosis is likely to be a hypovolemic shock. The patient's history of heart failure and bleeding ulcer, along with the lightheadedness, falling blood pressure, cool extremities, and poor capillary refill, are suggestive of hypovolemia or low blood volume. *The stable hematocrit suggests that the bleeding may have stopped, but the patient is still in shock due to the significant loss of blood.”*
- ***Right answer but wrong reasoning*** re: *Why is there a stable Hct?* It’s stable because it is an acute bleed and insufficient time for new equilibrium with interstitial fluid. And any low output will lead to activation of SNS with cool extremities and poor capillary refill!

Why didn't the patient respond to Norepi?

- ***Chat GPT***: "In some cases, the use of a single vasopressor may not be enough to reverse hypovolemic shock, especially if the underlying cause of the shock is not addressed. In this case, the addition of another vasopressor like phenylephrine may help augment the effects of norepinephrine and improve blood pressure and tissue perfusion."

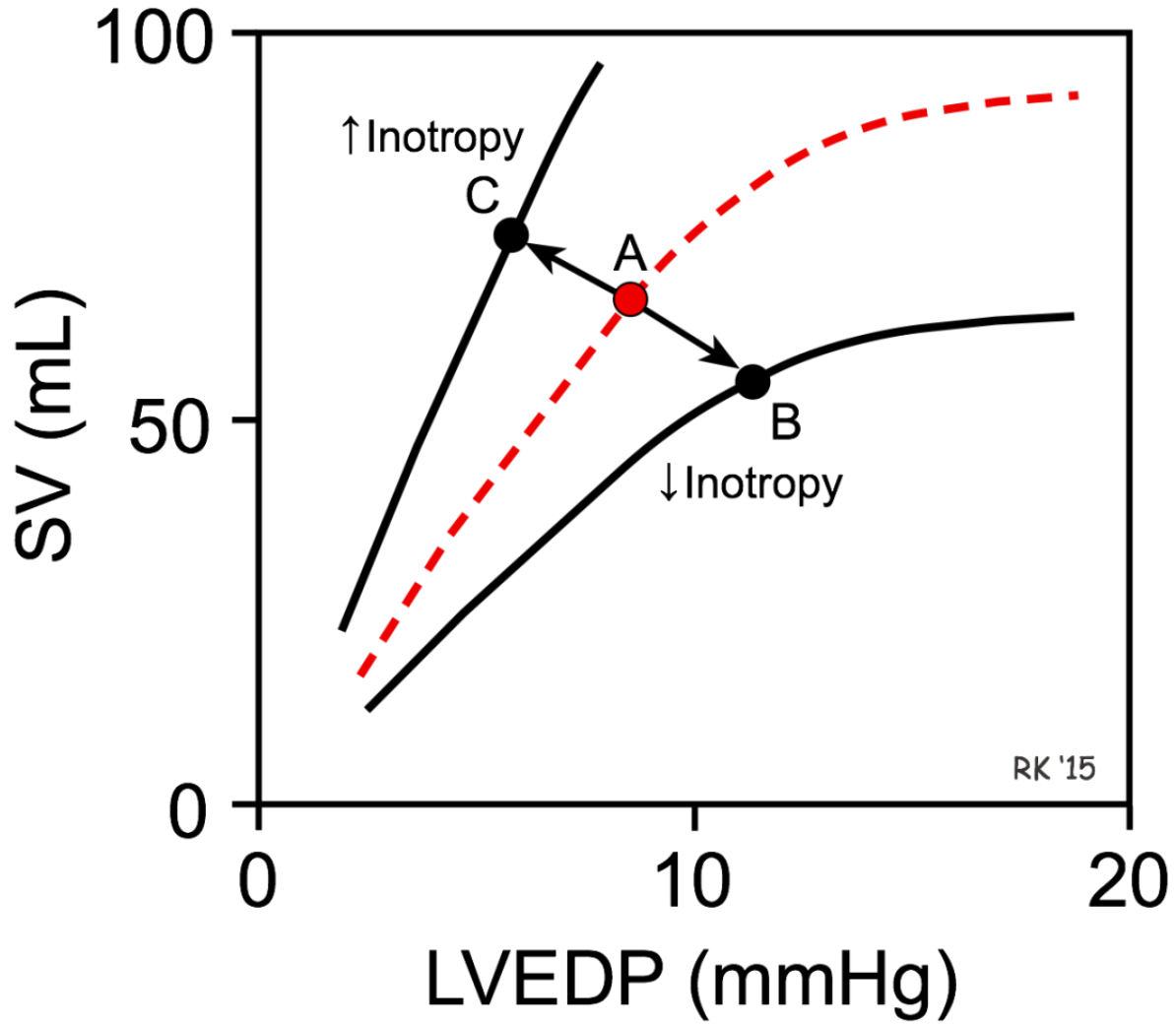
- ***Correct approach***: How do I think about blood pressure?

