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Diagnostic grand rounds: A new teaching concept to train diagnostic reasoning

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ABSTRACT

Introduction: Diagnostic reasoning is a core skill in teaching and learning in undergraduate curricula. Diagnostic grand rounds (DGRs) as a subform of grand rounds are intended to train the students' skills in the selection of appropriate tests and in the interpretation of test results. The aim of this study was to test DGRs for their ability to improve diagnostic reasoning by using a pre–post-test design.
Methods: During one winter term, all 398 fifth-year students (36.1% male, 63.9% female) solved 23 clinical cases presented in 8 DGRs. In an online questionnaire, a Diagnostic Thinking Inventory (DTI) with 41 items was evaluated for flexibility in thinking and structure of knowledge in memory. Results were correlated with those from a summative multiple-choice knowledge test and of the learning objectives in a logbook.
Results: The students' DTI scores in the post-test were significantly higher than those reported in the pre-test. DTI scores at either testing time did not correlate with medical knowledge as assessed by a multiple-choice knowledge test. Abilities acquired during clinical clerkships as documented in a logbook could only account for a small proportion of the increase in the flexibility subscale score. This effect still remained significant after accounting for potential confounders.
Conclusion: Establishing DGRs proofed to be an effective way of successfully improving both students' diagnostic reasoning and the ability to select the appropriate test method in routine clinical practice.

1. Introduction

Diagnostic reasoning (i.e. clinical reasoning, clinical decision making, or medical problem solving) has been described as "the cognitive process that is necessary to evaluate and manage a patient's medical problem" [1]. Its theoretical basis has been studied over the past 30 years and progress has been substantial [2]. It has been argued that both deliberating practice with multiple examples and feedback is central for the acquisition of expertise [3]. These two factors should facilitate the effective transfer of basic concepts and ensure an adequate experiential knowledge base [3].

In general, teaching as the art and science of diagnostic reasoning has been addressed through a multitude of different techniques and approaches. For small groups of students, standardized patients, and problem- and case-based techniques have been applied [4,5]. Furthermore, based on research on how doctors reason, direct expert–student interactions have been used and various educational strategies have been recommended to promote clinical diagnostic reasoning [6]. Besides these techniques, grand rounds (GR) – focusing on integration and multiprofessional interaction – have been used as an instrument to teach large groups of attendees [7,8]. During GRs, medical experts from various disciplines introduce and discuss a given case in order to improve the clinical skills of practising physicians [7]. A variety of subforms of GRs have been described for certain medical disciplines as well as for undergraduate student education [9–12]. Among them are diagnostic grand rounds (DGRs) which use the multiprofessional interaction and integration of grand rounds not only to teach diagnostic tests but also to train diagnostic reasoning [9].

In this study we tested DGRs for their ability to improve diagnostic reasoning. We used a pre–post-test design to evaluate the students' progress in diagnostic reasoning.

2. Materials and methods

2.1. Participants and procedure

During the academic year 2006–2007, all 398 fifth-year students (36.1% male, 63.9% female) attended DGRs every second week

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for 1.5 h. In 8 DGRs, 23 clinical cases were presented throughout the winter term 2006. Goals to be achieved were to improve the students' knowledge about test methods and their skills to select the appropriate test and interpret its results. Each DGR was coordinated and moderated by a full professor and cases were presented and discussed by experts representing the major diagnostic disciplines (radiology, nuclear medicine, laboratory medicine, pathology, microbiology, and virology). Additional to the interactive discussions, students were asked to provide their suspected diagnosis, indicate their diagnosis on an allocation form, and decide on the next diagnostic step. The solution was then presented and explained by different experts so that the students got immediate feedback on their given diagnosis. Occasionally, patients were invited to tell their stories and real medical apparatuses were demonstrated live during DGRs (e.g., incident light microscopy in dermatology).

2.2. Measures

2.2.1. Diagnostic Thinking Inventory (DTI)

After attending the first DGR unit, students were contacted by e-mail and were asked to fill out an online questionnaire. Two weeks later, a reminder was sent out to students who had not yet responded. At the end of term, students were again asked to fill in the questionnaire, after which individualized feedback about test scores was provided. After two weeks a reminder was sent out. We used a key method to control multiple participations: A unique key was sent with each e-mail study invitation. When students initially accessed the online questionnaire their individual key was stored. Thus, repeat participation was avoided to ensure data quality.

