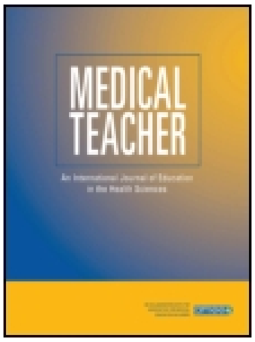

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WEB PAPER

The Ventriloscope® as an innovative tool for assessing clinical examination skills: Appraisal of a novel method of simulating auscultatory findings

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Abstract

Background: Simulation is increasingly used as a teaching tool and in assessment. The Ventriloscope® (VS) is a new auscultation simulator. This modified stethoscope allows pre-recorded sounds (activated wirelessly) to be integrated with a simulated patient (SP, professional actor).

Aims: This study explores the instrument's potential for overcoming limitations of current objective structured clinical examination (OSCE) assessment by increasing validity while retaining reliability.

Methods: After training SPs to synchronise the device with their breathing (recreating abnormal signs), we evaluated the VS during a third year undergraduate medical student OSCE. Students ($n = 385$), examiners ($n = 19$) and SPs ($n = 10$) completed post-exam questionnaires which were analysed using a coding framework. OSCE performance data were analysed using Stata 10.

Results: When 'compared to their usual stethoscope' 40% of students found no difference in using the VS; 69% found it easier to identify sounds; 68% found examination with the VS very or fairly realistic when 'compared to examining a real patient'. Examination scores were comparable with other OSCE stations.

Conclusions: The VS reliably provided consistent 'abnormal' auscultatory signs within an OSCE framework. Using a VS may increase OSCE validity, allowing examiners to assess students' application of knowledge in a realistically simulated setting. The VS can help bridge the gap between simulation and real patients.

Introduction

The objective structured clinical examination (OSCE) is a well-established method for assessing clinical skills of medical students (Harden & Gleeson 1979; Newble & Swanson 1988). Ideally, these skills would be assessed on real patients and would test students' abilities to recognise and interpret physical signs. However, difficulties associated with finding large numbers of well patients with appropriate, consistent and stable clinical signs have seen increased utilisation of simulated patient (SP) and standardised patient. This has improved the standardisation and reliability of assessing medical students, but raises issues of validity and authenticity (Dauphinee 1995).

SPs are professional actors or lay people (usually healthy) trained to simulate a variety of medical problems in a consistent, reliable, realistic and reproducible manner. The SPs being 'well' poses a problem when assessing learners' ability to recognise abnormal clinical signs and to apply and integrate knowledge. When faced with a SP in an OSCE, medical students may perform on 'auto-pilot', carrying out the motions of examination knowing that there will be no abnormality to detect. Their ability to identify abnormal signs and interpret them in a clinical context is therefore not assessed. This pattern of 'tick-box' learning at undergraduate level may explain the numerous reports of poor diagnostic ability of postgraduate trainees (Mangione & Nieman 1997; Peitzman et al. 2000; Ozuah et al. 2001; Houck et al. 2002).

Attempts have been made to overcome such limitations with the aid of simulation technology (Peitzman et al. 2000; Ozuah et al. 2001; Houck et al. 2002; Morgan & Cleave-Hogg 2002), particularly to facilitate learning of audible clinical signs. These include audio recordings, multimedia CD-ROMs,

Practice points

- The Ventriloscope® auscultatory simulator was straightforward to integrate into a large medical school OSCE and performed reliably.
- The simulator produces realistic and consistent simulated sounds.
- There was minimal disruption to the flow of the physical examination using the simulator.
- Consideration has to be given to simulating non-auscultatory signs to give the simulation clinical coherence.
- Adopting the simulator has significant cost implication.