MAP = CO X SVR

CO depends on preload, afterload of RV, and contractility…How is it disrupted in this patient???

- The preload is so low that an increase in contractility will not improve stroke volume, as predicted by the Starling curve.

Effect of Inotrope on Empty Heart



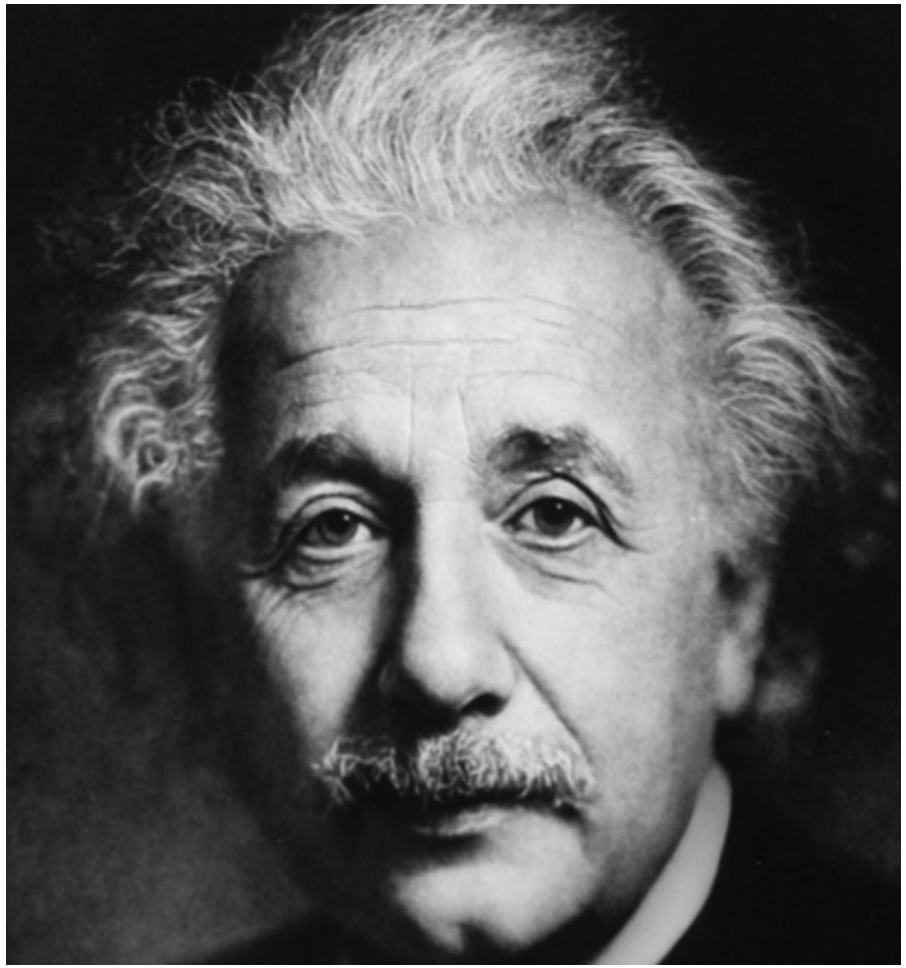
Asking Questions to Stimulate Curiosity and Thinking

- Why?
- How?
- Tell me how you think about this problem?
- What do you know about X?
- Avoid questions that have one word answers; quiz show questions
- “You know more than you think!”

The Importance of Questions

If I had an hour to solve a problem and my life depended on it, I would spend the first 55 minutes determining the questions to ask.

Albert Einstein



https://www.biography.com/people/albert-einstein-9285408

Back to the case…

Resident still insisting that the problem is cardiac failure despite the fact that the lungs are clear and the patient's oxygenation is normal.

Knowledge and Cognitive Biases

- *Cognitive bias and cognitive dispositions to respond*
- *Metacognition: think about how you are thinking*

- ***Availability bias*** **-** probability assigned based on ease of recall of specific examples
- ***Confirmation bias*** - selectively accepting or ignoring data
- ***Anchoring bias*** - defend your position

Anchoring Bias

- ***VA study of care for patients presenting to ED with dyspnea***
  - Patient visit reason cites or does not cite hx of “CHF”
  - Outcomes: testing for PE, time to testing for PE, dx of PE in ED

JAMA Int Med 2023;183:818-823

- Results of study
  - 108,900 patients over 7 years
  - Mention of CHF resulted in significant reduction in testing for PE, significantly longer time to testing for PE, and significantly lower likelihood of dx of PE in ED
  - Frequency of PE same in both groups.