The DTI consists of 41 items (sample items in Table 1) designed to measure two aspects of diagnostic thinking: (1) the degree of flexibility in thinking (20 items) and (2) the degree to which knowledge in memory is structured (21 items) [13–18]. Each item of the DTI consists of a question stem and a rating scale. The rating scale consists of 6 boxes with opposing statements at either end. Respondents have to check the box that best describes their position on the continuum between the two opposing statements. Flexibility in thinking refers to a trait that is beneficial in determining the right diagnosis during the diagnostic process. Structure in memory refers to the availability of knowledge stored in memory during the diagnostic process and assumes that availability is a direct consequence of adequate organization of knowledge. Different thinking processes and a more highly structured medical knowledge base are the characteristics of advanced diagnostic reasoning [19]. Two researchers (AP, SS) developed the German version of the English DTI, using the parallel blind technique [20].

Table 1
Sample items.

Flexibility in Thinking subscale of the DTI:	4. When I am interviewing a patient: I often seem to have a fixed idea in my mind about what might be wrong I usually find it easy to explore various possible diagnoses
Structure of Knowledge in Memory subscale of the DTI:	13. When I am collecting information about a patient: The individual units of information usually seem to group themselves in my mind I am often unable to see how the units of information relate to each other
Multiple-choice knowledge test:	The best radiological method to verify a meniscus rupture of the knee is: A: X-rays B: Ultrasonography C: CT D: MRT E: Scintigraphy

2.2.2. Summative multiple-choice knowledge test

The test was administered at the end of the academic year and consisted of a random set of multiple-choice questions drawn from a pool. Each question was validated and approved by a review committee. The multiple-choice knowledge test for fifth-year students was performed at the end of the fourth year, before the students entered clinical clerkships. The test consisted of 125 multiple-choice questions, each with 5 possible answers, and only one correct choice per question (sample item see Table 1). Cronbach's α of multiple-choice knowledge tests are around 0.90.

2.2.3. Diagnostic learning objectives in the logbook

The students continuously follow a logbook with predefined learning objectives and predefined skill levels, which are attested by the teachers when satisfactorily fulfilled by students. Each student has to accomplish a certain number of learning objectives related to diagnosis. The number of achieved learning objectives relating to diagnosis during the 4-month time period ranged from 4 to 47 (differences were due to variations during clerkship in the scheduled rotations through different wards).

2.3. Statistical analysis

DTI scores were calculated by assigning numbers (1–6) to the checkboxes. Means and standard deviations (S.D.) were calculated for both the total score and the two subscale scores flexibility and structure. Internal consistency was assessed by Cronbach's α. Pre- and post-test score differences were assessed by dependent T-test. Effect sizes were assessed by Cohen's D [21]. In the social and behavioural sciences, D-based effect sizes around 0.20 or lower are considered as small, around 0.50 as medium, and around 0.80 or higher as large. Associations between DTI scores and knowledge test scores, as well as the number of achieved learning objectives pertaining to diagnosis recorded in the logbook were assessed using Pearson's correlation coefficient. The influence of the knowledge test scores on the DTI was assessed by linear regression. A five percent significance level was used for all tests.

3. Results

3.1. Response rate, sample representativeness, and reliability

In the pre-test, the response rate (students accessed the first page of the online questionnaire) was 81.7% and the attrition rate (students dropped out before the end) was 19.7%. In the post-test, the response rate was 34.9% (65.5% of these students had also responded to the pre-test) and the attrition rate was 18.7%. The majority of students who completed both tests were female (pre-test: 61.1%, post-test: 60.0%). There were no differences between responders and non-responders regarding sex (χ^2[1] = 1.70, P = 0.190) and scores in the students' multiple-choice test (summative assessment examination; T[422] = 0.456, P = 0.649). Internal consistency of the DTI, as measured by Cronbach's α, was satisfactory, amounting to 0.72 for the flexibility subscale, 0.85 for the structure subscale and 0.88 for the total score.

