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Clinical Reasoning: The Core of Medical Education and Practice

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Abstract

Clinical Reasoning (CR) is an important aspect of health professional education and practice. The basics and fundamentals, when put together, reflect a physician's ability to make decisions and diagnoses. The cognitive processes involved in clinical reasoning are complex and layered. CR is the process through which physicians gather cues and data (usually from history and physical examination as well as other clues or information available), process the information, come to an understanding of the patients' problems or situation, plan and implement the necessary interventions, evaluate the responses and outcomes, as well as reflect on or off the job as relevant for deeper learning. It is a complex series of steps and cognitive functions, involving higher level thinking to define the problems, examine the evidence and then making decisions and choices to improve the patient's physiological and psycho-social state.

This paper discusses, in a simplified manner, critical thinking and CR, the Dual Process Framework continuum (from the intuitive to the analytical) to explain physicians' approach to CR as well as the common errors and biases involved in the process.

The first step to create awareness of the need to enhance and sharpen CR is indeed to become more conscious of the steps undertaken, on a daily basis, as physicians encounter their patients and plan their management.

Keywords: Clinical reasoning; Critical thinking; Dual process framework; Analytical; Hypotheses building; Cognitive processes

Introduction

Clinical Reasoning (CR) is a core and essential skill for physicians. In fact it represents a critical component in the development and training of physicians from the time they are medical students. CR is the process through which physicians gather cues and data (usually from history and physical examination as well as other clues or information available), process the information, come to an understanding of the patients' problems or situation, plan and implement the necessary interventions, evaluate the responses and outcomes, as well as reflect on or off the job as relevant for deeper learning. It is a complex series of steps and cognitive function, involving higher level thinking to define the problems, examine the evidence and then making decisions and choices to improve the patient's physiological and psycho-social state [1-3]. CR goes beyond the initial diagnosis and extends into all aspects of clinical practice and management. The process of CR has not changed since the time of Hippocrates, but what has changed is the practice of Medicine, over the years. The scientific paradigm of medicine has changed and evolved dramatically over the decades. The pace with which we work and manage clinical cases, the quick and efficient tests and use of technology today have affected the way CR is executed. An apt example would be the less detailed history and data gathering done because sophisticated and technology driven investigations can be readily ordered to help make the diagnosis [3-6].

Adequate and good CR is also strongly linked to the delivery of optimal patient care through the inculcation of diagnostic acumen, understanding the risks versus benefits of investigations and the thoughtful analyses and treatment to be rendered. The diagnostic processing steps have to be executed adequately in order to ensure excellent CR. The steps in the diagnostic process would usually include:

1. Generation of diagnostic hypothesis/ses

2. Refinement of the hypotheses

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3. Diagnostic testing

4. Causal reasoning and

5. Diagnostic verification

From these systematic action steps, hypotheses are derived which will drive and direct decision making and ordering of specific tests and investigations, as well as plan the management. CR is often used to assess readiness for clinical practice and performance in clinical practice [3].

CR goes beyond just the initial diagnosis and extends to all aspects of clinical practice and management. There are multiple levels of complexities involved in each aspect of the work process and it represents a fundamental armamentarium of a physician's daily work and thought process [6-12]. In the paper by Yazdani S et al., [11] CR has been identified to have 9 major attributes, influenced by factors such as workplace context, practice frames of reference, practice models and clinical skills, amongst other factors. The nine major attributes are [11].

1. CR is a cognitive process, which involves data gathering, interpreting, analyzing, making management decisions, managing expectations and evaluating.

2. Knowledge acquisition and application. CR and clinical knowledge are strongly interdependent and statistics, tacit numbers are often needed for CR processes.

3. Thinking is a part of CR. Many may not be conscious of this but physicians do this every day. In fact thinking is inseparable from CR and the process of thinking about thinking is known as metacognition.

