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Computer-assisted medical image examination as a complementary exam concerning initial clinical studies.

Examen de imágenes médicas asistido por computadora como examen complementario a los estudios clínicos iniciales.

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Abstract.

Introduction. The evaluation of medical students during the medical course can have different types of examinations, including written and practical exams. Computer-assisted evaluation has been made available by widely available technology. **Methods.** We devised a computer-assisted online medical image examination to stand as a complementary exam in a Medical School examination concerning initial clinical studies. The exam was in the multiple-choice format, showing for each question a list of 5 diagnoses, one of which to be chosen, attempting at eliciting fast visual pattern recognition. The exam was carried out by using Moodle software. Non on-site exams were controlled with simultaneous face monitoring by using the Zoom software. The exam included physical examination findings, electrocardiograms, chest X-rays and CT scan, as well as neurologic disease findings. **Results.** The exam was completed by 264 students, out of 273 enrolled students. The average grade was 15.4 (standard deviation of 2.9) /20, with a range of 6.7-20.0. A total of 9 students received a rating under 10/20. Two students experienced technical difficulties and quit the exam, later replaced by a practical clinical additional exam. **Conclusions.** Computer-assisted evaluation has been made available by widely available technology. We devised a computer-assisted online medical image examination to stand as a complementary exam in a Medical School examination concerning initial clinical studies. This exam deals with a real and relevant problem: the importance of visual diagnostics in Medicine. It aims at stimulating a different way of thinking, when compared to written tests. Given the easy availability of this type of medical image online exam, alternatives using written text to question about medical images are called into question.

Keywords: medical education; medical image; examination; clinical studies; online

Resumen.

Introducción. La evaluación de los estudiantes de medicina durante la carrera puede incluir diferentes tipos de exámenes, incluyendo exámenes escritos y prácticos. La evaluación asistida por computadora se ha hecho disponible gracias a la amplia disponibilidad de tecnología. **Métodos.** Diseñamos un examen de imagen médica en línea asistido por computadora como examen complementario en un examen de la Facultad de Medicina sobre estudios clínicos iniciales. El examen fue de opción múltiple, mostrando para cada pregunta una lista de 5 diagnósticos, uno de los cuales debía elegirse, buscando obtener un rápido reconocimiento visual de patrones. El examen se realizó mediante el software Moodle. Los exámenes no presenciales se controlaron con monitoreo facial simultáneo mediante el software Zoom. El examen incluyó hallazgos de la exploración física, electrocardiogramas, radiografías de tórax y tomografía computarizada, así como hallazgos de enfermedades neurológicas. **Resultados.** El examen fue completado por 264

estudiantes, de un total de 273 matriculados. La calificación promedio fue de 15.4 (desviación estándar de 2.9) / 20, con un rango de 6.7-20.0. Un total de 9 estudiantes obtuvieron una calificación inferior a 10/20. Dos estudiantes experimentaron dificultades técnicas y abandonaron el examen, que posteriormente fue reemplazado por un examen clínico práctico adicional. **Conclusiones.** La evaluación asistida por computadora se ha vuelto accesible gracias a la amplia disponibilidad de tecnología. Diseñamos un examen de imágenes médicas en línea asistido por computadora para que sirviera como examen complementario en un examen de la Facultad de Medicina sobre estudios clínicos iniciales. Este examen aborda un problema real y relevante: la importancia del diagnóstico visual en Medicina. Su objetivo es estimular una forma de pensar diferente, en comparación con las pruebas escritas. Dada la fácil disponibilidad de este tipo de examen de imágenes médicas en línea, se cuestionan las alternativas que utilizan texto escrito para preguntar sobre imágenes médicas.

Palabras clave: educación médica; imagen médica; examen; estudios clínicos; en línea

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1. Introduction.

The evaluation of medical students during the medical course can have different types of examinations, including written and practical exams. The development, in recent years, of technology allowing computer-assisted evaluation has been an important change in the available instruments for the evaluation of students (1). This type of technological advances has made it possible for students to be evaluated using online exams, taken either on-site or elsewhere. Medical image is of the utmost importance in Medicine, including the observation of cutaneous changes and body habitus, among other findings, a practice known as inspection. Medical images in areas such as radiology, cardiology and several others are currently a mainstay of medical diagnosis.

The evaluation of medical students with direct observation of images, rather than the description of the same images, seems to be a reasonable approach. This has now been made not only possible but also easy, even if the hundreds of students are to be evaluated simultaneously.

We report on our experience with a medical image exam in a curricular unit involving initial clinical studies, as a complementary method to a formal onsite written theoretical examination.

The medical image exam is followed by a written one, and they were constructed in such a way as to aim at possibly using different modes of thought. The written exam involves the slow, deliberate, effortful, and analytical way of thinking (2), whereas the medical image exam aimed at stimulating the fast, visual, pattern recognition type of cognition. Since the two exams were carried out with a five week interval (online image exam first), no attempt was made to compare the results of the two exams. This report deals only with the online exam.