3.2. Pre- versus post-test comparison

The total score, the structure subscale score, and the flexibility subscale score of the DTI were significantly higher after 4 months

Table 2
Mean scores of the Diagnostic Thinking Inventory in the pre- and post-test and results of a dependent *T*-test.

	Pre-test Mean	Post-test Mean	*T* (94)	*P*	*D*
Flexibility	84.5	89.1	−6.26	<0.001	0.64
Structure	80.6	87.3	−8.42	<0.001	0.86
Total score	165.1	176.4	−8.71	<0.001	0.89

D = Cohen's *D* effect size.

Table 3
Correlation between pre- and post-test difference scores of the Diagnostic Thinking Inventory, and the number of learning objectives regarding diagnosis that were achieved during clinical clerkships.

	Mean	*r*	*P*
Difference, flexibility	5.3	0.23	<0.05
Difference, structure	7.7	−0.02	ns
Difference, total score	13.0	0.12	ns

ns = not significant.

Table 4
Correlation between scores on the Diagnostic Thinking Inventory and the multiple-choice knowledge test.

	Pre-test	*P*	Post-test	*P*
Flexibility	−0.01	ns	0.01	ns
Structure	−0.06	ns	−0.12	ns
Total score	−0.04	ns	−0.07	ns

ns = not significant.

of DGR attendance (Table 2). Cohen's *D* effect sizes were medium to large.

3.3. Influence of achieved diagnostic learning objectives from logbook on the DTI scores

The differences between pre- and post-test values were calculated for the total score, the flexibility subscale, and the structure subscale. These difference scores were correlated with the number of achieved learning objectives in the logbook concerning diagnosis. Only the flexibility subscale was significantly but weakly correlated with the number of achieved learning objectives (Table 3).

3.4. Correlation with multiple-choice knowledge test

For both the pre- and post-test, correlations of the DTI scores with the multiple-choice knowledge test score were all non-significant (Table 4). A linear regression revealed that DTI scores which were higher in the post-test than in the pre-test could not be explained by higher scores on the multiple-choice knowledge test ($\beta = -0.14$, $T = -1.47$, $P > 0.05$).

4. Discussion

Attending DGRs lead to a significant increase in the students' ability of diagnostic reasoning. This increase was independent from other factors, such as the students medical knowledge assessed through a multiple choice knowledge test and acquired diagnostic relevant learning objectives in clinical clerkships recorded in the students' logbooks. Compared to the pre-test score, Students on average scored 11.3 points higher on the post-test DTI score after four months of attending DGRs. Beullens and colleagues registered an average increase of 4 points in DTI total scores after two months of 70 problem-solving clinical seminars in which students acquired clinical reasoning skills [14]. These results are less pronounced than the increase in all scores registered in the present study with a time frame of four months in which the students dealt with 23 clinical cases. The attendance of DGRs led to an improved ability to make the right diagnosis by means of greater flexibility in thinking as well as restructuring knowledge in memory.

The strengths of this study were the implementation of a pre–post-test design based on a large sample by using the DTI as an already well-established robust and reliable measure. Moreover, we used additional data (achieved logbook learning objectives, score of multiple-choice knowledge test) to exclude other possible explanations potentially accounting for the found effect in the improvement of diagnostic reasoning. Only the flexibility subscale showed a significant, but weak, positive correlation (0.23) with the number of achieved learning objectives regarding diagnosis during the clinical clerkships. Thus, the real encounters with patients also influenced flexibility in thinking, but only to a minor degree. Furthermore diagnostic thinking is supposed to be independent of medical knowledge. This independence is one of the major advantages of the DTI [13]. The effect we found was independent of actual medical knowledge as measured by a multiple-choice test. High scores on the multiple-choice knowledge test did not predict higher scores on the post-test DTI.

The results were weakened by the fact that only with an experimental design the found effect could be attributed solely and exclusively to the intervention, which was in our case teaching students with DGRs. We tried to use Erasmus students as a control group but were unsuccessful in recruiting a sample size big enough to reach the required statistical power to refute our null hypothesis.

