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Multimedia presentation of lung sounds as a learning aid for medical students

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Multimedia presentation of lung sounds as a learning aid for medical students. P. Sestini, E. Renzoni, M. Rossi, V. Beltrami, M. Vagliasindi. ©ERS Journals Ltd 1995.
ABSTRACT: New educational technologies might help to compensate for the decrease in time and emphasis dedicated to physical examination in medial training. This may, in particular, be applicable for improving the skills in auscultation of the chest. We investigated whether a multimedia presentation of acoustic and graphic characteristics of lung sounds could improve the learning of pulmonary auscultation by medical students, in comparison with conventional teaching methods.

We studied 48 medical students without clinical experience, who had received conventional formal teaching on chest examination. Chest auscultation skills were evaluated using an inaccuracy score for the student's auscultation report on three patients, selected according to a standardized procedure. After a baseline evaluation, 27 students in groups of 5–10, participated in a multimedia seminar on lung sounds during which digitized lung sounds were played and the corresponding time-expanded waveform and frequency spectrum were commented on and displayed on a computer. The remaining 21 students received conventional bedside training, acting as control group. The following week, all the students underwent a second evaluation of chest auscultation skills.

No differences in the inaccuracy score were observed between the two groups in the preliminary test. However, in the second postintervention assessment, the inaccuracy score of the students who had followed the seminar (11.2±1.3 points) was significantly lower than that of the controls (16.6±1.6 points). The answers to a feedback questionnaire confirmed that the great majority of the students found the association of the acoustic signals with their visual image to be useful for learning and understanding lung sounds.

We conclude that the exposure of inexperienced medical students to a multimedia presentation significantly boosts their learning of lung sounds compared to students receiving only conventional teaching.
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The development of powerful methods of analogic and digital signal processing and the diffusion of computers in medical settings over the recent years has provided a valuable tool for the study of the acoustic characteristics of lung sounds [1–4]. Although clinical applications of these studies are still limited [5, 6], they have already had a forceful impact on the understanding of the origin of lung sounds, leading to the development of a standardized classification based on objective acoustic characteristics [3, 7], and bringing order to a long-standing confusion of terms and adjectives [8]

A further recent development of digital technology has been the popularization of sound and video boards, allowing microcomputers to record and play images and sounds with a reasonably high definition, an ability largely covered by the term "multimedia". Multimedia technology lends itself particularly well to a teaching environment, and could be particularly useful in teaching clinically relevant sounds, such as heart and lung sounds, for which the utility of a method of acoustic reproduction, provided usually as an audio tape, has long been recognized [9, 10]. A pioneer experience of multimedia, using an analogic apparatus, was reported as early as 1971 [11]. The advantage of the use of computers as supporting devices for learning has been successfully experimented with in several medical disciplines [12–14], but only recently has it been applied to respiratory sounds [15, 16].

The present study was devised to verify whether the simultaneous presentation of sounds together with their expanded waveforms (amplitude *versus* time plots on an expanded time scale) and spectrum analysis (amplitude *versus* frequency plots) can enhance the understanding and learning of medical students approaching the study of lung sounds for the first time.

Materials and methods

Students

All of the 65 students attending the course of Respiratory Diseases in the 4th year of Medical School at the Università degli Studi di Siena in the year 1994 were invited to participate in the study. The course of Italian medical studies is structured so that this was the first course involving patient examination, except for a general course in Semeiotics, which had been held 3 months before, in which the students had limited practical experience. At the beginning of the course in Respiratory Medicine, the students were given a formal lesson on chest examination, including information on the classification and characteristics of lung sounds. Although our study was conducted within the time allotted for the course of Respiratory Diseases, participation in the study was freely chosen, and an informed consent form was given to all participants.

Study design

The course of Respiratory Medicine was held over a period of 2 months in March and April 1994, and included a weekly session of 4 h dedicated to patient examination, clinical case simulations, and attendance at clinical laboratories. To avoid overcrowding, the students were divided into five groups, all of which attended the ward for at least 1 h in each session, according to a schedule arranged so that no more than two groups were simultaneously present.