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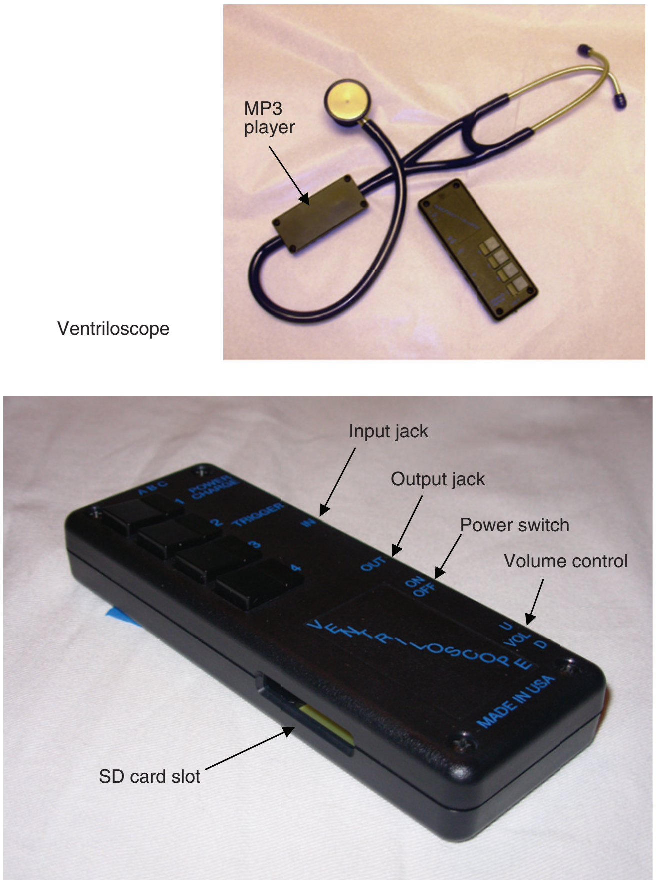

Figure 1. Lecat's VS (reproduced with permission of Dr Paul Lecat).

electronic heart sound simulators and manikins (Gordon et al. 1980b; Mangione & Nieman 1997; Issenberg et al. 1999). Simulators have been shown to enhance physical examination skills of learners in undergraduate and postgraduate settings (Gordon et al. 1980a; Issenberg et al. 2002; Issenberg et al. 2005). Students have also been shown to value simulation-based teaching very highly (Weller 2004). However, simulators are separate from real people, and therefore cannot recreate the interpersonal aspects of a clinical encounter.

Postgraduate high stakes examinations have begun to utilise simulation technology as part of the assessment of clinical competence (Dillon et al. 2004; Hatala et al. 2005). Furthermore, a key action point from the Chief Medical Officer's recent report states that simulation should be 'fully integrated and funded within clinical programmes for clinicians at all stages' (Department of Health 2009). With these considerations in mind it would be prudent to introduce simulation devices into medical school exams. Thus far, use of simulation technology in examinations has consisted mostly of the candidate or student examining a SP and then stopping their flow of examination to concentrate on a form of audio-visual simulation (Hatala et al. 2008) or focusing solely on video clips (Lieberman et al. 2003; Millos et al. 2003). This break in the flow of examination unarguably impairs perceived realism.

The artificial separation of auscultatory signs from their clinical context fragments the learning of key skills. Work on hybrid simulation has highlighted the importance of placing a real person at the centre of a clinical encounter (Kneebone et al. 2006). While this has been explored for a range of procedural skills, the integration of simulators and real people for assessing the *interpretation* of clinical signs has not been addressed.

New technology offers the potential to overcome this artificial separation between simulator and patient. The Ventriloscope® (VS) (Castilano et al. 2009; Lecat 2010) (Figure 1) resembles a stethoscope but incorporates an inbuilt MP3 player. Pre-recorded auscultatory sounds on a secure digital memory card can be played through this MP3 player and heard via the stethoscope ear pieces. The sounds are controlled by a remote transmitter. When examining an SP, the student will hear simulated pre-recorded sounds just as they would with a normal stethoscope.

This offers a means of 'grafting' abnormal auscultatory signs onto a healthy person, requiring students to recognise and interpret such signs within the wider context of a clinical encounter. From an assessment perspective, the ability to select from a variety of authentic 'signs' offers obvious benefits in terms of consistency and reliability.

This study aimed (1) to evaluate whether the VS could be used reliably to provide audible clinical signs for students to integrate with the rest of the clinical examination in an OSCE setting, (2) to investigate opinions of students, examiners and SPs regarding use of the VS as an assessment/examination tool and (3) to compare students' exam results with other stations requiring physical examination in a third year OSCE. To our knowledge, this is the first study of such a simulation device in the UK.