5. Conclusion

Although grand rounds are sometimes called into question because of their educational value we think that they are still of value for educational reasons especially because of the integration and multiprofessional interaction that they provide [22]. As we could show, diagnostic reasoning improved significantly during a 4-month period when students attended DGRs. During DGRs the students dealt with a total of 23 clinical cases, occasionally with the patients' presence and with a live demonstration in the auditorium. The students experienced the entire process of finding the right diagnosis of a given case within a very short period of time, presented by different clinical experts. They could observe different diagnostic methods (e.g., X-rays, diagnostic blood findings, histological sections and multi-slice CT), entire medical apparatuses and several other exhibits. DGRs were also recorded and broadcasted live on the Internet for students in teaching hospitals. DGRs focused on teaching students how to find the right diagnosis by ruling out other potential diagnoses and they were less focused on teaching medical diagnosis.

DGRs are an effective new way of teaching both knowledge of diagnostic tests in order to select the appropriate test method in routine clinical practice and the ability of diagnostic reasoning. Another advantage of DGRs is that they can be applied to large groups of students in lecture halls without getting the touch of lectures. DGRs are interdisciplinary and interactive and can be successfully implemented in any modern reformed curriculum.

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References

[1] Barrows HS, Tamblyn RM. Problem based learning: an approach to medical education. New York: Springer; 1980.

[2] Round A. Introduction to clinical reasoning. J Eval Clin Pract 2001;7(2):109–17.
[3] Norman G. Research in clinical reasoning: past history and current trends. Med Educ 2005;39:418–27.
[4] Shawler C. Standardized Patients: a creative teaching strategy for psychiatric–mental health nurse practitioner students. J Nurs Educ 2008;47: 528–31.
[5] Banbassat J, Baumal R, Heyman SN, Brezis M. Viewpoint: suggestions for a shift in teaching clinical skills to medical students: the reflective clinical examination. Acad Med 2005;80:1121–6.
[6] Bowen JL. Educational strategies to promote clinical diagnostic reasoning. N Engl J Med 2006;355:2217–25.
[7] Hull AL, Cullen RJ, Hekelman FP. A retrospective analysis of grand rounds in continuing medical education. J Contin Educ Health Prof 1989;9:257–66.
[8] Stobo JD, Murphy PA. Medical grand rounds at Hopkins [editorial]. JAMA 1989;261:3164.
[9] Praschinger A, Stieger S, Kainberger F. Diagnostic grand rounds in undergraduate medical education. Med Educ 2006;41:1107–8.
[10] Ablon SL. Psychiatry grand rounds. Am J Nurs 2008;108:49.
[11] Allen M, Mann K, Kells C, Ferrier S, O'Connor N, MacDonald P. Cardiology grand rounds: effect of videoconferencing on educational value. J Telemed Telecare 2007;13:136–41.
[12] Jolly B, Hopingkong H. Independent learning—an exploration of student grand rounds. Med Educ 1991;25:334–42.
[13] Bordage G, Grant J, Marsden P. Quantitative assessment of diagnostic ability. Med Educ 1990;24:413–25.
[14] Beullens J, Struyf E, Van Damme B. Diagnostic ability in relation to clinical seminars and extended-matching questions examinations. Med Educ 2006;40:1173–9.
[15] Groves M. Problem-based learning and learning approach: is there a relationship? Adv Health Sci Educ 2005;10:315–26.
[16] Groves M, Scott I, Alexander H. Assessing clinical reasoning: a method to monitor its development in a PBL curriculum. Med Teach 2002;24:507–15.
[17] Jones UF. The reliability and validity of the Bordage Grant & Marsden diagnostic thinking inventory for use with physiotherapists. Med Teach 1997;19: 133–40.
[18] Sobral DT. Medical students' mindset for reflective learning: a revalidation study of the reflection-in-learning scale. Adv Health Sci Educ 2005;10:303–14.
[19] Patel VL, Kaufman DR, Arocha JF. Emerging paradigms of cognition in medical decision-making. J Biomed Inform 2002;35:52–75.
[20] Behling O, Law KS. Translating questionnaires and other research instruments: problems and solutions. Thousand Oaks, CA: Sage; 2002.
[21] Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Erlbaum; 1988.
[22] Heberts RS, Wright SM. Re-examining the value of medical grand rounds. Acad Med 2003;78:1248–52.

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