4. Patients' inputs. This is critical as any CR done without this would be deemed incomplete.

5. CR is context-dependent and domain specific.

6. CR is not linear but a complex and iterative process.

7. CR is a multi-modal cognitive process. It can be analytical or intuitive depending on the expertise and context.

8. CR supports and is a part of professional principles and this is fundamental.

9. CR must be done in support of and in the context of the health system mandate of the institution or country where the healthcare practitioner is working. These can be generic or more unique to certain countries and states.

The inculcation and development of CR is also said to be able to help enhance self-awareness. However, it is important to also realize that there is really no strict gold standard to measure CR against, but rather to pitch it at the same level as peers would have functioned or performed. CR can also be used as a form of summative assessment of a physician as they go through their training [12-15].

Critical reasoning and critical thinking

Critical Thinking (CT) is the process of intentional higher level thinking to define a patient's problems, assess the evidence-based practice recommendations and then making choices on the delivery of care for that patient. CT should help physicians to clarify goals, assess assumptions, uncover hidden or not too obvious values, elucidate the evidence, accomplish actions and assess the conclusions or deductions made. The word "critical" refers to the centrality or importance of thinking to an issue or a problem. These deliberations help physicians come up with workable solutions to complex issues. CT improves patients' outcomes and physicians' satisfaction in the delivery of care. High performance teams such as that in emergency department resuscitation rooms need teams with strong CT skills [15-18].

CR on the other hand, refers to the applications of CT to the clinical situation. CR is essentially reasoning in clinical medicine. CT is therefore, an umbrella term that includes reasoning both inside and outside the clinical setting (Figure 1).

There are common elements and principles in the reasoning process for both (highlighted in yellow) within and outside the clinical settings. These principles may represent some of the fundamental elements for reasoning Studies on human cognition suggest that problem solving strategies depend on the nature of the clinical problem and even more, on the expertise of the physicians. A physician, when in contact with a patient will generate his cognitive process or diagnostic reasoning skills to clinically reason and sort out the issues faced by the patient [2,3,11,15,18-20]. The steps involved in the systematic approach and understanding of the CR process are as follows [20-22].

Hypotheses generation: In our daily lives, we generate hypotheses about people and things we come in contact with. These hypotheses provide a framework for us to explain and make sense of all our unstructured experiences. Therefore it's the same with our patients whereby we generate the initial hypothesis from their symptoms, whether single or multiple. We will continue to generate these hypotheses as long as we gather new information and feel we are not satisfied that we have the right and most accurate ones. The non relevant hypotheses can be eliminated. These hypotheses generated is also influenced by knowledge of incidence, prevalence, demographic factors, physicians' experience which may alert them to certain more rare or serious diagnoses for example. As one can conclude, this is a process with too many variables and is indeed an imperfect process, with no guarantees on getting to a spot-on diagnosis every time.

Hypothesis refinement or case building: This comes on with the sequential data gathering and interpretation, in the interaction with patients. There may be information to be added or deleted. It is important to realize that this happens because clinical data gathering is an imperfect, non-exact science and clinical data is not collected from patients in a fixed way. At times when the data fit into a certain mental model, it may make the decision making and diagnosis, more obvious and faster to attain. Thus, the refinement occurs as data continue to evolve and remain dynamic.

Diagnostic testing: Appropriately ordered tests and investigations can help to elicit new information or confirm preliminary diagnoses. There must be a cognitive basis for the decision to order certain tests and to interpret the results. Knowing the specificity and sensitivity of tests for certain clinical conditions is also very helpful. This is also where we should be aware of the term: 'The Threshold Concept'. This refers to the consideration of the likelihood of the disease and the trade-offs between the risks and benefits of the test or treatment. It also knows about 'when to test" and 'when to treat'.