Methods

Setting and study participants

The subjects were 358 third year medical students undertaking the end of year OSCE exam at Imperial College School of Medicine. The OSCE was carried out on 1 day, across three hospital sites in London. One of the 12 stations was modified to incorporate the VS. Strategies were put in place to enable the station to continue in the event of VS malfunction or failure. In accordance with our usual examination practice, students were prevented from talking to each other at changeover.

Anonymous questionnaires were given to each of the students and to 19 examiners about their experience in the station where the VS was used.

The students received a general OSCE briefing 2 months before the exam in which they were informed about the VS being introduced into one of the exam stations. They were not given prior practice with the VS.

Design and data collection

To explore participants' perceptions and interpretations of their experience, we selected a mixed method's research design including questionnaire feedback.

Training of SPs. Two researchers (Himanshu Bhatt and Anju Verma) familiarised themselves with the workings of the VS and designed clinical scenarios in which the VS could simulate clinical signs of respiratory disease.

An actor experienced in medical student exams and OSCE-type scenarios was given training on how to use the VS by two of the authors (Himanshu Bhatt and Anju Verma). The SP was responsible for coordinating the appropriate button(s) on the transmitter device with inhalation and exhalation as the candidate/student auscultated their chest.

The VS can produce a full range of clinical auscultatory sounds such as heart, respiratory and bowel sounds and bruits. In this study, respiratory sounds were chosen to overcome any difficulties associated with a lack of peripheral signs (such as abnormal pulse) and issues with timing with a pulse. The station simulated a patient with moderate asthma as part of which the VS was used to provide polyphonic expiratory wheeze throughout the lung fields. All 358 students in the exam undertook this OSCE station.

Training of examiners. As part of normal exam practice all examiners are expected to attend a hands-on training session observing and marking three stations. Each examiner was additionally sent information explaining what the VS was and how it works. In the OSCE station, the SPs briefed the 19 examiners on the mechanics of the VS. Circulating senior examiners ensured that examiners in the respiratory station were comfortable using the VS. As part of this all examiners were asked to examine the SP's chest using the VS. Examiners were CCT accredited physicians or general practitioners.

Pilot – mock OSCE and semi-structured interviews. The VS was piloted in the respiratory station of a mock OSCE using the same trained actor (SP). The scenario was repeated in exam style with four different examiners and four candidates. This exam scenario could be visualised by video link in a main seminar room by a group of 30 volunteers from the academic faculty at Imperial College, comprising examiners, actors and administrative examination officers. Each scenario was also recorded to make training videos.

Focus group discussion with the observers after each run through of the respiratory station enabled fine tuning of the equipment set-up in the room, and ensured face validity of the station. Content validity was assessed by comparing the content of the station against the undergraduate curriculum.

Himanshu Bhatt and Anju Verma carried out semi-structured interviews with examiners and candidates who participated in the mock OSCE to help construct questionnaires (see below).

End of third year OSCE station – set-up. After creating suitable training videos Himanshu Bhatt and Anju Verma undertook training of a group of 20 actors (SPs) until they were comfortable and competent at using the VS.

The final OSCE station set up (Figure 2) involved the SP on a couch in a hospital gown with the transmitter device hidden under a hospital blanket. Hidden out of view were loudspeakers (connected to the transmitter) to allow actor and examiner to synchronously hear what the student was hearing through the VS ear pieces to ensure consistent use of the equipment by the SP. This station was replicated across three different OSCE sites with 10 simultaneous circuits and thus 10 VSs in use at any one time. This set up was very similar to other physical examination stations in the OSCE.

Mark scheme for respiratory station using VS. We based the mark scheme on a standard respiratory examination station marking scheme used at Imperial College that routinely assesses communication, consultation, professionalism, interpretation of data and diagnostic ability, including criteria for correctly identifying the abnormal sound and for correct diagnosis.

OSCE – questionnaires. The questionnaire was based on the emergent themes from semi-structured interviews that authors Himanshu Bhatt and Anju Verma conducted. Separate questionnaires were created for students, examiners and SPs. Each contained questions using five-point Likert responses, multiple choice and space inviting free text responses. Questionnaires were distributed, completed and collected at the end of the third year OSCE to maximise return rates.

