Digital Tools to Enhance Clinical Reasoning

Reza Manesh, MD[a,*], Gurpreet Dhaliwal, MD[b,c]

KEYWORDS

• Clinical reasoning • Diagnostic skills • Virtual patients • Clinical problem-solving

KEY POINTS

- Physicians can improve their diagnostic accuracy by adopting a simulation-based approach to reading published cases.
- Virtual patients are computer-based programs that foster learning through simulation of real-life case scenarios.
- The move from static formats to electronic platforms increases the accessibility of cases and makes learning more active and durable.

INTRODUCTION

A core component of providing excellent patient care is analyzing and synthesizing clinical data to arrive at the correct diagnosis. Despite the increasing demands placed on clinicians, physicians owe it to their patients to constantly seek ways to improve their diagnostic accuracy. Methods to enhance knowledge and improve clinical reasoning skills that underpin diagnostic excellence are point-of-care learning, feedback, simulation, and deliberate practice.[1]

Technology does not provide a shortcut to clinical excellence but it does lower the barrier to building knowledge and developing reasoning skills that lead to outstanding clinical performance (**Table 1**). This article highlights online resources that can increase the number of cases a clinician can experience and learn from.

Disclosure Statement: Dr R. Manesh is supported by the Jeremiah A. Barondess Fellowship in the Clinical Transaction of the New York Academy of Medicine, in collaboration with the Accreditation Council for Graduate Medical Education (ACGME). Dr R. Manesh receives an honorarium from the Human Diagnosis Project for serving as Global Morning Report supervising editor. Dr G. Dhaliwal reports receiving honoraria from ISMIE Mutual Insurance Company and Physicians' Reciprocal Insurers.

[a] Department of Internal Medicine, Johns Hopkins Hospital, Johns Hopkins University School of Medicine, 600 North Wolfe Street, Meyer 8-34D, Baltimore, MD 21287, USA; [b] Department of Medicine, University of California San Francisco, San Francisco, CA, USA; [c] Medical Service, San Francisco VA Medical Center, 4150 Clement Street, San Francisco, CA 94121, USA
* Corresponding author.
E-mail address: rsedigh1@jhmi.edu

Med Clin N Am 102 (2018) 559–565
https://doi.org/10.1016/j.mcna.2017.12.015 **medical.theclinics.com**

Table 1
Enhancing clinical reasoning through technology

Task	Purpose	Examples
Build general knowledge	Augment knowledge for unspecified future encounters	• Journal table of contents email alerts • Journal & FOAM podcasts • Journal & FOAM Twitter accounts
Build case-specific knowledge	Augment knowledge in real time for current encounters	• UpToDate • Google • PubMed
Decision support	Augment decision making in real time for current encounters	• Isabel • VisualDx • DxPlain
Feedback	Learn from patient outcomes	• Electronic medical record • Asynchronous electronic communication with other clinicians
Simulation	Practice with additional cases	• *New England Journal of Medicine* Interactive Cases • *Journal of General Internal Medicine* Exercises in Clinical Reasoning • Human Diagnosis Project

Abbreviation: FOAM, free open access medical education.

WHY CASES?

Professionals who wish to improve their knowledge and performance seek opportunities to practice their relevant skill. Experts in chess, the military, and aviation practice their craft through self-created or externally imposed simulations. Medicine has embraced simulation for psyhomotor skills like laparoscopic surgery but not for cognitive skills.

Published cases simulate the diagnostic journey of the treating clinicians. The tight coupling of clinical problems and their solutions affords readers the opportunity to efficiently upgrade their illness scripts (structured knowledge of a specific disease) and schemas (structured frameworks for common problems). The more times clinicians practice accessing and applying those knowledge structures, the better their approach will be to future patient-cases. Although the final diagnosis at the end of published cases is sometimes rare, it is the journey that provides lessons for everyday patient encounters (eg, approach to dyspnea, anemia, or renal injury).[2]

Virtual patients (VPs) are computer-based programs that foster learning through simulation of real-life case scenarios.[3] Well-designed VPs allow users to practice decisions and learn from feedback. VPs also integrate distractors such as misleading test results and extraneous information that mimic authentic clinical environments. Learning theory and education reviews propose that the greatest pedagogical value of VPs is the enhancement of clinical reasoning skills.[4] VPs aim to transform abstract knowledge into tacit knowledge through active problem solving.

