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Website: www.jehp.net

DOI: 10.4103/jehp.jehp_355_23

Teaching clinical reasoning to medical students: A brief report of case-based clinical reasoning approach

Mostafa Alavi-Moghaddam[1], Arman Zeinaddini-Meymand[2], Soleiman Ahmadi[3], Aryan Shirani[4,5]

[1]Department of Emergency Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran, [2]Gastroenterology and Liver Diseases Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran, [3]School of Medical Education and Management, Shahid Beheshti University of Medical Sciences, Tehran, Iran, [4]Student Research Committee, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran, [5]USERN Office, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Address for correspondence:
Dr. Aryan Shirani, Student Research Committee, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran - 19615-1178, Iran.
E-mail: shiraniaryan@gmail.com

Received: 13-03-2023
Accepted: 10-07-2023
Published: 26-02-2024

Abstract:

BACKGROUND: Case-based clinical reasoning (CBCR) is the proposed method to improve clinical reasoning. This brief report aimed to evaluate CBCR effectiveness to improve clinical reasoning via an online course.

SETTINGS AND DESIGN: This study is a brief report of a before–after quasi-experimental study to evaluate CBCR in medical students of Shahid Beheshti University of Medical Sciences.

MATERIALS AND METHODS: Ten online weekly 2-hour sessions of CBCR presentations were instructed to medical students. Each session started with an illness script, and then, the instructor posed the students' five clinical questions in five steps according to the CBCR approach. The clinical reasoning ability of students was evaluated before and 2 weeks after the online courses using four types of standard clinical questions.

STATISTICAL ANALYSIS USED: A Wilcoxon signed-rank test was used to assess the difference between pretest and posttest examination scores.

RESULTS: This brief report revealed that twenty-one medical students participated in all ten sessions of the CBCR online course and were evaluated in pretest and posttest examinations. A significant improvement in the clinical reasoning total scores in the posttest examination compared with the pretest examination was observed ($P = 0.001$). In terms of specific types of clinical questions, the mean posttest scores for clinical reasoning problem (CRP) and key feature (KF) examinations were higher than the pretest scores ($P = 0.001$ and $P = 0.005$, respectively).

CONCLUSIONS: Applying the CBCR approach improved the total clinical reasoning score of medical students during the course. Further studies are needed to evaluate whether this improvement would persist in workplace settings or not.

Keywords:

Best evidence medical education, clinical decision-making, clinical reasoning, medicine, undergraduate

Introduction

More than 250,000 patients die annually due to medical errors in the United States. In fact, malpractice is the third important reason for patient mortality.[1] The annual expenditure caused by medical errors is about $20 billion in the United States.[2] Studies showed that one of the principal causes of inpatient and outpatient malpractice is a lack of knowledge and skills. Basic knowledge, clinical expertise, and leadership skills are essential in practice.[3]

When a physician faces a problem, in terms of disease diagnosis or treatment, some mental processes called "clinical reasoning" happen to solve the problem.[4] Based on the report of the Institute of Medicine, a prominent cause of diagnostic errors of physicians is a lack of clinical reasoning.[5]

How to cite this article: Alavi-Moghaddam M, Zeinaddini-Meymand A, Ahmadi S, Shirani A. Teaching clinical reasoning to medical students: A brief report of case-based clinical reasoning approach. J Edu Health Promot 2024;13:42.

Improving the way of thinking and so-called clinical reasoning can make gross progress in clinical practice as clinical reasoning is the most valuable skill a physician should achieve. A myriad number of methods in teaching medicine have been proposed so far in different parts of the world.[6,7]

Methods in teaching clinical reasoning could be categorized based on the purpose as knowledge-oriented and process-oriented[6] or based on the way of presenting the case (gradually or in a whole case format) to the students.[8] The process-oriented methods focus on teaching the students how to reason and the process by which the students reach the correct diagnosis, and this method seems to be more appropriate to prepare students for real practice.