Achieving Quality in Clinical Decision Making: Cognitive Strategies and Detection of Bias

Pat Croskerry, MD, PhD

Acad Emerg Med
2002;9:1184-1204

TABLE 2. Strategies in Decision Making

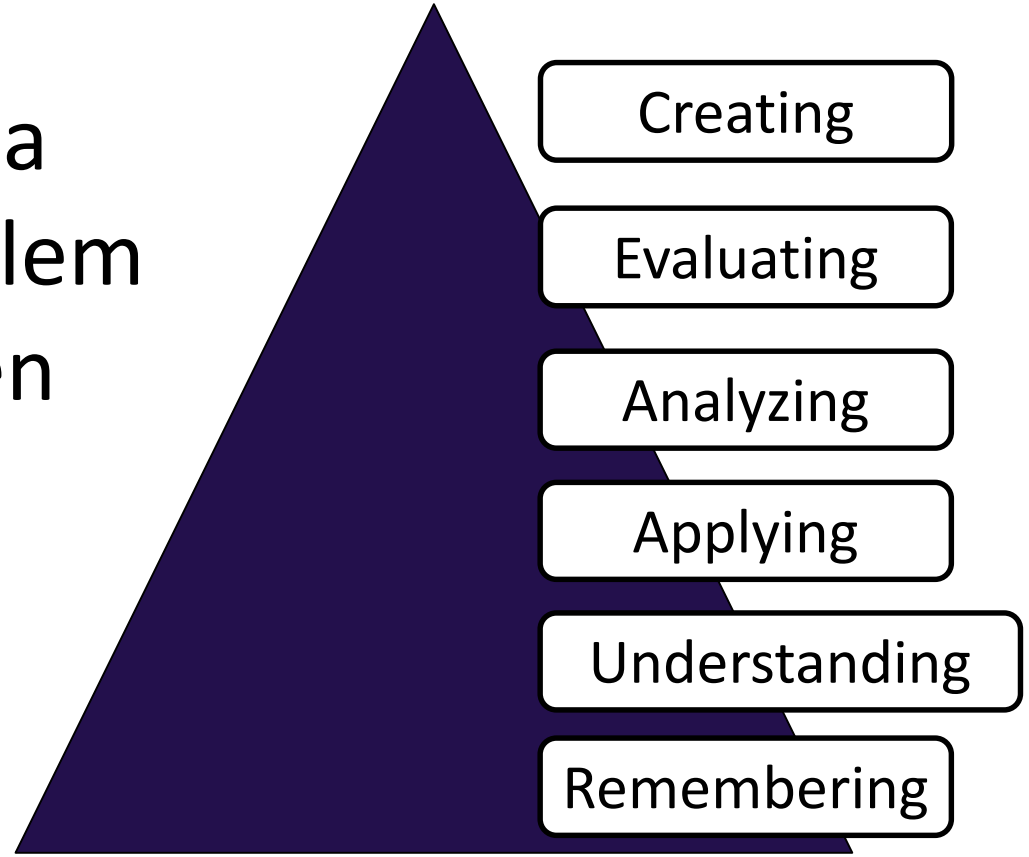
Pattern recognition
Rule out worst-case scenario (ROWS)
Exhaustive method
Hypothetico-deductive method
Heuristics
Cognitive disposition to respond (CDR)

TABLE 3. Failed Heuristics, Biases, and Cognitive Dispositions to Respond

Aggregate bias	Confirmation bias	Multiple alternatives bias	Posterior probability error	Sutton's slip
Anchoring	Diagnosis momentum	Omission bias	Premature closure	Triage-cueing
Ascertainment bias	Fundamental attribution error	Order effects	Psych-out error	Unpacking principle
Availability and non-availability	Gambler's fallacy	Outcome bias	Representativeness restraint	Vertical line failure
Base-rate neglect	Gender bias	Overconfidence bias	Search satisfying	Visceral bias
Commission bias	Hindsight bias	Playing the odds		Yin–yang out
				Zebra retreat

Expertise and Creativity

Can you create a solution to a problem you haven't seen before?