THE CLINICAL PROBLEM-SOLVING FORMAT CASE

Medical journals (such as the *New England Journal of Medicine*, *Journal of Hospital Medicine*, and *Journal of General Internal Medicine*) publish cases in the clinical

problem-solving format. In these series, a case is presented in a step-wise fashion where each portion of the case chronology (eg, history of illness or laboratory test results) is followed by an expert's analysis. The following approach can enhance the challenge (and learning) that comes from reading a clinical problem-solving case:

- Avoid the title of the case, as it often hints at the final diagnosis.
- Do not look ahead at any images, as it might bias your clinical reasoning (eg, an early glance at a pathology slide may limit the diagnostic possibilities you contend with).
- After analyzing one section of case data, skip the expert's discussion, and move on to the next section; often the expert suggests or arrives at the diagnosis early in the case, which artificially influences your thinking in subsequent sections.
- Stop after each section and write down your assessment: How are you framing the case? What is your working diagnosis? What would be your next steps?
- Commit to a final diagnosis before it is revealed at the end of the case; getting feedback on your decisions is the only way to refine your judgment.
- Return to the beginning of the case and compare your sequential assessments with the expert's evolving thinking during the case.
- Read the commentary that follows the case and create or refine your illness scripts and schemas for the relevant diseases and problems, respectively.

Reading cases in this way recreates the struggle of the treating clinicians and allows the reader to compare how they would handle the situation against the decisions of the treating clinicians and expert discussant. This approach fortifies the reader's knowledge structures (illness scripts), approaches to problems (schemas), and ability to discern the most important elements of a complex case (problem representation).

When approached in this way, print-based cases are effective forms of clinical reasoning practice. Electronic platforms can make this exercise more efficient and more engaging. The following sections outline 3 formats of online cases (**Table 2**). The first 2 feature traditional print media cases that are enhanced by online presentations. The third is exclusively online. All of the featured resources are free.

Journal of General Internal Medicine: Exercises in Clinical Reasoning

The Exercises in Clinical Reasoning (ECR) series of the *Journal of General Internal Medicine* (*JGIM*) presents a challenging case with an in-depth focus on the clinician's cognitive strategies.[5] By analyzing the clinician's thought process, core concepts and strategies in clinical reasoning are highlighted.

Technology-enhanced learning

A select number of published ECR cases are grouped into an online toolbox with extra features to enhance understanding of the underlying clinical reasoning theme.[6] Each concept is highlighted on a Web page and includes a link to the ECR case, an introductory document that highlights the reasoning concept's application in daily practice, and a slide deck of the case.

Example The ECR case, "A 22-Year-Old Woman with Abdominal Pain"[7], defines and examines the illness scripts concept through a case of abdominal pain. The slides provide the reader with a visual representation of the components of an illness script for a disease: pathophysiology, epidemiology, time course, symptoms and signs, diagnostics, and treatment. The case begins with a 22-year-old woman with 2 days of abdominal pain. The slide deck invites the reader to elaborate the illness scripts of leading diagnoses. The reader later has the opportunity to review illness scripts for 4

Table 2
Online case-based simulations

Resource	Typical Time per Case	Distinguishing Features	Similar Digital Resources
Journal of General Internal Medicine Exercises in Clinical Reasoning	30–60 min	• Teacher's guide • Practice applying clinical reasoning concepts	
New England Journal of Medicine Interactive Medical Cases	30–60 min	• Multimedia learning modules • Performance score compared with other users	• i-Human Patients • MedU • *The Lancet* Interactive Ground Round series • *Annals of Internal Medicine* Virtual Patients
Human Diagnosis Project	5–10 min	• Comparison with differential diagnosis of other users • Performance score compared with other users	• QuantiaMD • The JN (*JAMA* Network) Challenge

candidate diseases by clicking on hyperlinks for Crohn's disease, acute mesenteric ischemia, herpes zoster, and adrenal insufficiency. Before the final diagnosis is revealed, the presentation calls on the reader to compare and contrast the illness scripts of the candidate diagnoses.