Exam scores. Exam scores were collated in a standard manner by the Undergraduate Medical Office at Imperial College, as for all other stations in the OSCE.

Figure 2. OSCE station set-up.

Data analyses

Responses from completed questionnaires were collated in an Excel spreadsheet. Multiple choice and Likert-scale questions were analysed using descriptive statistics. Himanshu Bhatt and Anju Verma individually coded free text responses from the questionnaires using a coding framework (Cresswell 1998; Strauss & Corbin 1990). They then met to conduct between-coder comparisons to assess inter-rater reliability. Paul Booton and Roger Kneebone individually coded samples of free text responses. All four authors then met and after extensive discussion reached agreement about the definition of coding categories and themes.

OSCE scores in the respiratory (RS) station (using the VS) were compared with scores at the breast (Br) examination, cardiovascular (CVS) examination and lower limb (LL) examination stations. These stations were chosen for comparison as they all involved physical examination.

Chi square or Fisher's exact test (Altman 1991) was used to compare categorical variables such as proportions of students achieving the maximum score, proportions passing but not including the top score, proportions attaining the borderline score and proportions failing. This method was also used to compare student and examiner responses to identical questions. Cronbach's alpha was calculated to assess reliability and internal consistency (Cohen 1992). Stata version 10 was used for analyses (Texas, USA; Stata Corporation).

Results

From the questionnaires sent out, 286 were returned by medical students (79.9% return), 17 were returned by examiners (89.4% return) and 10 were returned by SPs (100% return).

Student questionnaire responses

When 'compared to their usual stethoscope' 40% of student respondents found no difference in using the VS and 69% reported it being easier to identify sounds. 68% reported examination with the VS was very or fairly realistic when 'compared with examining a real patient'. 48% of respondents did not feel that using the VS 'changed my examination technique', with a further 19% reporting a better exam technique. 76% of respondents were not aware that sounds were also being played over a loudspeaker (Table 1).

Thematic analysis of the written comments revealed five themes: ease of use, sound quality, clinical examination, realism and students' expectations (Table 2). Some of the students' comments within these themes are included.

Examiner questionnaire responses

When 'compared to their usual stethoscope' 41% of examiner respondents found no difference in using the VS and 47% reported no difference in identifying sounds. 41% of respondents felt the sound clarity was the same as their usual stethoscope and 47% reported it as better. 'Compared to other OSCE stations' 53% of examiner responses indicated that using the VS made the station feel more like a real patient examination (Table 3). The examiner free text responses were mainly about realism and station set-up: 'more like a real patient with signs', 'useful as we can hear as the student is auscultating'.

SP questionnaire responses

All SPs (actors) reported receiving appropriate training in using the VS, 40% reported that using the VS 'made my role more like a real patient' and 60% felt that the VS helped their performance as an actor. 70% of SP respondents found the loudspeakers 'bettered' their use of the VS and 80% reported loudspeakers made standardising their role 'easier'.

Comparison of student and examiner responses to identical questions

There was no difference between opinions of student and examiner regarding the ease of use of the VS and identification of sounds. A greater proportion of student respondents reported better sound clarity than examiner respondents and a greater proportion of examiner respondents found the station more like a real patient encounter than student respondents (Table 4).

Table 1. Student questionnaire responses.

