

computed tomography and an incidental unruptured aneurysm on cerebral angiography. Magnetic resonance imaging may help to differentiate between acutely haemorrhagic aneurysms and the incidental unruptured aneurysms that occur in a patient with trauma. Patients with a haemorrhagic aneurysm need to be operated on as early as possible while those with an unruptured aneurysm should be operated on after they have recovered from the head injury.

Many causes exist of collapse or brief loss of consciousness, which can lead to head injury. Myocardial infarction, cardiac arrhythmias, pulmonary embolism, transient ischaemic attacks, fainting, vasovagal episodes, hypoglycaemia, alcohol consumption, and epileptic seizures should be considered. Systemic examination and routine investigations would probably reveal one of these medical conditions, and a head injury would not conceal them. Subarachnoid haemorrhage and head injury, however, may look similar on computed tomography, and it may be difficult to distinguish one from the other. Lumbar puncture would probably show blood in patients who have either spontaneous or traumatic subarachnoid haemorrhage. More importantly, lumbar puncture may be dangerous in patients with trauma because of possible intracranial haematomas or contusions and an inhomogeneous increase of intracranial pressure; withdrawing cerebrospinal fluid may lead to tentorial herniation and compression of the brain stem.

It is of paramount importance, therefore, to pay extreme attention to detail in taking the medical history, especially from witnesses. Severe headache, neck stiffness, or photophobia that persist in a pattern disproportionate to the severity of the head injury should always be observed critically. Doctors should bear in mind the association between subarachnoid haemorrhage and trauma and use computed tomography more often in patients who may have subarach-

noid haemorrhage. If there is any doubt the history, clinical findings, and results of computed tomography of such patients should be discussed with neuroscientists. Discussion is particularly important because in undifferentiated cases in which investigations are incomplete, recurrent haemorrhages occur in about one third of patients within eight weeks.⁵ The common features in our cases are that all patients suffered a fall, the first two from high up; and all patients had external signs of injury and a fracture on radiography of the skull.

We suggest the following policy for assessing the likelihood of subarachnoid haemorrhage: if the circumstances of an injury are unclear, and a reasonable chance exists of a spontaneous cerebrovascular haemorrhagic event as a cause of the accident then a patient with trauma should have a computed tomography as soon as his or her systemic condition allows, regardless of the severity of the head injury. If the computed tomography shows features suggestive of possible spontaneous cerebral haemorrhage then the patient should have magnetic resonance imaging or cerebral angiography. High quality cerebral magnetic resonance angiography, which is increasingly available, may prove to be a suitable screening investigation for such patients.

- 1 Smith RR. Pathophysiology and clinical evaluation of subarachnoid hemorrhage. In: Youmans JR, ed. *Neurological surgery*. 2nd ed. Philadelphia: W B Saunders, 1982;1627-44.
- 2 Kassell NF, Torner JC, Haley EC Jr, Jane JA, Adams HP, Kongable GL, et al. The International cooperative study on the timing of aneurysm surgery. Part 1: overall management results. *J Neurosurg* 1990;73:18-36.
- 3 Stehbens WE. Aneurysms and anatomical variations of cerebral arteries. *Arch Pathol* 1963;75:45-64.
- 4 McCormick WF, Rosenfield DB. Massive brain hemorrhage. A review of 144 cases and an examination of their causes. *Stroke* 1973;4:946-54.
- 5 Pakarinen S. Incidence, aetiology, and prognosis of primary subarachnoid hemorrhage. *Acta Neurol Scand Suppl* 1967;29:1-128.

(Accepted 9 August 1994)

How To Do It

Set up and run an objective structured clinical exam

Colin Selby, Liesl Osman, Margery Davis, Michael Lee

Objective structured clinical exams are increasingly used as a way of assessing a range of clinical skills at both undergraduate and postgraduate level. To those planning to introduce such assessments, this article provides basic guidance on their development and structure and the personnel required. For those already using the assessments, our article may provide new ideas or be the impetus for an exchange of ideas. For those who are facing such formal assessment as candidates, we hope this article shows the efforts that are made to achieve the necessary structure and objectivity in this type of examination.