Technology-enhanced teaching

The online ECRs feature a teaching guide with each slide deck. As the case unfolds, the educator can use strategies outlined in the teacher's notes to interact with trainees, such as soliciting the components of an illness script for a common diagnosis. Selected slides have questions that prompt the group to reflect on the clinical reasoning process (metacognition).

Summary

The *JGIM* ECR series simultaneously enhances knowledge of medical and clinical reasoning concepts. Online ECRs allow readers to examine clinical reasoning concepts and teach those concepts to trainees and colleagues.

The New England Journal of Medicine Interactive Medical Case Series

The *New England Journal of Medicine* (*NEJM*) Clinical Problem-Solving (CPS) series presents case information in stages to an experienced clinician who reveals their sequential thinking. In 2009, the *NEJM* launched the Interactive Medical Case (IMC) series, which is a collection of online cases (virtual patients) that follow the CPS format.[8] Some cases appear in the print journal as a CPS and online as an IMC; other cases are only presented as an IMC.

Technology-enhanced learning

The *NEJM* Interactive Medical Case utilizes interactive learning features including multiple choice questions (MCQ), matching exercises, and identification tasks.[9] After each challenge, a detailed answer is provided in conjunction with a multimedia presentation. After completing a case, the learner receives an overall score that compares their performance with the worldwide readership.

Example "Dissecting a Case of Abdominal Pain" starts with a 43-year-old man with acute, severe abdominal pain.[10] This opening is followed by an animated physical examination that promotes interpretation and incorporation of key findings (eg, left upper quadrant tenderness) into the reader's working assessment. The first interactive test of knowledge prompts the user to identify 4 conditions that cause acute left upper quadrant pain. A detailed explanation follows each MCQ providing justification (and references) for the correct choice and analysis of the incorrect options. For example, after a splenic infarct is revealed, a module highlights the anatomy and function of the spleen using pathology images.

Technology-enhanced teaching

By projecting the IMC onto a screen and directly teaching from the *NEJM* website, a teacher can lead a group session focused on solving the case. At the predetermined breaks, the teacher can have trainees address the interactive challenge exercises and review the learning elements from the multimedia content.

Summary

The *NEJM* IMCs are professional-grade virtual patients. The interactive elements facilitate decision-making practice and learning about common conditions and relevant pathophysiology through spaced challenges and multimedia teaching content.

The Human Diagnosis Project

The Human Diagnosis Project is an online system that allows physicians to upload and solve cases shared by clinicians worldwide.[11]

Technology-enhanced learning

The Global Morning Report (GMR) series highlights one case per day for the entire community. It takes approximately 5 minutes to solve the GMR case on an electronic device and an additional 3 minutes to review the teaching points. As a patient's case is presented in stages, the system prompts users to enter their leading diagnoses at each step.

An accuracy score reflects how high the correct diagnosis was ranked in the user's final differential diagnosis. An efficiency score reflects the number of clinical data points the user needed before she first included the correct diagnosis in her differential diagnosis. The program also provides users with percentile rankings (compared to all users) in accuracy and efficiency on all cases they analyzed over the previous 14 days.

Example GMR case 192 begins with a 58-year-old woman who presents with confusion and an image of a nonblanching bilateral lower extremity erythematous rash.[12] Users are prompted to enter their early diagnostic considerations (eg, thrombocytopenia, disseminated intravascular coagulation). In the next section, fever and generalized arthralgia are disclosed, prompting users to revise their differential diagnosis (eg, infective endocarditis, Henoch-Schonlein purpura). Then the patient's history of mitral valve prolapse is revealed, which might lead the user to prioritize infective endocarditis. The final 2 findings are a histopathologic image of leukocytoclastic vasculitis and a description of a brain computed tomography revealing age-indeterminate infarcts. At this stage, clinicians must submit their final ranked differential diagnosis. The users then receive a performance score, teaching points, and a listing of diagnoses with their frequencies entered by the community.