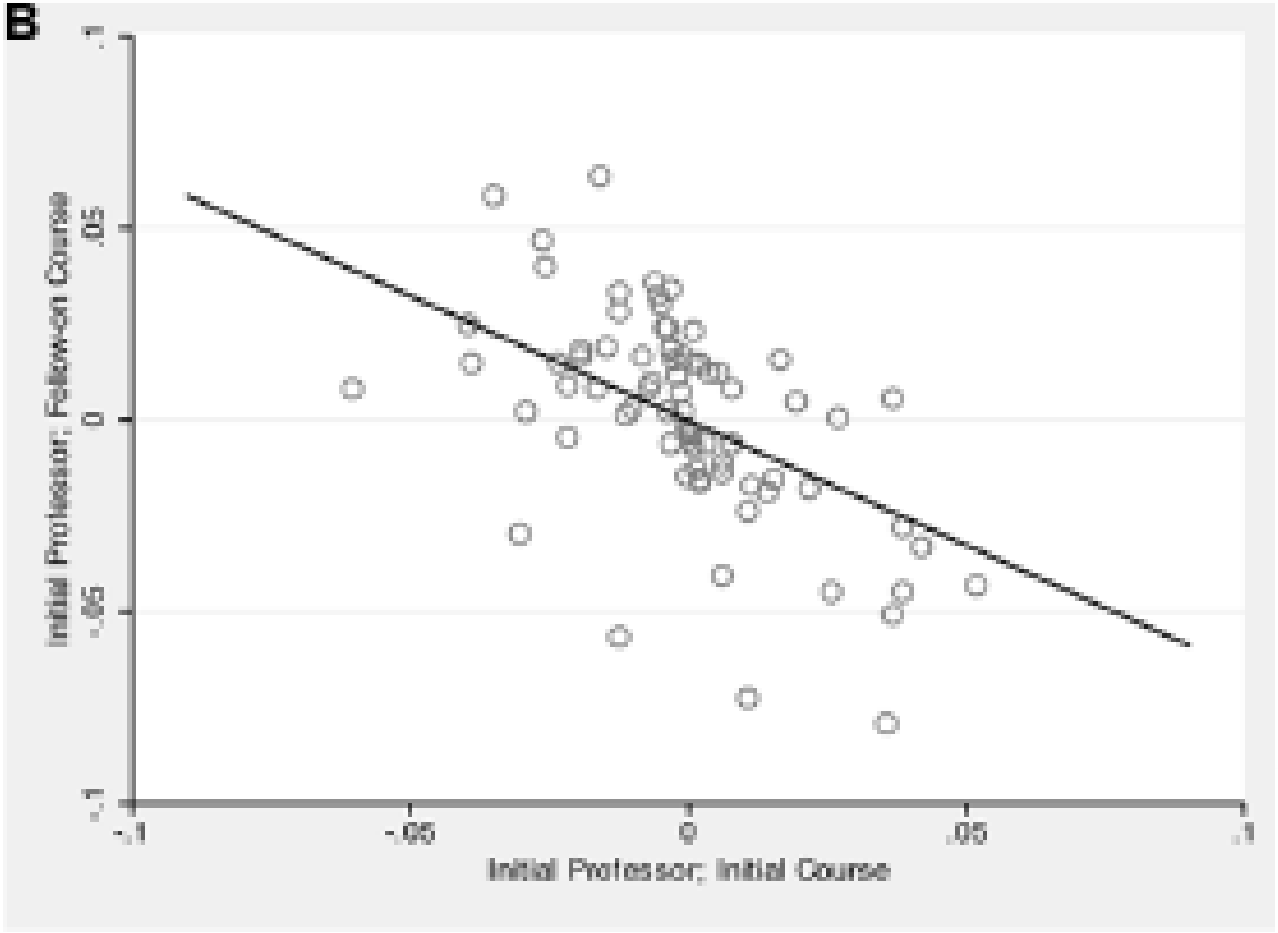
www.nwlink.com

What is the "value" added of a teacher?

Effortful learning feels "bad" but produces better outcomes

Carrell SE, West JE. J of Political Economy 2010;118:409-432

- Students randomly assigned to calculus professors at Air Force Academy; student evaluations of faculty and student performance in initial and subsequent courses.
- Student perception of value added by professor (helped them; hints; made it easy) in first year course inversely related to how well student does on 2nd year course in same field.