The objective structured clinical exam has come to prominence as a means of assessing undergraduate and postgraduate candidates.¹ Its basic structure is a circuit of assessment stations, where a range of practical clinical skills are assessed by an examiner using a previously determined, objective marking scheme.² This mechanism of assessment is at the "showing how" level of Miller's pyramid of knowledge.³ Compared with clinical "short cases"—where examination candidates see various patients at different times and are assessed by examiners who may not work to identical marking schemes and standards—the

objective structured clinical exam offers the advantages of uniform marking schemes for examiners and consistent examination scenarios for students. It has proved an appropriate means of assessment for the clinical skills now being emphasised in the medical undergraduate curriculum.^{4,5}

This article is designed to give some guidance, derived from our recent personal experience, to those planning to introduce such a type of assessment (box).

Steps in developing an objective structured clinical exam

- Determine skills to be examined
- How many skill assessment stations needed?
- Skill assessments
- Marking schemes
- Space for exam
- Personnel needed:
 - Examiners
 - Marshals and timekeepers
 - Patients or volunteers
- Arrangements on the day of exam
- Review outcome

Department of Medicine (RIE), University of Edinburgh, Royal Infirmary, Edinburgh EH3 9YW
Colin Selby, lecturer in medicine

Centre for Medical Education, University of Edinburgh, Edinburgh EH8 9DR
Liesl Osman, lecturer in medical education

Centre for Medical Education, Ninewells Hospital and Medical School, Dundee DD1 9SY
Margery Davis, senior lecturer in medical education

Clinical Pharmacology Unit, Department of Medicine (RIE), University of Edinburgh, Royal Infirmary, Edinburgh EH3 9YW
Michael Lee, professor

Correspondence to: Dr Selby.

BMJ 1995;310:1187-90

We also hope that this article may provide further ideas to those already using such assessments, and we welcome any comments or questions based on experience in other centres.

Determine skills to be examined

For both postgraduate and undergraduate assessments, the competencies being examined must be clear. For example, an assessment early in a clinical undergraduate course may be concerned solely with the candidates' ability to take a clinical history and their competence at physical examination. For such an assessment, volunteers can simulate patients, and the marking scheme should concentrate on correct techniques or gathering of appropriate information during history taking (see examples in boxes). In addition, some assessment stations can examine interpretation of images and data.

In contrast an objective structured clinical exam at the end of an undergraduate clinical course could include robust patients with physical signs to be elicited and appropriately described and for whom a working diagnosis should be formulated. Postgraduate assessments can place greater emphasis on advanced

Marking scheme for assessment of taking a patient's history

Skill station: history 2 (pneumonia)

Primed and knowledgeable mock patient.

Instructions to candidate

Would you take a short and to the point history from this patient, who has presented to the accident and emergency department with cough and breathlessness. In due course, let me know your thoughts on the diagnosis. You have six minutes.

Marking scheme

Introduction—"I'm X"	1
Obtaining information on:	
Duration of symptoms	1
Sputum	
Appearance	1
Volume	1
Specifically blood?	1
Breathlessness—exercise tolerance, wheeze	2, 1, 0*
Associated symptoms—pleurisy, fever, rigor	2, 1, 0*
Contacts	1
Smoking	1
Occupation	2
Diagnosis	2
	<hr/>
	15

*2=Satisfactory coverage of all points; 1=some points covered; 0=inadequately or not performed.

Scenario for mock patient

You are a previously well, non-smoking, 18 year old military recruit of three months' standing. For the past three days you have noticed undue and increasing breathlessness, now even on quiet activities. Initially this was associated with a non-productive cough, but over the past 24 hours you have coughed up a total of an egg cup of green sputum without blood. During this illness you have felt hot and shivery and last night had a bedshaking rigor, when the resident medical officer recorded a temperature of 39.5°C. This morning, you were sent to casualty.

On direct questioning, you will recollect some right sided chest discomfort over the past couple of days that is worse on breathing in and particularly on coughing. Five other members of your training company have fallen ill over the past fortnight with similar symptoms.

Marking scheme for assessment of making a physical examination

Skill station: respiratory system examination

Mock patient

Instructions to examiner

Reinforce and encourage the candidate to provide a running commentary, talking through the examination.