Technology-enhanced teaching

The Human Diagnosis Project allows educators to engage multiple trainees simultaneously in the same case. Members of the group (eg, on a small medical team) revise

their differential diagnosis on their devices as each piece of data is revealed. The thinking of the different learners at each stage of the case can be compared and contrasted in a group discussion. The exercise concludes by reviewing the teaching points.

Summary

The Human Diagnosis Project is an efficient way for clinicians to practice their diagnostic skills and compare their performance to their peers. The short time requirement and phone-based application lowers time and accessibility barriers to case-based practice.

SUMMARY

The clinical encounter remains the cornerstone of clinical reasoning growth for all physicians. But the skill level that practitioners achieve from daily experience alone is insufficient. Estimates that 10% to 15% of all clinical encounters have diagnostic errors[13] reminds us that every clinician—whether newly minted or seasoned—has an obligation to continually refine their ability to collect, analyze, and synthesize clinical data. Case-based simulations can improve reasoning skills by increasing the number of episodes of practice that are tightly coupled with feedback. If a day on the front lines diagnosing and treating patients is akin to a cognitive workout, then analyzing additional digital cases is like getting in a few more "reps" at the end of the day.

The move from static (print) formats to digital platforms increases the accessibility of cases and makes the learning more active and durable. This article outlined digital resources that transform the clinician from a passive reader to the front-line physician. The clinician who takes advantage of these resources can increase their experience and their expertise.

REFERENCES

1. Dhaliwal G. Lifelong learning in clinical reasoning. In: Trowbridge RL Jr, Rencic JJ, Durning SJ, editors. Teaching clinical reasoning. Philadelphia: American College of Physicians; 2015. p. 191–204.
2. Peile E. More to be learnt from the discussion than the diagnosis. BMJ 2003; 326(7399):1136.
3. Posel N, Mcgee JB, Fleiszer DM. Twelve tips to support the development of clinical reasoning skills using virtual patient cases. Med Teach 2015;37(9):813–8.
4. Cook DA, Triola MM. Virtual patients: a critical literature review and proposed next steps. Med Educ 2009;43(4):303–11.
5. Henderson M, Keenan C, Kohlwes J, et al. Introducing exercises in clinical reasoning. J Gen Intern Med 2010;25(1):9.
6. Kohlwes J, Connor D, Manesh R. Introduction to exercises in clinical reasoning. In: JGIM web only. Available at: http://www.sgim.org/web-only/clinical-reasoning-exercises. Accessed July 29, 2017.
7. Geha R, Connor D, Kohlwes J, et al. Illness scripts overview. In: JGIM web only. Available at: http://www.sgim.org/web-only/clinical-reasoning-exercises/illness-scripts-overview. Accessed July 29, 2017.
8. McMahon GT, Solomon CG, Ross JJ, et al. Interactive medical cases—a new journal feature. NEJM 2009;361:1113.
9. The New England Journal of Medicine interactive medical cases. Available at: http://www.nejm.org/multimedia/interactive-medical-case. Accessed July 29, 2017.

10. Casey J, Vaidya A, Frank N, et al. In: The new england journal of medicine interactive medical cases. Available at: http://www.nejm.org/doi/full/10.1056/NEJMimc1516704. Accessed July 29, 2017.
11. The Human Diagnosis Project. Available at: https://www.humandx.org/. Accessed July 29, 2017.
12. Hwang J. Global morning report 192. In: The human diagnosis project. Available at: https://www.humandx.org/o/e5bc7iwo5633tzt1p7mrmurz9/solve?s=MR. Accessed July 29, 2017.
13. National Academies of Sciences, Engineering, and Medicine. Improving diagnosis in health care. Washington, DC: The National Academies Press; 2015.