Causal reasoning: This refers to the cause-effect relations between the clinical variable or a group of variables that is obtained for the particular patient. It is a function of the anatomic, physiologic

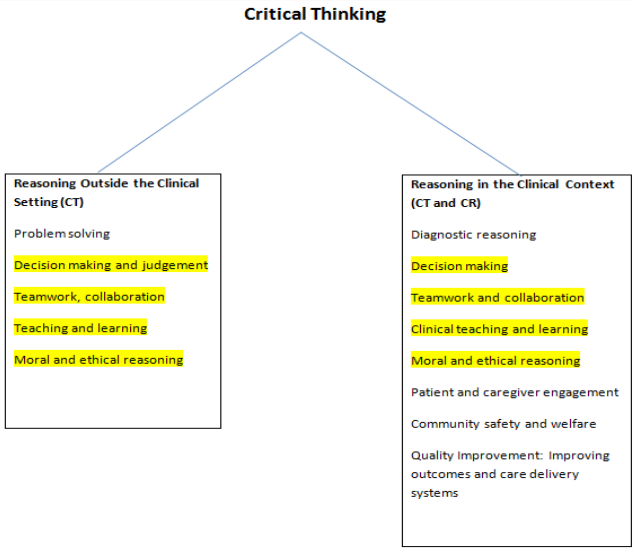

Figure 1: Critical Thinking and Clinical Reasoning.

and biochemical mechanisms that operate in the normal human body and the pathophysiology between these and disease mechanisms.

It is also about arriving at the diagnosis with all the interpretation of the dynamic data and test results. Cause and effect are related in time and space. An effect will be generated for a known cause. Causal reasoning can be applied at various steps of the diagnostic process as the generating and handling data, its refinement and testing will put forth new information and results to be put together for the big clinical picture and thus, the final diagnosis/ diagnoses. Therefore, causal reasoning can provide a framework to tie all the elements and clinical findings together.

Diagnostic verification: This is the validity assessment of checking the clinical findings against patterns of known diseases and clinical entities. The credibility of a diagnosis is also a function of its likelihood, which will help physicians understand how high the probability of their diagnosis is. Preliminary diagnoses will be confirmed and finalized with the verification steps. If not fully verified or not coherent, then there may have to be review and revisit. At times, if a diagnosis is not clearly available, then a premature closure of the case has to be decided on.

The dual process framework

The cognitive continuum of CR ranges between the Intuitive (System 1 thinking) to the Analytic (System 2 thinking) and together this model is known as the Dual Process Framework (Table 1). This Framework showcases the dual approach and thought process physicians utilize for their diagnostic process CR and decision making. The ability to use both in the appropriate combination and settings when managing patients is a skill which needs to be inculcated, nurtured, developed and maintained through regular practice and applications. The framework is often used to explain the hypothetico-deductive process which contributes towards pattern recognition [14,15].

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Some have explained that experts and more senior physicians tend to use more of System 1 processing due to their many years of accumulated experience and thus, having a larger repertoire of pattern recognition in their neural networks.

When making decisions, experts tend to use more directive factors and their psycho emotional and cognitive abilities. They use reflection in action to enable them to utilize internal and external cues in the decision making process. This is also how they make modifications and customizations to standard management plans and individualize the management of each patient. The novice on the other hand, with less experience, may tend to be more deliberative, thus utilizing System 2 thinking. They thus, tend to use more informative factors such as academic knowledge, some degree of their limited personal experience and perhaps even anticipate patients' preferences from these. They use reflection on specific action, whereby decisions are made after the patient interaction.

However this is still a controversial topic of active discussion. Questions which often arise include who uses which System and in what combination or ratio, does the type of clinical situation affect the utilization of the thinking process e.g., an acute medical situation such as septic shock or cardiac arrhythmia require immediate intervention whilst a less emergent clinical situation requiring a work up and testing may allow time for more deliberative thinking. Is one type of System thinking more suited for certain types of condition or is there a recommended optimal or combination ratio? Decision making, afterall, is not so straightforward and may involve transitions between Systems 1 and 2, and there is always a need to consider the work environment and context.