During the very first session of clinical practice, all the participating students were requested to report on a form their findings of chest auscultation of three selected patients. After the test, the students of three randomly selected groups attended a multimedia lung sound presentation session lasting approximately 1 h (see below). At the same time, the remaining two control groups attended 1 h of conventional bedside teaching on lung sounds, in which each student was allowed to listen to the chest of 4–5 patients, selected as representative of definite patterns of lung sounds, and the findings were discussed with the tutor. The following week, during the second clinical session, the students of all five groups repeated the auscultation test using the same method as on previous occasion, but with different patients

In subsequent weeks, the control students also attended the multimedia lung-sound session, without repeating the auscultation test. At the end of the course on Respiratory Medicine, all the students were requested to fill out an anonymous feedback questionnaire regarding various aspects of the organization of the course, including a few questions concerning their participation in this study.

Evaluation of auscultation skills

Each student was given a form, labelled with an anonymous identification code, on which he or she reported the auscultatory findings for each of a group of three patients, about whom no clinical information was given. The form contained a checkbox to specify whether the finding was normal or not, and separate rows to describe the characteristics and localization on the chest of breath-sound abnormalities, wheezes, rhonchi and crackles, when present.

The testing cases for the study were selected among the patients hospitalized in our 24 bed University Clinic for various respiratory diseases. Each patient was examined by three of the authors (ER, MR and PS) in the morning preceding the student's practical session, and a consensus was obtained on the relevant features present on auscultation.

The criteria for patient selection were: 1) the auscultation findings were clear and definite and a consensus on the classification of the relevant features was easily obtained; 2) their clinical condition was such that they could stand multiple chest examinations; and 3) they gave informed consent to participate in the study.

Groups of three patients to be assigned to the different groups of students were assembled according to the following criteria: 1) each group of patients would include at least one case in which crackles were present, at least one with continuous adventitious sounds (wheezes and/or rhonchi), and one with either decreased breath sound or a completely normal finding; 2) each patient would be examined by an approximately equal proportion of students of the multimedia and control groups; 3) none of the patients would be assigned twice to the same student group; and 4) the difficulty of the auscultation findings would be reasonably balanced between the different groups of patients.

We recruited seven groups of patients and each group was examined by an average of 14 students. The number of relevant features identified during the preliminary consensus auscultation as the ones that had to be detected by each student was similar in the patients examined by the multimedia and the control group, both in the preliminary and in the postintervention assessment.

The test was performed in groups of 5–10 students accompanied by a tutor, and approximately 5 min were allotted to each student for each patient. The tutor also examined the patient at least once during the session, to verify that the auscultatory findings were unchanged in patients who were considered potentially unstable.

All the forms were scored independently by two of the research team (ER and PS), without knowledge of which group they belonged to. Each researcher first considered each relevant finding, as identified in the previous consensus auscultation, evaluating whether it had been detected, undetected or misclassified (when a wrong name was given to a present feature). When localized bilateral basal crackles were present, right and left crackles were considered as two separate findings, whereas difuse rhonchi (low pitched continuous adventitious sounds), wheezes (high pitched), reduction of breath sounds and widespread crackles were each considered as a single finding. Misclassification of crackles as pleural rubs was not considered, and no distinction was made between fine and coarse crackles, as these distinctions were considered too difficult a task for students at this stage. Irrelevant misclassifications, such as reports of modest reduction of breath sounds where it was not present, were not considered unless the patient presented the opposite abnormality or they were reported as the only abnormality in that patient. Those findings fabricated by the students (reported but not present) were also counted.

Furthermore, timing (inspiratory *versus* expiratory) and localization errors (absent or incorrect data) were taken into account. The above data were then used to compute a lung sound description inaccuracy score (LSDIS) for each form. One (inaccuracy) point was assigned for each timing error, two for each localization error, and four for each undetected, misclassified or fabricated finding.