2. Methods

The teaching topics for the curricular unit of Medical Propaedeutic are shown in table 1. This curricular unit is followed, in our medical studies, by Surgical Propaedeutic, and therefore it does not deal with abdominal issues. The recommended reading includes current editions of Harrisonś Principles of Internal Medicine, Bates' Guide to Physical Examination and History Taking, and the online encyclopedia UpToDate.

The assessment of medical students in our curricular unit of Medical Propaedeutic involves both a practical and a theoretical evaluation. The practical evaluation is carried out by the completion of a mandatory list of medical gestures (including blood pressure and other vital signs

measurement, peripheral pulse examination, cardiac and pulmonary auscultation, cranial nerve examination, thyroid examination, jugular venous pressure measurement, among others).

Table 1. List of teaching topics for the curricular unit of Medical Propaedeutic.

General	Cardiac	Pulmonary
Introduction to Clinical Medicine, including philosophical basis of diagnosis.	Cardiac examination	Pulmonary examination
Clinical History	Chest pain	Obstructive lung disease
Vital signs	Dyspnea	Restrictive lung disease
Physical examination	Edema	Chest X ray
Fever	Heart failure	**Infectious diseases**
Systemic diseases evaluation	Arterial hypertension	Hospital-acquired infection
Acid-base disorders	Clinical Electrocardiography	Respiratory infection
Oncology	**Rheumatology**	Neurology/Psychiatry
Solid tumors evaluation	Rheumathology examination	Mental state evaluation
Geriatrics		Neurological examination
Geriatric clinical evaluation		

The theoretical evaluation was carried out by a written formal multiple-choice exam (60 questions, 70 minutes), with 85% weight in the final grade (minimum of 9.5/20 to pass), and by a computer-assisted medical evaluation, involving medical images (15 images, 16 minutes), with a 15% weight in the final grade. The written exam covered the topics shown in Table 1. The medical image exam showed images listed in table 2.

Table 2. List of images used in the online examination, with the results (264 students).

Images	Correct answers, n(%)
Chest x-ray – pulmonary tuberculosis	133 (50.4)
Hands – rheumatoid arthritis	167 (63.3)
Tongue – central cyanosis	111 (42.0)
Face – periorbital edema	126 (47.7)
Face - xanthelasma	263 (99.6)
Pulsus alternans (tracing)	234 (88.6)
Tongue - right hypoglossal nerve palsy	261 (98.9)
Visual fields - lesion of the optic chiasm - bitemporal hemianopsia	198 (75.0)
Chest computerized tomography – pulmonary embolus	218 (82.6)
Face - “butterfly wing” erythema, systemic lupus erythematosus	262 (99.2)
Neck – increased jugular venous pressure	258 (97.7)
Chest x-ray – pleural effusion	191 (72.3)
Eyes – third cranial nerve palsy	234 (88.6)
Electrocardiogram – normal tracing	251 (95.1)
Electrocardiogram – left bundle branch block	135 (51.1)

In every case, a simple list of five diagnoses was presented, to choose one. Examples of medical image exam questions are shown in table 3.

Table 3. Examples of medical image exam questions.

Tongue, central cyanosis. Image available at: https://www.nejm.org/doi.org//abs/10.1056/NEJMicm2304082 (left image) Question. Please indicate the most probable diagnosis: a) central cyanosis. b) Raynaud's phenomenon. c) peripheral vasoconstriction. d) telangiectasias. e) Herpes simplex.
Face, periorbital edema. Image available at https://www.nejm.org/doi.org//abs/10.1056/NEJMicm2210861 (left image) Question. Please indicate the most probable diagnosis: a) Sjögren syndrome. b) Huntington's disease. c) Graves's disease. d) Trousseau's sign. e) periorbital edema.

The medical image exam was carried out by using Moodle software, with a multiple-choice format. Questions and paragraphs were presented in a random way to each student. The software was programmed to open and close the test automatically at the defined timing, and could be accessed anywhere in the world following personal validation (therefore including the Portuguese Atlantic islands).

Students could perform the exam on-site or elsewhere, in this latter case with simultaneous face imaging by using the Colibri-Zoom software. The exam staff had a separate control room with four separate virtual rooms, and two examiners per virtual room. The examiners task was to check the attitude of each individual student, and to check if any facial image would disappear (which would lead the test to be null). Students taking the onsite exam were not required to use the Colibri-Zoom software (in fact, video cameras were not even available).

Date were anonymized and inserted in a Microsoft Excel file. Numerical calculations were made either in Excel or using SPSS Statistics software, version 30.

This report was authorized by the Medical Course Director and by the Ethics Committee of our medical school.