Developing competency in CR

In medical school, students are first taught subjects such as Anatomy, Physiology, and Microbiology, whereby they need to build up their content knowledge and basic foundational knowledge and understanding. They must understand the basis between normal and pathological physiology. Following this, the exposure to task-based training help to drive home the skills they need to be able to perform. Integration and then applications follows closely as they move into the clinical years. The build-up to understand more and more clinical cases, scenarios and presentations as well as the exposure and experiential learning will help to set the foundational CR capabilities. Thus, it is a step by step inculcation process to reach the higher levels of cognitive performance. It can also be viewed as a cycle which needs to be continually reinforced, strengthened and broadened through exposure, experience and more pattern recognition. This will help develop CR in a young physician. They will start with simpler scenarios and cases and gradually move on to more complex ones. They will be guided through bedside tutorials and scenario based learning until they reach an independent and competent practice stage. In the paper by Levin M et al., [5] the authors shared on the use of case-based illness scripts approach to teach CR to second year medical students. This involved a short clinical stem, followed by open ended questions, whose structure must be carefully considered in order to integrate basic and clinical science together, realistically. Some of the verbatim feedback from the students included: "teaches you how to reason through differential diagnosis" and "I felt that it pushes us to think like physicians". The positive feedback from the exercise has resulted in the implementation of these case-based scripts into their pre-clerkship system-based curriculum.

The use of simulation based learning too can help in developing CR skills [16,17]. Simulation involves repetitive and deliberate learning

Table 1: The Dual Process Framework.

System 1: The Intuitive	System 2: The Analytical
Automatic and rapid	Slower and more deliberated
Intuitive and less analytical	More analytical
Tends to be more error prone	Perhaps less error prone because of the more deliberated approach
Use of the subconscious mind	Utilise more of the conscious mind
For more routine decision making	When time permits and allows more deliberation possible and thus used for less urgent clinical cases
For encounter with clinical patients with a higher level of certainty for certain conditions or diagnoses	When higher stakes or outcomes may be involved or there is some degree of uncertainty
For more time-dependent clinical cases	In handling more complex, multi-faceted clinical situation and the diagnosis/ diagnoses is less apparent or less obvious.
	Cases with more ambiguity and less "routine" or non- "bread and butter" clinical presentation

Table 2: Guide to CR assessment for EM Medical students (case presentations assessments).

1. Ability to gather data from history and examination. Is this sufficient to generate the necessary hypotheses to build up their case
2. Ability to summarize and articulate clearly the problem list, in order of priority
3. Ability to present and defend the choice of diagnostic or therapeutic tests put forth
4. To be able to articulate the treatment and management plans for the priority diagnoses
5. Ability to reason and evaluate how they verify their final or differential diagnoses

in an immersive environment which is safe and authentic enough for teaching, developing and even assessing CR skills and competencies. Simulation offers a choice for varying the fidelity according to the level of the learner or the topic being taught. It can be integrated into a planned curriculum and does offer some level of standardization as well. It is also useful for coverage of selected scenarios, whether commonly-encountered ones versus the more rare cases, whereby the exposure can be customized accordingly [16]. Simulation can deepen the learning conversations with our learners and improve motivation by providing the necessary learning scaffolding and opportunities.

Simulation based training to inculcate, and maintain CR skills can be a very useful tool with wide applications. In fact it can be used from the very basic training to even continuing professional development programmes for senior physicians. It thus can be used throughout a physician's career span in a variety of ways, considering the need for frequent upgrading and continual learning as Medicine is an extremely dynamic and rapidly transforming discipline. Even the use of Standardised Patients (SPs) for summative assessment of clinical skills, decision making and other elements such as communications and explanation in non medical jargon is useful.

The regular utilization can help to reinforce the Kolb's Learning Cycle, which involves a four part process: [18,19]

Phase 1: Learning through concrete experience.

Phase 2: Reflection on the experience.

Phase 3: Conceptualization of their reflective observation in more abstract models.

Phase 4: Experimentation of new experience and principles to guide decisions and thus, leading to new concrete experiences.