A fundamental point in teaching medicine, especially the clinical parts, is to prepare the students for real situations. Real clinical situations, especially emergency ones, require good preparation. Understanding clinical reasoning concepts needs a basic level of medical science. Therefore, introducing those concepts should be among students who have passed basic science and elementary clinical courses. According to Kim *et al*., the best method for educating medical students in the pre-internship stage is the case-based approach.[9] In addition, Dolmans and colleagues have proven case-based clinical education as an effective method of education for undergraduate medical students. They have designed guidelines for clinical case selection and making instructive scenarios. This method of education needs less time and has more attraction for students, resulting in more coherent teaching.[10]

Case-based clinical reasoning (CBCR) is brought up for the development of clinical education in the frame of standard clinical cases.[11] Keemink *et al*. declared that CBCR education can evolve the way of approach to specific diseases; however, its effect on general practice remained unclear.[12] A standard course for CBCR is presented by at least three experts, including a program director and two clinical tutors, and it takes about 105 to 150 minutes to introduce the main case. This process has five stages: The first stage addresses the issue and clarifies the patient's complaint; in the second stage, the full patient's history is presented; the third stage similarly describes examination and physical findings; in the fourth stage, laboratory and, if existed, imaging data are listed; and the last stage presents therapeutic options and clarifies the patient's management and follow-up.[4]

Regarding the importance of teaching clinical reasoning to medical students, in this brief report we reported a CBCR teaching method aiming to evaluate the effectiveness of the CBCR approach in improving clinical reasoning among medical students before and after participating in an online course.

Materials and Methods

Study design and participants

This was a brief report of a before–after quasi-experimental study to evaluate CBCR effectiveness to improve clinical reasoning via an online course. Forty medical students of Shahid Beheshti University of Medical Sciences, Tehran, Iran, who were candidates to participate in the National Clinical Reasoning Medical Students Olympiad, were enrolled in the study. These students had passed basic science courses, undergone at least 12 months of clinical clerkship, and were in the internship or externship stages. The total sessions were instructed between January 10 and March 10, 2022, and included 10-weekly 2-hour sessions. The first and last sessions were conducted on Monday and Thursday, respectively, while the other sessions were conducted on Sunday. The time of each session was scheduled for the evening, when all the students had time to participate in the course. The study was approved by the ethical committee of Shahid Beheshti Medical Sciences (code: IR.SBMU.RETECH.REC.1398.415). At the beginning of each session, an illness script was provided to the students. Then, according to the CBCR approach and during five steps, five clinical questions were posed to the students. At each step, the instructor explained and answered the questions. At the end of each session, a similar case study was introduced to the students and they were requested to answer the clinical questions as homework.

To evaluate clinical reasoning among these students, the students were evaluated before and 2 weeks after the last online course, by pretest examination and posttest examination, respectively. A full professor of medical education and two medical doctors who were previously experienced in CBCR education evaluated courses and examinations.

Course structure

Ten online 2-hour sessions of CBCR weekly presentations were instructed to medical students through the Adobe Connect version 11 platform. The headline of all of these 10 sessions was among the high-risk chief complaints and included acute dyspnea, jaundice, loss of consciousness, chest pain, abdominal pain, gastrointestinal bleeding, back pain, headache, seizure, and weakness. During the online session, each student was permitted to give comments or answer the clinical questions in the chat box to the presenter. The answers to the clinical questions were explained by the instructor after a discussion with the participants.