Student responses (%) (*n*)				
I found using the VS (compared to my usual stethoscope)				
Much easier	Slightly easier	Made no difference	Slightly harder	Much harder
21% (59)	17% (49)	40% (113)	19% (54)	3% (8)
I found the sound clarity of the VS (compared to my usual stethoscope)				
Much better	Better	The same	Worse	Much worse
27% (76)	46% (132)	20% (58)	6% (16)	1% (2)
I found identifying the sounds I heard (compared to my usual stethoscope)				
Much easier	Slightly easier	Made no difference	Slightly harder	Much harder
30% (83)	39% (109)	25% (70)	6% (16)	1% (3)
Using the VS changed my examination technique				
For the better	Not at all	For the worse	Cannot say	
19% (53)	48% (136)	16% (44)	17% (48)	
Compared to other OSCE stations, using the VS made this station feel				
More like a real patient examination	Made no difference	Less like a real patient examination	Cannot say	
27% (75)	33% (93)	38% (108)	2% (7)	
Compared to examining a real patient, performing this examination felt				
Very realistic	Fairly realistic	Not very realistic	Cannot say	
11% (24)	57% (121)	27% (57)	5% (10)	
Were you aware that whilst you were listening, the breath sounds were also being played over a loudspeaker?				
Yes	No			
24% (61)	76% (194)			
Overall impression				
Good	Bad	Okay	Free text comments	
75% (118)	4% (7)	20% (32)	'Good test of third year skills', 'Scary', 'Fun, fun, fun', 'Interesting to listen to different breath sounds', 'Good to have pathology'	

Table 2. Thematic analysis of free text comments – students.

Theme	Sub-category/properties	Students responding *n* (%)	Example of comment
Ease of use	Weight	17 (63)	Heavier
	Comfort	4 (15)	
	Usability	6 (22)	I could put it on his hand and it could work Could not change the bell/diaphragm
Sound quality	Volume	45 (39)	Loud inspiratory component got me a bit confused
	Clarity	47 (41)	Good quality audio
	Interference	6 (5)	Background noise, sounds like a radio
	Distinctiveness	16 (14)	
Clinical examination	Attentiveness	9 (33)	Because there were signs
	Technique	18 (67)	Too much to do at once
Realism	SP's timing of breathing	15 (20)	
	Realistic/Lifelike	51 (69)	Good to have pathology
	Signs and Symptoms	8 (11)	Better to have real patients
Students' expectations	Abnormality	8 (22)	
	Anxiety	5 (14)	Anxious about it
	Familiarity	24 (65)	Felt naked without my own stethoscope

Student exam results/performance data

There was no evidence of difference between the proportions of students at each OSCE station involving physical examination that achieved the maximum score, the proportion that passed (but not including the maximum score), the proportion that attained the borderline pass mark and the proportion of students who failed per station when compared with the respiratory station (Table 5).

Of the 358 students, 266 (74%) identified the abnormal sound in the VS and gave the correct diagnosis. Of those of who correctly identified the abnormal sound (294 of 358) 90% also gave the correct diagnosis. Of all the students that gave the correct diagnosis (315 of 358) 84% identified the abnormal sound correctly.

There was very strong correlation between student scores in the respiratory station and the overall scores (Spearman's correlation coefficient 0.97, $p < 0.001$), and strong correlation

Table 3. Examiner questionnaire responses.

Examiner responses (%) (*n*)				
I found using the VS (compared to my usual stethoscope)				
Much easier	Slightly easier	Made no difference	Slightly harder	Much harder
29% (5)	12% (2)	41% (7)	17% (3)	0% (0)
I found the sound clarity of the VS (compared to my usual stethoscope)				
Much better	Better	The same	Worse	Much worse
12% (2)	35% (6)	41% (7)	12% (2)	0% (0)
I found identifying the sounds I heard (compared to my usual stethoscope)				
Much easier	Slightly easier	Made no difference	Slightly harder	Much harder
12% (2)	35% (6)	47% (8)	0% (0)	6% (1)
Compared to other OSCE stations, using the VS made this station feel				
More like a real patient examination	Made no difference	Less like a real patient examination	Cannot say	
53% (9)	18% (3)	18% (3)	12% (2)	
The use of loudspeakers made standardising this station				
Much easier	Slightly easier	Made no difference	Slightly harder	Much harder
62.5% (10)	37.5% (6)	0% (0)	0% (0)	0% (0)
How would you rate the consistency of the actor's use of the VS?				
Very consistent	Consistent	Inconsistent	Very inconsistent	
62.5% (10)	37.5 (6)	0% (0)	0% (0)	
Would you consider using the VS as a teaching tool?				
Yes	No			
100% (17)	0% (0)			

Table 4. Comparison of student and examiner responses to the same questions.