When candidates begin to examine the anterior thorax, ask them to immediately go to the back (that is, not to examine the front of the chest).

Instructions to candidate

Please examine this person's respiratory system. Please tell me what you are doing as you go along.

Marking scheme

Approach to patient:

"I'm X"	1
"I'm going to examine your chest"	1
Hands and fingers (colour, temperature, nails, flap)	2, 1, 0*
Tongue	1
Neck (nodes)	2, 1, 0*
Tracheal position	2, 1, 0*

Examiner: give instructions to examine only the back

Posterior thorax:

Inspection	1
Palpation, chest expansion equal	2, 1, 0*
Percussion technique, symmetrical examination	2, 1, 0*

Examiner: ask candidate to show when percussion becomes dull posteriorly

Auscultation:

Vocal resonance	2, 1, 0*
Breath sounds, breathing through open mouth	2, 1, 0*
	<hr/>
	20

*2=Satisfactory coverage of all points; 1=some points covered; 0=inadequately or not performed.

practical techniques and problem solving abilities. At all levels assessments can examine communication skills.

How many stations?

How long an assessment lasts is determined by the number of assessment stations and the time each candidate will spend at each station. To accommodate the required number of candidates the examination may be repeated or held at different sites at the same time.

Fewer than 10 stations are inadequate for a satisfactory range of topics to be examined, but more than 20 can become unwieldy and require large numbers of examiners. There is scope for a greater range of features to be assessed if each candidate is at a particular station for, say, six minutes rather than three minutes. If 12 minutes are needed to assess a particular skill a double station with a staggered candidate start could be introduced. For an objective structured clinical exam early in the undergraduate clinical course, we have found a satisfactory compromise to be 10-15 stations, each requiring six minutes for assessment. We know, however, that other centres use 15-20 stations with only three minutes at each point.

Skill assessments

The tasks to be assessed should be of different types and of varying difficulties to provide a mixed assessment circuit. This is less demanding for the candidates

Circuit of objective structured clinical exam for undergraduate students*

- 1: Funduscopy
- 2: Cardiovascular examination (directed)
- 3: Blood pressure measurement
- 4: Respiratory examination (directed)
- 5: Urine analysis
- 6: Knee joint examination
- 7: History 1: cardiovascular
- 8: Abdominal examination
- 9: Neurology: deep tendon reflexes
- 10: History 2: respiratory

Students allowed six minutes at each station.

*At end of first clinical attachment of eight weeks.

and helps discrimination between candidates of varying abilities. The box shows an assessment circuit that we have used in undergraduate clinical assessment in Edinburgh. When an examination is being designed it is useful to construct a table as shown to demonstrate the competencies and content to be tested.

Content and competencies tested in assessment of undergraduate students

Content	Competencies		
	History taking	Physical examination	Investigative procedures
Cardiovascular system	✓	✓	
Eyes		✓	
Respiratory system	✓	✓	
Urinary system			✓
Musculoskeletal system		✓	
Alimentary system		✓	
Nervous system		✓	

Marking schemes

For each skill to be assessed, a simple and unambiguous marking scheme should be developed which limits digression by individual examiners. Interested specialists must be included in the development of such schemes to decide important points and the discriminators for adequate performance. Marking schemes should be concise and unambiguous and should focus on actions that discriminate a good performance from a poor one. They also need to be sufficiently focused to avoid overrewarding candidates who do everything—"grapeshotting." The marking schemes should be tested at dummy runs and then modified in the light of experience. Dummy runs also enable exam designers to ensure that the tasks can be completed within the time allocated.

We have found it essential to include at the top of each marking scheme instructions for the examiners. These can include instructions to be read out to candidates at the start of their assessment and outlining exactly the task required. Alternatively, instructions may be clearly displayed at the point at which candidates approach a station.

Different stations can contribute different maximum possible marks to the overall examination total, reflecting the relative importance of the topics assessed. The box shows the marking scheme developed for examining urine analysis early in a clinical course. The scheme reflects the important points of technique, basic interpretation, and associated knowledge and allows for some discrimination.

Each assessment station needs sufficient marking sheets. We provide these in a booklet form, with a list of candidates in the order that they will pass through the station bound in at the front. Alternatively, for unmanned stations, students may be given an answer booklet to be carried round and filled in station by

station and then handed in at the end of the examination.