Routine vs. Adaptive Expert

Mylopoulos M, Regehr G. Med Ed 2007

- **Routine Expert**
  - Novel problem → adapt problem to the solution with which they are comfortable
  - Characterized by speed, accuracy, automaticity
- **Adaptive Expert**
  - Use a new problem as a point of departure for exploration; expand knowledge and understanding
  - Characterized by innovation, creativity

How Do You Think about “Physical Diagnosis”

- Distinction between “physical exam” and “physical diagnosis”
- Inductive vs. hypothetico-deductive model of teaching and learning
  - Clues vs patterns
  - Mechanisms vs. diagnoses

Bedside Evaluation

Reinforce fundamental concepts as manifested in physical exam (anatomy, physiol, biochem)

- JVP
- Signs of O2 delivery
- Cardiac Gallops
- Respiratory patterns

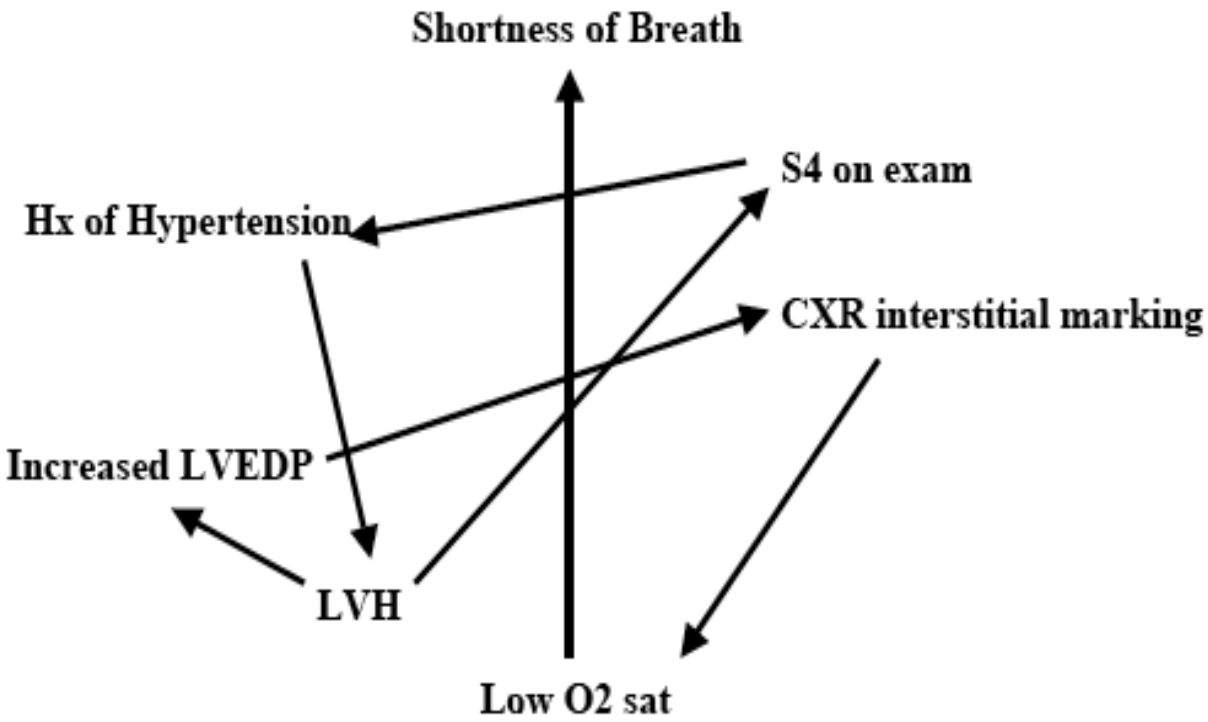
What does the sign “mean” rather than what dx is it