Validation of the method

To evaluate the reliability of the assessment of auscultation skills, a group of 12 respiratory medicine residents with 1–4 yrs of internship training were tested. Each subject was asked to report his or her findings on 12 patients, selected and assembled into four groups of three as described above, and the LSDIS was computed for each group as described. On a separate occasion, the auscultation skills of the same residents were evaluated using 12 digitally recorded lung sounds, selected from a published audio tape specifically designed for teaching purposes [9]. The sounds were digitized at a sampling rate of 11 kHz using a PC IBM-compatible personal computer with 16-bit audio card (SoundBlaster 16, Creative Labs, Singapore), and played through headphones with the same computer using a program written with a simple multimedia authoring system (HSC interactive, HSC Software, Santa Monica, CA, USA). The reports were evaluated as described above, with the obvious exception that sound localization was not considered.

Lung sound session

A multimedia presentation of lung sounds was always given by one author (MR). The presentation lasted approximately 60 min, was held in a small quiet room, and was attended by no more than 10 students at a time. The session consisted of a simple introduction to the basics of lung sounds and presentation of a panel of auscultatory findings previously recorded in various patients. The recording/reproducing system consisted of a custom made Phonopneumograph (EPL, Siena, Italy) based on an Atari STE microcomputer motherboard coupled to a stereo AD/DA converter, capable of a resolution of 16 bits per channel at a sampling rate of 15.5 kHz. One channel was used for the acoustic data, whilst the other was used to store respiratory movements, recorded using a pneumatic belt secured around the chest connected to a pressure transducer. The audio output of the system was connected to a series of analogue and digitals filters, amplified and fed to a speaker located in front of the audience at a distance of 6 feet from the front row at a height of 4 feet. The display was a 14 inch black and white monitor that was located just in front of the audience and was clearly seen by all the students.

Each sound was played several times and its acoustic characteristics were underscored by showing its time-expanded waveform together with the respiratory timing tracings and the graph of the acoustic power spectrum. The origins of the sound were discussed in relation to its acoustic properties, and the clinical conditions in which it was encountered were briefly reviewed. A minimum of eight sounds was presented in each session, covering normal and abnormal breath sounds (reduced breath sounds, bronchial breath), continuous adventitious sounds (wheezes and rhonchi), different types of crackles (fine, coarse, early inspiratory and late inspiratory). The students were encouraged to actively participate by requesting explanations whenever necessary, posing specific questions, and asking for replay of previous sounds.

Statistical analysis

Comparison of the number of detected, undetected and misclassified findings reported by each student in the two groups was performed using the Wilcoxon rank test. The homogeneity of the performance of residents and of the different groups of students in the baseline test was tested using Kruskal-Wallis one-way analysis by rank for discrete variables, and by one-way analysis of variance (ANOVA) on the inaccuracy score. The Spearman rank test was used to assess the correlation between LSDIS obtained in patients and on computer-transmitted lung sounds. The effect of the multimedia presentation on LSDIS was assessed by means of ANOVA, using the score obtained in the baseline test as a covariate [17]. A two-tailed α of 0.05 was used as the level of significance.

Results

Validation of the method

Multifactor ANOVA of LSDIS obtained by 12 residents on four different groups of patients failed to detect significant differences in LSDIS between the groups of patients (p=0.17), whilst a significant difference (p=0.03) was present between residents. Average LSDIS scored by individual residents ranged 3.6–16.6, with a mean of 8.1±1.0. These data indicate that our method was able to detect significant differences in auscultation skills among the residents, and that the criteria for selecting and assembling the patient groups were sufficiently reproducible. When these results were compared to the scores obtained by the same doctors evaluating computer-recorded sounds, most of them tended to perform slightly better with the latter, and no significant correlation was found between the LSDIS obtained by the same subject with the two methods (Spearman's rho= 0.41; NS).

Effect of multimedia presentation on students

Fifty four students agreed to participate in the study, 29 attending the multimedia seminar and 25 the control bedside teaching session; 48 of them completed the study, 27 in the multimedia and 21 in the control group.