Physicians will go through this cycle many times, over and over, in a variety of experiences which they will encounter. This is also where they will strengthen their 'reflection on action', exploring the more analytical part of clinical reasoning, after stressful simulation scenarios. 'Reflection in action' on the other hand has to be done during the period where the clinical reasoning is ongoing in the management of a patient. This is also where the standard debriefing model, whereby it is conducted at the end of a simulated scenario, has been modified to have interventions by a facilitator at strategic, critical points of decision making. This has been termed 'Simulation with Iterative Discussions' in the paper by Pennaforte T et al., [17] or the 'thinking out loud style'. For example, there may be a discussion with explorative questions regarding data gathering or history and physical examination, before the management of the scenario continues. Then there may be another intervention step to iron out the rationale for ordering certain tests and investigations. These interventions may also be carried out at another stop or 'feedback point' to understand how the diagnosis has been reached or why certain management decisions are made at various points in the management. These immediate and timely feedback can be very beneficial for the learners to see where they have taken a different turn in the decision making tree. It is almost like 'thinking-in-action'.

CR is in fact an iterative process in which judgement and decisions are adjusted in response to observations of interventions and the gathering of any new, updated information in the ongoing therapeutic process and relationship between the physician and patient.

The use of simulation has taken medical training to a new level. With its use, scenarios and scenes are created, scripts are prepared for SPs and practice can be repeated again and again to reach mastery and deepen understanding. However, the real world actual clinical contexts too are important. Senior and experienced physicians are very conscious of the influence of socio-cultural and psychological factors on medical disease and presentations. They will understand the importance of considering personal beliefs of patients and family members. They would likely have aced the skills of persuasion as they engage and communicate with more patients. They will also realize there may be alternative views and positions by the parties involved, thus the importance of the proper use of their capabilities to explain and get buy in for their accurate and correct diagnoses as well as management plans.

The novice and young physicians may be less aware or may not

think of these factors as significantly and thus may be "depersonalizing the knowledge of medical science" [16,20-22]. Also not all situations can be simulated and it does take a lot of effort to create meaningful effective teaching scenarios. Having said that, being older and more experienced also does not guarantee a better quality of care or lower risk of CR errors [23,24].

There are also physicians who feel that simulation is "pretend and make belief" and learners will never know the real consequences of their mistakes. Some may be unwilling to be engaged and may not be able to imagine (suspend disbelief in simulation).

Assessment of clinical reasoning

Physicians today are challenged daily by unprecedented, complex clinical encounters and problems in a rapidly changing world. They will need to have a broad, multi-faceted perspective in approaching every patient. As such our assessment of clinical reasoning too, is important and fundamental. It can be viewed at various steps and from different component elements. The assessment techniques and methods can range from self assessment to computerized simulated models. Also, it may be easier to measure System 2 CR compared to System 1. At the end of the day it is still important to realize that assessment of CR is very challenging and it is not a discrete, readily measurable quantity or number. It is also difficult to standardize measurement of CR. When doing assessment, factors that affect CR must also be borne in mind [23-25].

1. Patient factors: which represent the clinical variables?

2. Encounter factors: this refers to the environment and setting in which the patient is being evaluated, also known in the more generic term, as the context.

3. Human factors: this would include the staff (doctors, nurses and other healthcare providers) and their characteristics, work attitude, cognitive capabilities etc Lapses can happen with errors in execution, oversight and slips.

There are several CR assessment tools that have been put forth and shared in the literature. Amini M et al., [21] found that, in the National Medical Science Olympiad in Iran, the reliability of the following 4 tests were high for the participating cohorts:

1. Key features: measuring data gathering

2. Script concordance: measuring hypothesis formation

3. Clinical Reasoning (CR) problems and

4. Comprehensive Integrative Processes (CIP)

The CR problems and CIP measures hypothesis evaluation.

The Patient Management Problem (PMP) instrument is a tool that measures problem solving skills and it begins with the learner being presented with a clinical statement to analyze and probe further [22,25].

The IDEA Assessment Tool tests Interpretive Summary, Differential Diagnoses, Explanation of Reasoning and Alternatives is yet another example [26].