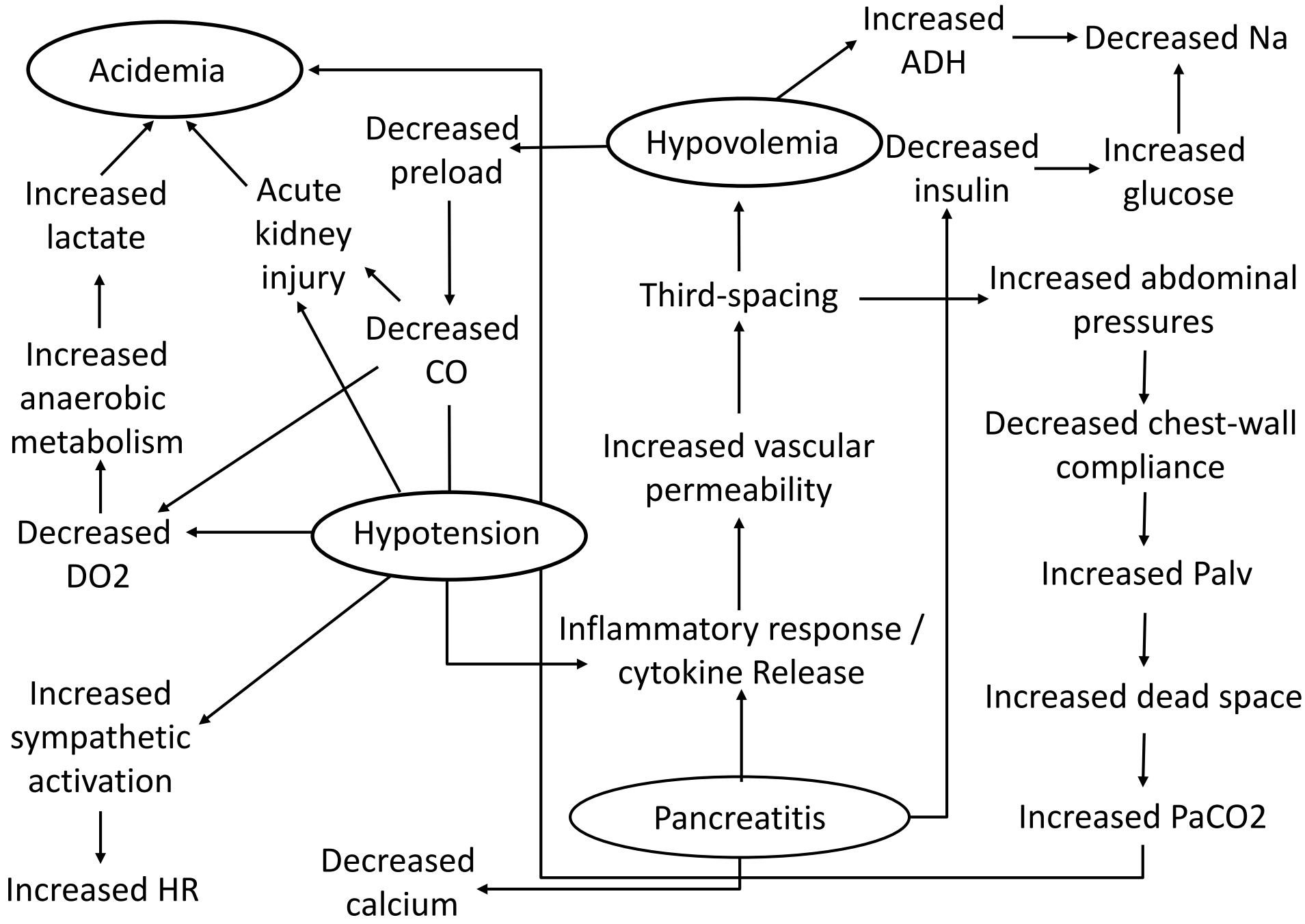
- Wheeze = turbulent flow, narrowed airway rather than “asthma”
- Edema = increased total body volume, increased venous pressure, or decreased oncotic pressure rather than “CHF”