Question	Number of responses		Response		
Compared to my usual stethoscope					
I found using the VS			Easier	No difference	Harder
	283	Student, *n* (%)	98 (38)	113 (42)	62 (22)
	17	Examiner, *n* (%)	7 (41)	7 (41)	3 (18)
		Risk ratio (95% CI)	0.98 (0.93–1.05)	1.08 (0.98–1.18)	1.01 (0.95–1.08)
		p-Value	0.583	0.098	1.000
I found the sound clarity of the VS			Better	The same	Worse
	284	Student, *n* (%)	208 (74)	58 (20)	18 (6)
	17	Examiner, *n* (%)	8 (47)	7 (41)	2 (12)
		Risk ratio (95% CI)	1.08 (1.00–1.16)	0.93 (1.00–1.16)	0.95 (0.82–1.10)
		p-Value	0.027	0.064	0.314
I found identifying the sounds I heard			Easier	No difference	Harder
	281	Student, *n* (%)	192 (69)	70 (25)	19 (6)
	17	Examiner, *n* (%)	8 (47)	8 (47)	1 (6)
		Risk ratio (95% CI)	1.06 (0.99–1.13)	0.94 (0.86–1.01)	1.00 (0.91–1.12)
		p-Value	0.070	0.083	1.000
Compared to other OSCE stations					
Using the VS made this station feel			More like a real patient examination	Made no difference	Less like a real patient examination
	281	Student, *n* (%)	75 (27)	100 (35)	108 (38)
	17	Examiner, *n* (%)	9 (53)	5 (30)	3 (17)
		Risk ratio (95% CI)	0.93 (0.86–1.00)	1.02 (0.96–1.07)	1.05 (1.00–1.11)
		p-Value	0.027	0.605	0.085

Note: *n*, number of respondents and CI, confidence interval.

between students passing the respiratory station and passing overall (Spearman's correlation coefficient 0.72, $p < 0.001$).

The overall reliability of the 12 station OSCE as measured by Cronbach's alpha was 0.65.

Technical appraisal

All ten VSs ran successfully throughout the OSCE. No problems were reported by SPs or examiners in using the VS or any associated equipment in the exam station. Plans for action in case a device failed were not activated. We recharged

Table 5. Exam score comparisons across four stations.

	Station						
	RS	Br		CVS		LL	
Score group	*n* (%)	*n* (%)	Risk ratio (95% CI)	*n* (%)	Risk ratio (95% CI)	*n* (%)	Risk ratio (95% CI)
Maximum score	73 (20.4)	94 (26.3)	0.78 (0.58–1.02)	58 (16.2)	1.26 (0.92–1.72)	86 (24.0)	0.84 (0.64–1.12)
Pass (not including top score)	257 (71.8)	233 (65.1)	1.17 (0.99–1.39)	263 (73.5)	0.96 (0.82–1.13)	245 (68.4)	1.08 (0.92–1.28)
Borderline score	17 (4.7)	19 (5.3)	0.89 (0.47–1.69)	27 (7.5)	0.63 (0.34–1.13)	24 (6.7)	0.71 (0.39–1.30)
Fail	28 (7.8)	31 (8.7)	1.10 (0.97–1.05)	37 (10.3)	1.03 (0.98–1.08)	27 (7.5)	1.00 (0.96–1.04)

Notes: *n*, number of students; CI, confidence interval, reference group, respiratory (incorporating the VS).
Stations: RS, respiratory; Br, breast; CVS, cardiovascular; and LL, lower limb.

the VSs over the lunch break as a precaution as we were uncertain of battery life in this situation.

Discussion

Main findings of the study

This study describes the integration of a novel auscultatory simulation within an OSCE setting, with minimal disruption to the candidate's flow of examination. The VS reliably produced consistent simulated sounds and there were no episodes of VS failure or malfunction. The VS has been well received by students, examiners and SPs (actors). Its utilisation did not affect student exam scores when compared with other OSCE stations involving physical examination, and showed strong correlation with overall OSCE scores. The majority of student respondents reported that using the VS imposed no change in their examination technique, and two thirds felt using the VS conveyed a sense of realism.