Other customized tools have also been developed for assessment of CR, including one by Fleiszer D et al., [27] which tests CR in trauma using virtual patients. Adams E et al., [28] suggested using a simple existing platform to assess CR, which is the use of progress notes which is written almost by all medical practitioners in the management of their patients. It shows the flow and train of thought in ordering tests, refinement of the hypotheses generated and thus planning the holistic management of the patients.

Whatever assessment tool or model is utilized, assessors and faculty are trying to look for some of the following characteristics and values [29-32].

a. Effective communications

b. Self awareness

c. Curiosity and inquisitiveness

d. Alertness to context, including being insightful and intuitive as needed

e. Being open, fair-minded and non judgmental

f. Analytical

g. Prudency in the approach to an undifferentiated patient

These values will reflect the rapport between physicians and patients, the line and depth of questioning taken and may have a bearing on the ability for data gathering, hypothesis generation and thus the causal reasoning ability.

In our Emergency Department when students come for their Emergency Medicine (EM) postings, they are expected to do case presentations after they have interacted and managed patients. They CR skills and capabilities are reviewed and analyzed using the following guide (Table 2).

The emphasis for the students would be to emphasize on their ability to think about their own thinking (metacognition), testing their curiosity and inquisitiveness in approaching the patients and their level of 'wanting to know'. It can also highlight their reflective capability to a certain extent.

Clinical reasoning errors

Most of the errors in CR are not due to inadequate knowledge or incompetence but arise from errors in cognitive difficulties. All decision making potentially is vulnerable to cognitive and affective errors. Some of these errors come about from the use of short cuts or personal routine rule of thumbs, which generally may be fine, but can predispose a physician to wrong pathway if not consciously done [33-35]. Some errors are inter-related and in fact there may be more than one error in a single patient. Errors may also arise due to cognitive resistance to changing one's mindset and thinking habits. Below are some examples of common errors in CR which can happen [34-37].

1. When physicians treat the numbers and not the patient. This can be due to over-reliance on statistics, prevalence etc and not focusing on the clinical case on hand.

2. Trying to fit everything available into a single diagnosis. At times this may not be possible and practically, one patient can have more than one diagnosis. Thus physicians' need to consciously be aware of this when considering and deliberating on their decisions.

3. Common conditions are common but there will be occasions whereby there will be very close differential diagnoses to consider as well.

4. Locking in a diagnosis too early in the CR process before all information and results are known can be a pitfall. Physicians must be willing to reavaluate and adjust accordingly in these dynamic

situations.

5. CR and cognitive processes are definitely shaped by prior experiences, assumptions and preconceptions. For example, these could be age related, race biased stigma or stereotyping.

6. There is a phenomenon of 'confirmation bias' whereby physician s look for clinical evidence only to confirm an impression they have in mind rather than to disconfirm it. This too may present a loophole in the CR process.

7. Premature closure of the case or patient management can result from the inability of physicians to be able to verify adequately and review with change.

8. Overconfidence too can be a pitfall, especially when not all the data and information are available adequately.

9. Extrapolation errors can happen if there is a high level of dependence on certain clinical trial results for example, which may not match the current patient being managed.

10. Not gathering all the necessary information before establishing the diagnosis/ differential diagnoses.

Knowing and having encountered some of these errors, it is important that we are conscious of them and incorporate them into our teaching programmes and continuing professional development sessions for physicians and healthcare staff.

The reinforcements are critical. Senior supervision may need to take a more iterative approach to understand problems and challenges with decision making. An open culture of the institution is also helpful in this context, to help support clinical decision and training. Open feedback and peer-review sessions too become useful for deepening our understanding of this process. Senior role-modelling the process of their CR and 'thinking out aloud' can also be useful to train the juniors. This may make them think more about their own thinking process.

Conclusion

All clinical teachers teach CR, intentionally or not. However, to ensure effective teaching goes on, both teachers and learners need a shared vocabulary to understand, be aware and acknowledge CR in the work they do. They must share knowledge and skills to deepen the cognition of this important area [38]. In fact, CR is also an important topic to revisit with faculty development and continuous professional development programmes.

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