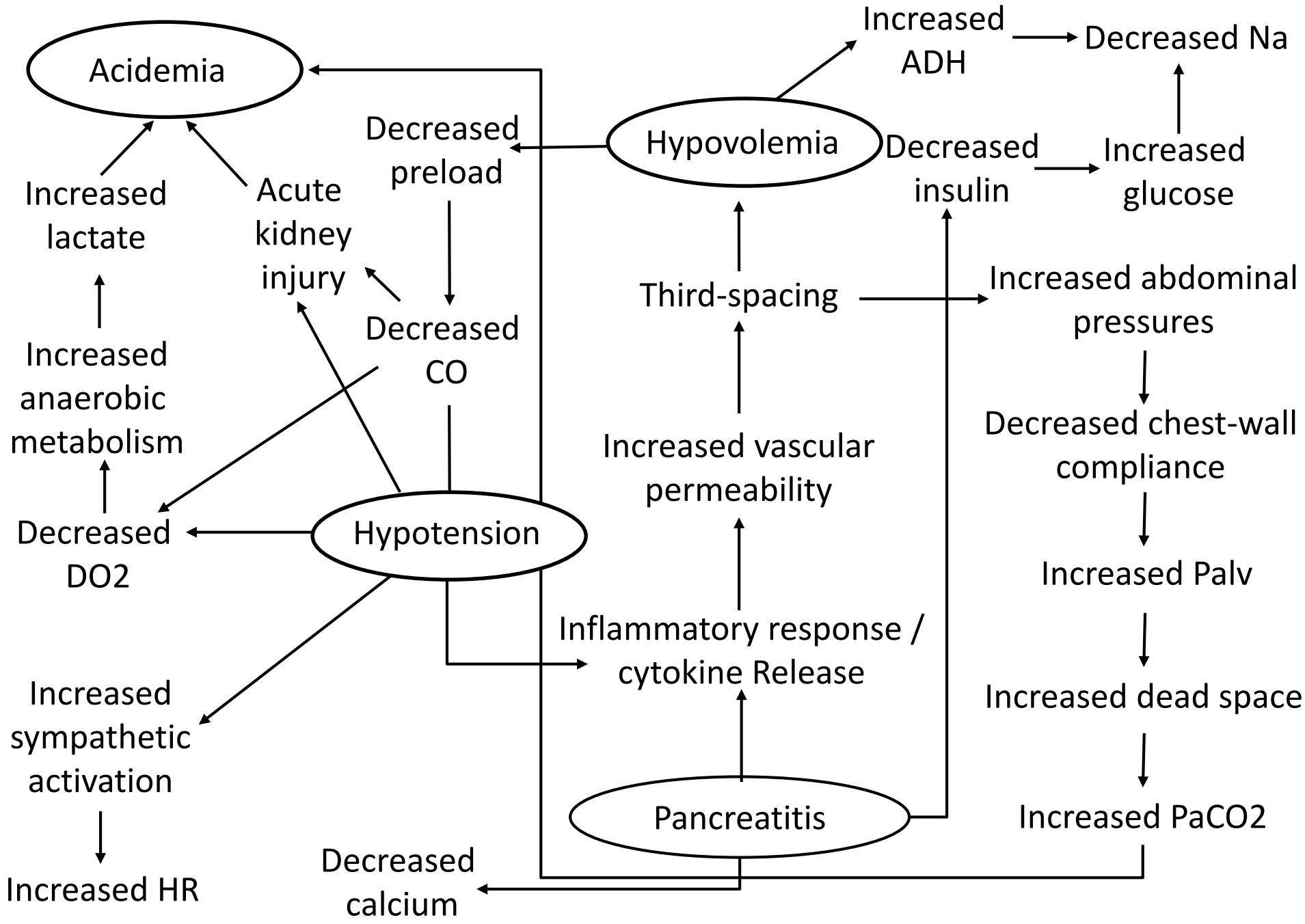
Concept Maps

Guerrero, Acad Med 2001;76:385

- Graphic devices to represent relationships between multiple concepts
- Reinforce mechanistic thinking
- Make links explicit




Acidemia
Increased lactate
Acute kidney injury
Increased anaerobic metabolism
Decreased DO2
Decreased preload
Decreased CO
Hypotension
Increased sympathetic activation
Increased HR
Increased ADH
Decreased Na
Hypovolemia
Decreased insulin
Increased glucose
Third-spacing
Increased abdominal pressures
Decreased chest-wall compliance
Increased Palv
Increased dead space
Increased PaCO2
Increased vascular permeability
Inflammatory response / cytokine Release
Pancreatitis
Decreased calcium


Acidemia
Increased lactate
Acute kidney injury
Increased anaerobic metabolism
Decreased DO2
Decreased preload
Decreased CO
Hypotension
Increased sympathetic activation
Increased HR
Increased ADH
Decreased Na
Hypovolemia
Decreased insulin
Increased glucose
Third-spacing
Increased abdominal pressures
Increased vascular permeability
Decreased chest-wall compliance
Inflammatory response / cytokine Release
Increased Palv
Increased dead space
Pancreatitis
Increased PaCO2
Decreased calcium

Can We Enhance Curiosity and Teach Critical Thinking?

Lambe KA, et a. BMJ Qual Saf 2016;25:808-820

- Meta-analysis of empirically investigated interventions to enhance analytical and non-analytical reasoning
- 28 studies included
- 5 categories: educational interventions, checklists, cognitive forcing strategies, guided reflections, “other”
- Significant heterogeneity of measurement approaches
- Guided reflection (5 studies), cognitive forcing strategies most successful.

Can We Teach Critical Thinking?

Bonifacino et al. Diagnosis 2019;6:165-172.

- Randomized controlled trial of medical students on clinical clerkship (U of Pittsburgh)
- Intervention: On-line modules on diagnostic error; cognitive psychology of decision-making, specific clinical reasoning skills; cognitive biases and heuristics. Workshop to practice skills.
- Assessment: knowledge of clinical reasoning principles; IDEA tool to assess reasoning abilities – assess patient note written by student

Formal teaching about Cognitive bias and reasoning

Randomized trial; core clinical year students. ***Improved data synthesis and diagnostic reasoning*** in the intervention group when hospital admission notes were assessed.

Bonifacino et al. Diagnosis 2019;6:165-172

Table 1: Mean hospital admission note scores per item using IDEA assessment tool.