The teaching program in the online session was a five-step model according to the CBCR approach. For

each step, twenty minutes were allocated: 15 minutes for the presentation and discussion and 5 minutes for the conclusion. Each online session opened with an illness script related to one of the high-risk chief complaints, which were selected for an online course. Then, the instructor asked the participants the key question: "What is the most probable or most critical differential diagnosis for this chief complaint?" In steps 1 and 2, the most related and most important items in the history and physical examination of the patient were, respectively, reviewed. Then, the five most probable diagnoses were clarified and the students were requested to determine whether each item mentioned in the history and physical examination is consistent too, in arguing with, or unrelated to each diagnosis. In step 3, the most useful ancillary tests including laboratory and imaging studies were discussed according to the most probable differential diagnosis, in terms of diagnostic performances. In step 4, treatment options of the mentioned clinical case were discussed according to the most probable diagnosis and effectiveness indices. In step 5, the short-term follow-up of the patient was presented and a volunteer trainee summarized the diagnostic process for the clinical case, which was presented during the session. At the final of each session, a similar case study was introduced to the students and they were requested to answer the clinical questions as homework.

Tests design

Both pretest and posttest examinations had four types of clinical questions, which were recognized to assess clinical reasoning, including clinical reasoning problem (CRP), script concordance (SC), key features (KF), and puzzle (To view an example of each question type, please check out the "Supplementary Materials" section). The themes of these clinical questions were selected according to the ten high-risk chief complaints, which were presented in online sessions. In each pretest or posttest examination, the maximum scores for CRP and SC questions were 60 and 30, respectively, and the maximum scores for the KF and puzzle questions were 40 and 15, respectively. The correct answer for both pretest and posttest examinations was determined based on the expert responses. The total clinical reasoning score of each student was defined as the delta posttest and pretest examination scores. These examinations were designed equal to the national examinations. Therefore, questions had credits such as those in standard examinations and we utilized these credits for the total scoring of the participants. In this manner, credits for questions were 1, 2, 2, and 4, in puzzle, SC, KF, and CRP examinations, respectively. At the end of the sessions, 21 medical students were considered eligible to participate in the tests. The inclusion criteria were active participation in all 10 sessions. Both pre- and posttest examinations were performed on paper and conducted in open-book settings. Previously designed answer sheets were used to correct the examinations.

CRP

In this type of test, the participant faced a case history with two probable diagnoses that should be chosen out of six offered diagnoses. Consequently, the participant took five subjects from 12 written subjects for each diagnosis and defined whether each subject supports the diagnosis or disclaims it. We designed five different cases for each pretest and posttest. The subject's score was considered unless the diagnosis was false.

SC

Each question had a short scenario comprising three rows of scripts. A five-point Likert scale from -2 to +2 choices should be given to the declared hypothesis about the cited procedure or treatment. If the examinee chose the correct point exactly, a full score was given. Half of the score was considered for another choice if it truly determined the positivity or negativity of the scale. Each examination had 10 SC questions.

KF

In KF multiple-choice questions, the examinee should choose four of 16 options that were more compatible with the case history. Each true choice had one score. Ten different KF questions were designed for both pretest and posttest examinations.

Puzzle

Each question comprised four clinical cases. Four items including history, physical examination, laboratory or imaging findings, and treatment options were considered for each case. These items were clustered in rows, and the examinee should match the items of each case. Every correct match had 1/3 point, and a total score of 3 was given to a puzzle question. We brought up five puzzle questions for each examination.

Statistical analyses

Descriptive statistics were used to categorize test items, including CRP, SC, KF, puzzle, and the total clinical reasoning scores. The Kolmogorov–Smirnov test was used to check the normal distribution of data. The difference between pretest and posttest examination scores was analyzed by the Wilcoxon signed-rank test. Analyses were performed using Statistical Package for the Social Sciences (SPSS) ver. 22 (IBM SPSS Inc.). A P value <0.05 was considered statistically significant for all analyses.

Results

Of 40 students participating in the CBCR course, twenty-one medical students could participate in all ten

sessions of the CBCR online course and were evaluated in both pretest and posttest examinations and were included in the study (12 males and nine females with mean age of 24 ± 1 of years). A comparison of the pretest and posttest scores revealed a significant improvement in the total clinical reasoning scores (63.97 to 76.81, P = 0.001). Considering the type of clinical reasoning question, the mean of CRP (23.28 to 30.23, P = 0.001) and KF (18.61 to 22.90, P = 0.005) scores showed a statistically significant increase in the posttest compared with the pretest examination [Table 1]. The mean puzzle scores (6.64 to 7.52) and SC scores (15.42 to 16.14) also increased, but these improvements were not statistically significant (P = 0.401 and P = 0.566, respectively).