Table 1. – Auscultation skills during preliminary and postintervention assessment

	Preliminary		Postintervention	
	Controls	MM	Controls	MM
Total number of findings*	102	133	116	155
Student results				
Detected	56 (55)	60 (45)	66 (57)	98 (63)
Undetected	27 (26)	40 (30)	39 (34)	42 (27)
Misclassified	19 (19)	33 (25)	11 (9)	15 (10)
Fabricated	25 -	18 -	26 -	7* -
Localization errors	10 -	22 -	10 -	8 -
Timing errors	27 -	16 -	26 -	32 -

*: total number of ausculatory findings which students should have detected. Values in parenthesis are percentages of the total number of findings possible. MM: multimedia; *: p<0.01 *vs* controls.

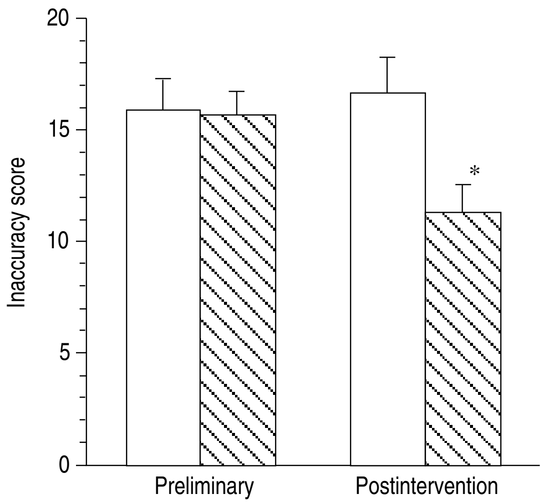

Fig. 1. – Lung sound description inaccuracy score (LSDIS) of students before and after attending the multimedia seminar (▧) or conventional teaching (controls) (□). Data are presented as the mean and SEM. *: multifactor ANOVA p<0.01 *vs* conventional teaching.

Table 2. – Type of fabricated sounds during preliminary and postintervention assessment

	Preliminary		Postintervention	
	Controls	MM	Controls	MM
Abnormal breath sounds	10	7	12	1
Wheezes	2	3	0	1
Rhonchi	4	1	2	2
Crackles	7	4	9	3
Undefined	2	3	3	0

Since the composition of the five original groups of students attending the clinical session was not properly randomized, we first checked the homogeneity of the performance of the different groups in the baseline test. No significant differences between the groups were found in the number of detected, undetected, misclassified and fabricated findings or in the LSDIS. Minor differences were found in the localization and timing fault scores, with one group being significantly worse in the first and better in the latter, compared to the other groups.

In the preliminary test, no significant difference in the LSDIS or in any of the parameters of the study was found between intervention (multimedia seminar) and control students (table 1). By contrast, in the postintervention assessment, the mean LSDIS of students who attended the lung sounds session was significantly decreased compared to baseline, and was significantly better than that of controls (fig. 1), whereas LSDIS of the controls did not change compared to baseline.

Among the various parameters used to compute the LSDIS, the number of detected features in the postintervention assessment was slightly higher and the number of undetected and misclassified features and that of localization and timing faults were lower in the intervention group than in the controls (table 1). However, only the difference in the number of fabricated features reached statistical significance (p<0.01). The analysis of the different type of fabricated sounds showed a reduction of undefined and breath sound abnormalities reported by the multimedia group, whereas adventitious sounds were less affected (table 2).

Feedback questionnaire

The feedback questionnaire was filled out by 55 students, 52 of whom had attended the lung sounds session. Of these, only one reported that the session had a deleterious effect on the learning of respiratory sounds, four that it had no effect, 39 reported a positive, and seven a very positive effect. Similarly, 85.5% of the students thought that the association of lung sounds with their visual image was useful, and 87.5% would recommend attending the seminar to other students, with the remaining 12.5% indifferent, and none suggesting not going. Regarding a possible computer program to be used by the students singly, only 56% of the students thought that it could be useful, whereas 13% disagreed and 31% were uncertain, sometimes adding as a note that they had no experience with computers. Finally, regarding their participation in the study, 51 of the students reported that performing the auscultation test was interesting or fun, one student that it was indifferent, and none found it tiring or boring.

Discussion

Our data indicate that the exposure of inexperienced medical students to a multimedia presentation of acoustic and graphic characteristics of lung sounds significantly boosts their learning process compared to students receiving only conventional teaching.