Item	Control (n = 33)	Intervention (n = 34)	p-Value[b]
Data gathering			
HPI – detail	2.5 ± 0.4	2.4 ± 0.4	0.26
HPI – description	2.0 ± 0.5	2.0 ± 0.5	0.69
HPI – chronology	2.2 ± 0.4	2.3 ± 0.4	0.07
HPI – context	2.0 ± 0.2	1.9 ± 0.2	0.14
Complete history	2.8 ± 0.3	2.8 ± 0.3	0.76
Physical exam – complete	2.7 ± 0.4	2.8 ± 0.3	0.16
Physical exam – pertinent	2.3 ± 0.5	2.3 ± 0.4	0.66
Section mean	2.3 ± 0.3	2.4 ± 0.2	0.58
Data synthesis			
I – interpretive summary	2.0 ± 0.4	2.2 ± 0.3	**0.03[a]**
D – differential	2.1 ± 0.6	2.5 ± 0.4	**<0.01[a]**
E – explanation	2.0 ± 0.7	2.4 ± 0.5	**0.02[a]**
A – alternatives	1.9 ± 0.7	2.2 ± 0.5	**0.02[a]**
Plan	2.0 ± 0.5	2.1 ± 0.5	0.81
Section mean	2.0 ± 0.5	2.3 ± 0.4	**0.02[a]**
Global skills			
Reporting	2.0 ± 0.3	2.0 ± 0.3	0.85
Diagnostic reasoning	1.9 ± 0.7	2.2 ± 0.5	**0.02[a]**
Decision-making	2.0 ± 0.6	2.0 ± 0.5	0.91
Total			
Overall mean	32.3 ± 5.2	34.2 ± 3.6	0.09

Scores per item range from minimum of 1 to maximum of 3. Total possible score on the rubric is 45. [a]Bolded entries are significant p-values. [b]Intervention scores vs. control scores (t-test for two independent samples).

Clinical Reasoning Curriculum at HMS

- 5 sessions woven into Practice of Medicine Course – cognitive theory; cognitive biases; link to basic science courses.
- Additional theoretical sessions followed by two sessions of practice with cases from CRICO (malpractice insurance carrier for HMS hospitals)
- Assessment with decision certainty analysis tool (DCAT)

Krupat E, Wormwood J, Schwartzstein RM, Richards JB. Avoiding premature closure and reaching diagnostic accuracy: some key predictive factors Med Education 2017

Assessment of Critical Thinking

- Script Concordance Testing
- SNAPPS – Summarize the differential, analyze the differential, probe preceptor about uncertainties, plan management, select case-related issues for self-study (*Acad Med 2009;84:517*)
- Concept maps
- Milestones approach

Milestones of Critical Thinking

- Core elements
  - Metacognition: reflect on one's thinking; knowledge of cognitive processes
  - Attitudes: seeks feedback; curiosity
  - Skills: toggle between system1 and 2; inductive reasoning; can make linkages between concepts

Papp KK et al. Academic Medicine 2014; Shapiro Institute Millennium Conference task force.

One last case…

34 year old woman presents with 24 hours of abdominal pain. Nausea for past day; eating and drinking very little. No diarrhea. Pain in RLQ; sharp in nature. Felt lightheaded today with change in position. Now in the ER and resident tells you that they think the patient's diagnosis is gastroenteritis and wants to give fluids and send her home.

Your response?

Your Response…

A. Sure, discharge sounds fine
B. What else could this be?
C. How does sharp pain arise pathophysiologically in the abdomen?
D. How does the anatomy of the RLQ help you think about this case?

Get the resident to “work the problem”

- Go the bedside with the resident.
- How do you think about abdominal pain?
- Why does pain occur in the abdomen? Are there different kinds of pain and how does that inform you about mechanisms of disease?
- Why do use the term “colic” for problems with the biliary system, the intestines and the urinary tract???
- How is your thinking about abdominal pain change based on gender and age of the patient?

The Brain Hates Uncertainty

“The mind is designed to make the best possible case for a given interpretation rather than represent all the uncertainty about a given situation.”

--- Amos Tversky

Summary

- Clinical Reasoning: likely a continuum between type 1 and type 2 thinking
- For type 2 thinking to be “faster”, you need to practice it, even when it is not absolutely needed
- Inductive reasoning may provide broader DDX and less susceptibility to cognitive biases
- To enhance clinical reasoning, focus on hypotheses rather than diagnoses acknowledge uncertainty → stimulate curiosity
- “Concept maps” may help you and your learners engage in analytical approaches to patient problems
- Assessment of reasoning: multifaceted approach may be best