Discussion

Clinical reasoning is a mental process required to prioritize, confirm, or refute the diagnosis or management plans based on the patient's data for a clinical case.[13,14] The present study evaluated the possible improvement of clinical reasoning ability of 21 committed medical students through the CBCR approach via 10 sessions of an online course. To reveal any improvement, we took a pretest and posttest, which comprised four types of standardized questions. From comparing the results of these tests, score progression was found in each type, which in CRP and KF was compelling. Finally, the comparison of total scores, beyond a shadow of a doubt, demonstrated the CBCR's effectiveness in medical education.

In the field of teaching clinical reasoning, abundant studies implemented a variety of methods. Regarding the way of presenting the clinical problems to the students, two main categories have been introduced: serial cues (gradually providing the information about the patients to the students starting with a chief complaint) and whole case (providing the information about the patients to the students at once).[6] As introduced, we used the serial cue way. Similar to our study, Keenmink *et al*. also hold a serial cue CBCR course in nine sessions. The students were divided into small groups, and in each session, a case was presented in standard format (history taking, physical examination, differential diagnosis, testing, and management); finally, they revealed that the CBCR course could enhance illness script richness and diagnostic performance, which could represent the clinical reasoning skill to some extent.[12]

Table 1: Comparison of the pretest and posttest examination of clinical reasoning scores

Question type	Pretest (mean±SD)	Posttest (mean±SD)	*P*
CRP	23.28±4.10	30.23±6.84	0.001
SC	15.42±4.20	16.14±3.17	0.566
KF	18.61±4.30	22.90±4.61	0.005
Puzzle	6.64±3.82	7.52±2.37	0.401
Total clinical reasoning score	63.97±8.33	76.81±10.77	0.001

CRP=Clinical reasoning problem, SC=Script concordance, KF=Key features, Wilcoxon test was used to compare pretest and posttest scores

In a randomized controlled trial by Moghadami *et al*., the impact of an educational intervention using the illness script method on the clinical reasoning skills of fourth-year medical students was measured. They compared posttest and pretest scores in the intervention (education of three diseases by illness script method) and control group (traditional lecture about three same diseases) and observed that posttest scores were significantly higher in the intervention group than in the control group and also than the pretest scores. Similar to our study, they compared pretest and posttest scores using script SC questions to assess clinical reasoning; however, they also compared the scores with a control group for better evaluation of the intervention.[15] Several other studies have also evaluated the effects of the illness script method in teaching clinical reasoning on improving clinical reasoning among medical students using CRP and KF questions.[13,16] In addition to the former traditional methods of teaching medicine, online and Web-based courses[17] have also been implemented.

Web-based and online courses have recently been at the center of attention, especially after the coronavirus disease 2019 (COVID-19) outbreak.[18] In the field of teaching clinical reasoning, Web-based teaching has been evaluated in previous studies.[19,20] Raupach *et al*. in 2007 or 2008 conducted a 6-week course on 148 fourth-year medical students. They divided students into two groups: Web-based and face-to-face groups. In each group, students discussed the differential diagnosis of dyspnea under the supervision of a teacher; finally, they compared the clinical reasoning skills of the students by KF examination and concluded that Web-based and traditional problem-based learning is as effective as each other.[17] Similar to our study, they showed the efficacy of Web-based clinical reasoning teaching and they also conducted a serial cue format of teaching however despite the present study which held online classes they used a Web-based module which has been completed by students on different days. In addition, to implement an appropriate teaching method of clinical reasoning, the way of assessment of this method is equally important.