Setting spaces

An objective structured clinical exam needs room for a circuit of assessment stations, with enough space at most stations for an examiner, a candidate, and a patient or volunteer or some apparatus. We have used a programmed investigation unit that has been cleared of all other patients and activities for the day, but these may not always be available. An advantage of this type of area is that some of the nursing staff may be prepared to help with the examination.

Stations for examining interpretation of images or data require less space. An ophthalmoscopy station should be in subdued lighting—a ward side room may be appropriate. If urine analysis is to be tested, facilities to contain spillages and a wash basin are required. Stations where communication skills are being assessed should be distant from stations where auscultation is important.

The stations should be clearly and logically numbered so that even the most nervous candidates can find their way round in the correct order. Large, A4 sized numerals clearly displayed at every station and arrows of white masking tape stuck to the floor to indicate the route greatly help progress round the circuit.

Personnel

EXAMINERS

In comparison with other forms of assessment objective structured clinical exams are expensive in terms of manpower and time.² While some stations may be unmanned, such as those where interpretation of images or data is assessed, most will require an

Marking scheme for assessment of urine analysis

Skill station: urine analysis

Two buffer solutions; one grossly spiked with blood, the other spiked with glucose and protein.

Instructions to examiner

Reinforce and encourage the candidate to provide a running commentary, talking through the examination

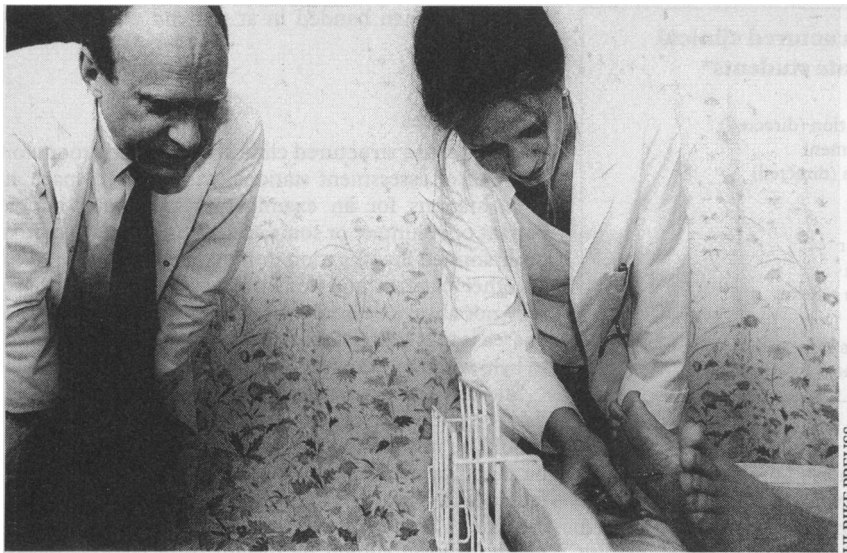
Instructions to candidate

Please examine these two urine samples.

Marking scheme

Universal precautions—gloves worn and subsequent disposal of stick and gloves	2, 1, 0*
Inspection of urines by eye	1
Lid replaced on bottle after dipstick removed	1
Correct use and orientation of dipstick and timing	2, 1, 0*
Correct result—blood (protein), glucose, protein	3
<i>Questions to candidate</i>	
What are the descriptive terms for the abnormalities elicited?	
Haematuria, glycosuria, proteinuria	3
Suggest a common cause for each abnormal urine.	
Urine 1—Carcinoma or papilloma of bladder (or other reasonable cause)	1
Urine 2—Diabetes mellitus	1
With renal impairment or nephropathy	1
	<hr/> 15

*2=Satisfactory coverage of all points; 1=some points covered; 0=inadequately or not performed.



Assessing competence at physical examination

ULRIKE PREUSS

they give realistic performances. When the ability to elicit abnormal physical signs is required stable and robust real patients are necessary.

On the day

An early start is required. The order of the assessment stations around the circuit must be decided, and the stations should be numbered early. Beds, chairs, and other apparatus should be positioned appropriately.