Several factors might have contributed to this difference. The effectiveness of bedside teaching could have been reduced by the limited availability of representative patients, by a shorter time dedicated to each student because of the need for individual auscultation, or by a lower motivation of the tutors compared to the teacher performing the multimedia presentation. However, the main difference between the two methods was undoubtedly the different type of information offered to student. We did not distinguish between the effect of using multimedia and that of giving additional information on the analysis of lung sounds, as these two aspects are deeply intertwined. The concepts on which the current classification of lung sounds is founded are themselves multimedial in nature [1, 3], and computer multimedia seemed to be just the best method available for their presentation. We suggest that the combination of acoustical, graphical and analytical representation of sounds provides a homogeneous set of information that is more easily fixed in memory and may match different learning styles [18]. This was, in part, confirmed by the feedback questionnaire, where the vast majority of the students reported that they found the association of acoustical and graphical sound representation to be useful for learning and understanding lung sounds.

It is interesting to note that, although all the parameters of lung auscultation used to compute the LSDIS were slightly improved in the multimedia group compared to controls (table 1), most of the effect of multimedia presentation on the cumulative LSDIS is due to a reduction in the number of fabricated findings, especially undefined and abnormal breath sounds. We speculate that students who are beginners are biased toward an excessive expectancy of sound abnormalities, and that a better knowledge of the origin and of the acoustic properties of lung sounds after the multimedia presentation could have induced an attempt at more precise identification of sounds, thus reducing the number of fabricated sounds.

Our data confirm a previous study indicating that practising with a multimedia computer program does improve the proficiency of medical students and residents in the recognition of recorded lung sounds [15]. Unlike that study, we used the computer as an aid for a small-group seminar, rather than using a program for individual use. Although this approach partially conflicts with the philosophy of personal computing, based on unrestricted individual usage of computing resources, we found that is also presents significant advantages. The first is that setting and maintaining a multimedia computing classroom with enough machines to guarantee sufficient access to all the students, not to mention the need for periodically upgrading the hardware at the current fast development rate of technology, may be prohibitively expensive, and most academic sites, including our university, do not provide such a facility [19, 20]. Using only one machine is cheaper, and any hardware or software upgrade is immediately available for all the classroom.

The second advantage of our approach is that it does not require previous computer experience by part of the students, or additional learning of program instructions and commands. Despite the increasing popularity of personal computing, the growth of educational computing in the academic setting is relatively slow as compared to the business environment, and sufficient computer skill cannot be expected in all the medical students [20]. It is noteworthy that, despite a general agreement on the computer approach on learning lung sounds, only 56% of our students reported that they would find a teaching program useful for individual use, mostly because they had limited experience with computers. Since the groups attending the multimedia presentation were kept relatively small, it was still possible for the students to participate interactively in the presentation, partially overcoming one of the possible drawbacks of this method compared to the individual use of a computer. We found this approach to be more satisfactory than giving a single seminar to the whole class in a large lecture room, using the same computer connected to a large-screen video-projector, as we had done the previous year.

Our method of evaluation of lung auscultation skills was also different from that used in previous studies, where the ability to detect lung sounds correctly was assessed on sounds previously recorded on audio tape [15]. Although that method allows a better standardization of the test sounds, we are not fully convinced of the quality and the realism of tape-recorded lung sound. We therefore preferred a more realistic test based on auscultation of actual patients, which also offers the opportunity of evaluating some aspects of lung sounds, such as timing and localization, that cannot be assessed on audio tape [11].

We certainly do not imply that a multimedia seminar can completely replace conventional bedside teaching in medical training, including teaching of auscultation skills. However, time and emphasis dedicated to physical examination in medical training has recently decreased, mostly because of the increasing amount of knowledge and technologies coming to medicine from basic sciences [21–23], whereas proper knowledge of lung auscultation is probably no less important today, when lung sounds have been rationally and reproducibly classified [3, 7, 24], and their pathogenetic mechanisms and clinical significance are increasingly known [25, 26]. In this perspective, being able to shorten and ease the learning curve of chest auscultation, multimedia presentation of lung sounds may improve the proficiency of the students in subsequent clinical activities.

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