The assessment of clinical reasoning could be performed in several ways. Keemink *et al*. assessed illness script richness, which could be considered an indicator of clinical reasoning after conducting CBCR courses for second-year medical students.[12] Performing standard examinations to assess the clinical reasoning abilities of the students is also a common way. Moghadami *et al*. used script concordance test (SCT) to evaluate clinical reasoning in medical students.[15] CRP-type questions

are also introduced as a reliable method for assessing clinical reasoning.[21] The KF-type questions have also been shown to be valid and reliable in assessing clinical reasoning.[22] We used the combination of these question types and puzzle questions to evaluate clinical reasoning among medical students as this type of examination is the standard format implemented in the National Clinical Reasoning Olympiad examinations in Iran.

Our study has three noticeable strengths; first, we utilized a constructed CBCR method, which was from a standardized curriculum and could be considered a unique intervention.[23] Second, our tests were comprehensive tools for the evaluation of participants, since they comprised different standardized types of questions that are needed for an accurate and conclusive evaluation.[24] Lastly, our study sample included medical students who were committed and have the goal of qualifying for the National Clinical Reasoning Olympiad. This factor attenuates the response bias, especially in terms of careless responses.[25]

However, several limitations of the current study need to be acknowledged. Due to concurrent COVID-19 epidemic waves, we had to apply for the online course in our study. Online-based learning has several weaknesses that may impact the effectiveness of the learning process. These include low computer literacy among students, poor time management skills, and limited interaction between participants and instructors due to low levels of student synergy. These shortcomings can possibly affect the learning outcomes of CBCR, which further necessitates an evaluation of online and in-person classes for comparison. Though the participants in our study may have participated in other concurrent educational courses, the study might suffer from diffusion bias. Finally, this study only examined the knowledge content of the student's competency toward clinical reasoning and practice-based learning and improvement or professionalism, and other components of the student's Accreditation Council for Graduate Medical Education core competencies, which are needed in real workplace settings, were not examined. The present brief report revealed that the application of the CBCR approach to medical students improved their total clinical reasoning scores. The impact of this improvement on the enhancement of clinical reasoning skills in real medical practice is yet to be identified; however, the application of CBCR in the curriculum of undergraduate medical students seems to be beneficial for the improvement of clinical reasoning.

Conclusion

The present brief report introduced a teaching course of case-based method in clinical reasoning to medical students and revealed improvement in the total clinical reasoning score of these students after participating in the course. This study serves as a baseline for which improvements can be directed and further studies are required to evaluate the proposed method of this study in the workplace.

Acknowledgment

The authors would like to thank the Clinical Research Development Unit of Imam Hossein Hospital, Tehran, Iran, and the Exceptional Talents Development Center of Shahid Beheshti University of Medical Sciences, Tehran, Iran, for their kind support of this project.

Supplementary Materials

An example of a clinical reasoning problem, script concordance, key features, and puzzle questions is shown in Boxes 1, 2, 3, and 4, respectively.

Financial support and sponsorship

This work was supported by the Research Council of Shahid Beheshti University of Medical Sciences under grant number 309.98.05.22.

Conflicts of interest

There are no conflicts of interest.

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Supplementary Materials

Box 1: Clinical reasoning problem

A 35-year-old man comes to the office due to moderate hemoptysis that started a week ago. Fever, night sweats, and significant weight loss are found over the past month. He has a past medical history of chronic sinusitis. His father has pulmonary tuberculosis. His blood pressure is $160/100_{mmHg}$, and his pulse rate is $120_{/min}$. Lung auscultation reveals bilateral basilar rhonchi. A cavitary lesion in the apex of the right lung and two round lesions in the left lung field are seen on the chest X-ray. Laboratory data include sputum stain for tuberculosis=negative Wight blood cells count=$35000/_{\mu L}$

Erythrocyte sedimentation rate=110mm/hour Serum creatinine=2.1mg/dL

Urine analysis=normal

1. Which is the most probable diagnosis?

1. Lung cancer	2. Pulmonary tuberculosis	3. Granulomatosis with polyangiitis
4. Hydatid cyst	5. Lung abscess	6. Lymphangitic carcinomatosis

2. Choose five findings and determine whether each one is compatible with or against your diagnosis (use+or -, respectively).