3. Results

Out of a total number of 273 enrolled students, 266 took the online exam and 264 finished it. The average grade was 15.4 (standard deviation of 2.9) /20, with a range of 6.7-20.0. A total of 9 students received a rating under 10/20. Two students experienced technical difficulties and quit the exam, later replaced by a practical clinical additional exam. This exam consisted of an evaluation of

a patient with prominent physical findings within the major scope of the discipline – cardiac, pulmonary or neurologic diseases. Table 2 shows the number of correct answers for each question.

4. Discussion

As the saying goes, "a picture is worth a thousand words". When compared to written tests, it is clear that showing the actual medical images, including images concerning the inspection of the Human body, x-rays, computerized tomography exams and electrocardiograms, has the attribute of being more genuine, of reproducing in a direct way medical practice. The image exam is, in a sense, more realistic than a written exam – it captures and shows reality directly.

As it were, medical students, by means of this kind of exam, can escape from the cave, where written questions concerning images act as shadows, and come to full light, to use the well-known concept of Plato. Coming to full light, they must act – choosing the right diagnosis, in anticipation of their careers as medical doctors, during which they are expected to act, on behalf of their patients.

The online medical image exam now described is easy to carry out and has very limited costs. In recent years, Objective Structured Clinical Examinations have been carried out under virtual conditions (1), and virtual examinations have taken place in different contexts (3). A virtual exam in the context of Radiology as an individual station in the setting of Objective Structured Clinical Examinations has been described (4).

In the present report, not only does the virtual exam rely solely on images, but the structure of the exam may also be of interest. The online image exam was aimed at stimulating the fast, visual, pattern recognition type of cognition. The presented images corresponded to topics and, in some cases, directly to images shown in the classes, meaning that students were asked to identify images already seen or closely resembling images previously analyzed.

Role training and practice have been presented as mainstays for the reactive and quick medical reasoning (probably addressed in the online exam now described), as opposed to critical thinking, recognized as important for the reflective, deliberative, analytical and procedural medical reasoning (probably addressed in our written exam) (5).

Online methods useful for teaching and for carrying out examinations were made widely available shortly after the start of the recent pandemic. In many medical schools, a high degree of usage of these methods followed. However, the moment has come to try to refine the practical use of this type of methods, by changing from online versions of previously used methods to new methods not previously possible to perform (or at least not easily available).

The method now described is not without its own problems. The method does not evaluate physical examination skills. Only clinical images corresponding to inspection were used, as well as images from ancillary diagnostic tests, leaving out auscultation, palpation and percussion. These latter aspects were assessed in a separate practical evaluation, as mentioned above. The possibility of academic dishonesty (6) can never be ruled out. For that reason, the percentage of the overall grading given to this online exam was low, meaning that in most cases only a change of 1/20 in the final grade was due to the exam. Issues have been raised concerning online proctoring, including unjustified invalidation due to unstable internet connection, as well as privacy issues (7). For that reason, the possibility was offered to each student for the exam to be taken onsite, with no video footage and no internet connection problems (table 4).

Table 4. Some important issues concerning the online image evaluation exam.

Issue	Comment
Privacy problems with footage; internet connection problems	The alternative onsite exam solves this issue for those interested
Academic dishonesty	Impossible to fully discard, even with online proctoring; low percentage in final grade mitigates the importance of this possibility
Physical examination skills not assessed	An independent practical evaluation is mandatory
Time period allowed for each question	Can be adjusted to the stage in medical studies in which the exam is carried out – longer periods for earlier stages
Stimulation of the fast, visual, pattern recognition type of cognition	Different type of cognition evaluated, when compared to standard written tests.
Cost issues	Extremely limited costs, since most of the machinery is already available for other purposes

Limitations.

This report deals with a single exam in a single institution. The time period allowed for each question (one minute, with an extra minute at the end to review the exam) is probably excessive, but shorter periods of time would be more adequate for research settings and not for real world exams. Online exams may always not be completed due to technical reasons (two students in this series), and may be prone to attempts at cheating, even with image control (taking into account this possible objection, a low 15% value was given for this exam in the final grade). A discrepancy was seen with the results of the electrocardiogram questioning when compared to the remaining topics, possibly because one single lecture was given on this topic, unlike other topics, presented in lectures, seminars and practical classes (e.g. cardiac auscultation, pulmonary auscultation, neurological examination). The method now described, although considered sufficiently robust to be applied, needs, from a formal scientific standpoint, to be further studied. A comparison with other assessment methods could be considered in future studies, in order to confirm its reliability.

5. Conclusions

- Computer-assisted evaluation has been made available by widely available technology. We devised a computer-assisted online medical image examination to stand as a complementary exam in a Medical School examination concerning initial clinical studies.
- This exam deals with a real and relevant problem: the importance of visual diagnostics in Medicine. It aims at stimulating a different way of thinking, when compared to written tests.
- Given the easy availability of this type of medical image online exam, alternatives using written text to question about medical images are called into question.

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