The volunteers or patients should arrive a little before the examiners; they will need gentle reinforcement of previous briefings or conversations, their stations must be identified, and refreshments should be provided as appropriate. A reserve volunteer patients is necessary for the sanity of the organiser.

The examiners should arrive early enough to allow for latecomers and to allow initial conversations between examiners and the volunteers or patients at their respective stations. Examiners should be reminded to pay attention to timekeeping and of particular points relevant to their skill assessment, instructions, or marking scheme.

Candidates should be checked in to a comfortable waiting area and should be briefed on the nature of the examination. We remind them to pay particular attention to the instructions given to them at the beginning of each station and, on the signal that time has been completed, to stop all activities and move quickly to the next station in the circuit.

Before each group of candidates leaves the site, their experience should be reviewed with them to provide immediate feedback. The examiners should also be consulted to identify any problems with their station or candidates who performed particularly poorly.

Outcome

Any form of assessment has its problems or concerns. Running an objective structured clinical exam requires a commitment of time and personnel, both in preparing for the exam and for examiners and patients or volunteers on the day itself. However, we have found that undergraduate students appreciate this form of assessment. In 1994 our 212 students who were examined at the end of their first clinical year found the assessment more relevant (96%) and less stressful (74%) than their previous examination experiences, and they thought that it fairly assessed their physical examination skills (97%) and their history taking skills (80%).

The assessment also allows early feedback. We have found that running it early in the first clinical year identifies candidates with a very poor performance. They can be asked to repeat the examination at a later stage. In conjunction with clear aims and objectives, we have also found that it focuses the minds not only of the students but also those of their clinical ward teachers. Having run it for three groups of students over an academic year, we noted gratifying improvements in performance at each successive intake. The technical evaluation of such forms of assessment is outside the scope of this article.

examiner. A reserve examiner should be identified for the day. This could be the person in overall charge of the organisation, the exam designer, who has at least some familiarity with each of the assessment stations and can step in at the last moment if required.

Examiners will need a briefing session before the exam, running through their marking scheme with the exam coordinator to make sure there are no ambiguities. An informal debriefing session at the end of the exam allows examiners new to this form of assessment to air any grievances and concerns. It also encourages development of the exam, with exchange of ideas and suggestions for improvement in either the tasks required or their formal assessment.

Even for exams early in undergraduate courses, the involvement of senior personnel is crucial both for their expertise in the tasks assessed and to give credibility to the examination system. However, even senior examiners must be prepared to dispense with personal preferences in the interests of objectivity and reproducibility and must assess students according to the marking scheme rather than rely on intuition.

MARSHALS AND TIMEKEEPERS

Our senior nursing staff act as examiners at appropriate stations and help with checking in candidates, timekeeping, and ensuring that candidates move promptly between stations at changeover time. They have also helped in controlling wayward senior clinical examiners. It is important that the signal for changeover is unambiguous and clearly audible everywhere in the examination circuit.

PATIENTS AT STATIONS

Using real patients as subjects for assessment stations can be difficult and may not be appropriate. Specially constructed plastic models or simulations may be used—for example, for rectal or breast examination, where the repetitive and intimate nature of the task makes the use of people inappropriate. Healthy volunteers may be used for assessments early in a clinical course where techniques of history taking and clinical examination are being assessed. Volunteers or mock patients in assessments of communication skills require more training than volunteers used only for physical examination. For the assessments that we have run at junior clinical level, we have had positive interest and commitment from our simulated patients, who give up two half days (including part of a weekend) and receive only token reimbursement for their expenses. They find the experience interesting and often return, and students' comments suggest that

- 1 Harden RM, Gleeson FA. Assessment of clinical competence using an objective structured clinical examination (OSCE). *Med Educ* 1979;13:41-54.
- 2 Lowry S. Assessment of students. *BMJ* 1993;306:51-4.
- 3 Mulholland H. How to assess junior doctors. *Hospital Update Plus* 1993; 56-58S.
- 4 General Medical Council. *Tomorrow's doctors: recommendations on undergraduate medical education*. London: GMC, 1993.
- 5 Newble D, Jolly B, Wakeford R. *Certification and recertification of doctors: issues in the assessment of clinical competence*. Cambridge: Cambridge University Press, 1993.

(Accepted 3 February 1995)