1. A 35-year-old man	2. Hemoptysis	3. Recent weight loss
4. The history of sinusitis	5. Fever and night sweats	6. WBC count=$35000/_{\mu L}$
7. ESR=$110_{mm/hour}$	8. Serum creatinine=$2.1_{mg/dL}$	9. Urine analysis=normal
10. Sputum stain for tuberculosis=negative	11. The cavitary lesion of the lung apex	12. The history of pulmonary TB in his father

3. If your diagnosis is ruled out, what is your next probable diagnosis?

1. Lung cancer	2. Pulmonary tuberculosis	3. Granulomatosis with polyangiitis
4. Hydatid cyst	5. Lung abscess	6. Lymphangitic carcinomatosis

4. Choose five findings and determine whether each one is compatible with or against your second diagnosis (use+or -, respectively).

1. A 35-year-old man	2. Hemoptysis	3. Recent weight loss
4. The history of sinusitis	5. Fever and night sweats	6. WBC count=$35000/_{\mu L}$
7. ESR=$110_{mm/hour}$	8. Serum creatinine=$2.1_{mg/dL}$	9. Urine analysis=normal
10. Sputum stain for Tuberculosis=negative	11. The cavitary lesion of the lung apex	12. The history of pulmonary TB in his father

Box 2: Script concordance

A 70-year-old man with a past medical history of atrial fibrillation presents with acute-onset nausea and vomiting;

	If you are thinking of	Then you find	Your hypothesis becomes*				
A	Digoxin intoxication	Serum potassium=3.9	2	-1	0	+1	+2
B	Mesenteric ischemia	INR=2.5	-2	-1	0	+1	+2
C	Peptic ulcer	A drug history of warfarin	-2	-1	0	+1	+2

*2=ruled out or almost ruled out; -1=less probable; 0=neither more nor less probable; +1=more probable; +2=certain or almost certain

Box 3: Key feature

A 65-year-old man with a past medical history of hepatitis B for the past 15 years presents to the emergency department with hematemesis and dizziness. His temperature is 36.8°C, blood pressure is $80/55_{mmHg}$, pulse rate is $125/_{min}$, and respiratory rate is $24/_{min}$. Physical examinations show generalized icterus, severe ascites, and peripheral edema. Which are the four options of the highest priority to perform or prescribe?

1- Propranolol	9- Electrocardiogram
2- Lamivudine	10- Upper gastrointestinal endoscopy
3- Ceftriaxone	11- Transjugular intrahepatic portosystemic shunt
4- Erythromycin	12-Airway evaluation
5- Furosemide	13- NG tube insertion
6- Albumin	14- Paracentesis
7- Lactulose	15- Viral markers evaluation
8- Hepatic ultrasound	16- Serum bilirubin

Box 4: Puzzle

Item A	
1	A 36-year-old woman with asthma for the past 4 years presents with dyspnea and dark sputum.
2	A 59-year-old man with a past medical history of COPD deals with his new exacerbation of dyspnea.
3	A 35-year-old woman who is a known case for AML presents with acute dyspnea.
4	A 27-year-old smoker man presents with acute-onset chest pain and dyspnea.

Item B	
5	Lung auscultation reveals rhonchi.
6	Normal bronchovesicular sounds are heard.
7	Attenuated pulmonary sounds are found on the left hemithorax.
8	The right lower lobe of the right lung is weak on auscultation.

Item C	
9	Chest CT scan: interstitial infiltration
10	Chest CT scan: bilateral right upper lobe infiltration + bronchiectatic changes
11	Chest X-ray: lobar infiltration
12	Chest X-ray: pleural edge

Item D	
13	100% O_2 with a simple mask
14	Cytoreduction
15	Intranasal corticosteroids and prophylactic itraconazole
16	Antibiotic