What is already known

Although simulation technology has been incorporated into assessment settings (Dillon et al. 2004; Hatala et al. 2005; Hatala et al. 2008), there are no reports of seamless integration of simulated auscultatory sounds into a standard physical examination where the SP is in control of a device to 'produce' the clinical abnormality. But, it has been shown that assessment of skills within a relevant clinical context is possible in operating theatre settings (Black et al. 2006) and during performance of certain procedures (Kneebone et al. 2002; Kneebone et al. 2005). It is imperative that the acquisition of clinical skills is not segregated from the clinical context or oversimplified (Kneebone 2009). We have tried in this study to adhere to these important principles by sampling multiple aspects of a real clinical encounter – communication, professionalism, identification of the clinical abnormality, interpretation of data and accurate diagnostic ability.

A recent review of simulation-based medical education research outlines 12 features and best practice points in order to 'use medical simulation technology to maximum educational benefit' (McGaghie et al. 2010). Our study, based on assessment, incorporates the following: outcome measurement, simulation fidelity and high stakes testing. Furthermore, we could apply more 'best practice points' by utilisation of the VS in a teaching setting, thus allowing for feedback, curriculum integration, deliberate practice, skill acquisition, mastery learning and instructor training. Consideration to postgraduate learners would allow for transfer to practice and team training.

Strengths and limitations of the study

The VS is highly practicable; it was straightforward to train actors (SPs) and staff in its use and it worked flawlessly in a large-scale real life exam. The positive comments from both students and examiners support the quality of the simulation. The VS also worked well within the time constraints of the exam. The VS were re-charged during the OSCE lunch break but we are not sure if this was necessary.

Incorporating the VS in a station contributes to face validity as it allows the candidate/trainee to hear abnormal breath (or other) sounds just as they would in a normal clinical examination. In addition, we have shown improved construct validity as the presence of 'pathology' increases the number of learning objectives that the station is able to test.

All students heard the same simulated abnormality. This consistency should improve the reliability of the VS station over a real patient station as it removed case variability. The examination setup did not allow us to test this.

A small number of students gave the correct overall diagnosis for the OSCE station ('asthma'), but failed to identify the auscultatory findings correctly. The possible explanations for this include the presence of other cues in the station such as a history and a peak flow chart, students guessing the sound and students finding ways of communicating with each other between circuits.

Ours was not a case-control study, thus we did not compare students exposed to the VS with those who were not exposed to the VS. We also did not compare student's performance using the VS at the respiratory station against their performance at a respiratory station involving a real patient with clinical signs.

The range of use of the VS in an exam setting is potentially limited by the ability to simulate the other signs that comprise a clinical presentation. For instance, in attempting to simulate aortic stenosis, the ejection systolic murmur and sounds of carotid radiation could be recreated with the VS, but a heaving apex, precordial thrill and slow rising pulse are difficult or impossible to bring into the simulation (Cline 2004).

At over £1000 per Ventriloscopes® the cost implications of such a device are significant.

Nevertheless, the VS is a step forward in the development of simulation techniques. It could also be a valuable teaching tool in which audible clinical sounds can be heard over and over again without the worry of patient fatigue.

Conclusions

Appropriate integration of simulated physical signs using SPs in an examination setting can help move away from the reductionist approach to assessment that is often found in medical schools. We have shown that the VS contributes to the authenticity of a clinical simulation and thus brings it closer to a real patient encounter and is both consistent and practical to use in a real examination setting.

The technology we have evaluated offers a 'menu' of normal and abnormal auscultatory findings which can be integrated at will with a real patient, thereby increasing validity without sacrificing reliability in assessment. This authenticity lies at the heart of effective clinical practice, where many skills and behaviours must be interwoven.

This innovative use of hybrid simulation addresses some of the constraints around assessment of clinical skills. By locating the detection and interpretation of clinical signs within a clinician-patient encounter (rather than as a decontextualised exercise), simulation can approach the authenticity of clinical practice while overcoming some of the practical difficulties. In this way, graded levels of diagnostic challenge can be designed, tailoring assessment to the evolving needs of learners as their skills and experience develop. This has wide implications for education at undergraduate and post-graduate levels.

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Ethical approval

Ethical approval for this study was obtained from Imperial College Research Ethics Committee.

Notes on contributors

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