Pulmonary Auscultatory Skills During Training in Internal Medicine and Family Practice

SALVATORE MANGIONE and LINDA Z. NIEMAN

Center for Research in Medical Education, Jefferson Medical College, Philadelphia, Pennsylvania; and Department of Family Practice and Community Medicine, University of Texas, Houston, Texas

We conducted a multicenter, cross-sectional assessment of pulmonary auscultatory skills among medical students and housestaff. Our study included 194 medical students, 18 pulmonary fellows, and 656 generalists-in-training from 17 internal medicine and 23 family practice programs in the Mid-Atlantic area of the United States. All participants listened to 10 pulmonary events recorded directly from patients, and answered by completing a multiple choice questionnaire. Proficiency scores were expressed as the percentage of respondents per year and type of training who correctly identified each event. In addition, we calculated a series of cumulative scores for sound recognition, disease identification, and basic knowledge of lung auscultation. Trainees' cumulative scores ranged from 0 to 85 for both internal medicine and family practice residents (median = 40). On average, internal medicine and family practice trainees recognized less than half of all respiratory events, with little improvement per year of training, and were not significantly better than medical students in their scores. Pulmonary fellows had the highest diagnostic and knowledge scores of all groups. These data indicate that there is very little difference in auscultatory proficiency between internal medicine and family practice trainees, and suggest the need for revisiting these time-honored skills during residency training. Mangione S, Nieman LZ. Pulmonary auscultatory skills during training in internal medicine and family practice. AM J RESPIR CRIT CARE MED 1999;159:1119–1124.

The invention of the stethoscope was the brainchild of a diminutive, asthmatic, and very shy French physician, confronted in 1816 with the "inadmissible" (1) task of placing his naked ear over the naked chest of a young female patient. A "cylinder" of rolled-up paper, subsequently made of wood, was the clever way out of this predicament, and the dawn of a new era in medical diagnosis.

If heart sounds were the first acoustic events detected by Laennec's cylinder, it was the lung that subsequently became the primary target of the stethoscope. In the decade preceding his premature death, Laennec used this tool extensively, correlating auscultatory findings with autopsy data and thus laying the foundation for a clinicopathologic classification of lung sounds. He was so enamored of his little tool as to become known in Parisian medical circles as "the cylindromanic" (2).

After Laennec's death in 1826, most of the clinical interest in stethoscopy turned gradually toward the more complex area of cardiac auscultation. Only over the past two decades has this shift stopped and possibly reversed, thanks to the application of computer technology to the analysis of respiratory sounds. This in turn has led to the creation of the International Lung Sound Association (ILSA), whose activities have consisted of a yearly international research conference and even the maintenance of a website, inclusive of respiratory sounds that can be downloaded at no cost. This renaissance of lung auscultation was recently acknowledged by a series of editorials in leading pulmonary and physiology journals (3–5), by a state of the art review (6), and by the European Commission's support of a multinational project dedicated to the standardization of computerized respiratory sound analysis (CORSA project [Contract No. BMH1-CT94-0928/DG12SSMA]).

Although applied research in the field of pulmonary auscultation has grown sharply, it is not clear whether this rekindling has translated into improved clinical skills or educational practices during training. There is actually evidence to the contrary. For example, in a national survey of internal medicine and family practice residencies, we recently found that only one out of 10 programs in the United States offered any structured teaching of pulmonary auscultation (7) (as opposed to one out of four programs for cardiac auscultation [8]), and that program directors still consistently attributed much less importance to this skill than to cardiac auscultation.

To better elucidate whether the decreased emphasis given to lung auscultation during residency might have actually led to a lesser degree of proficiency among trainees than that for cardiac auscultation, we surveyed the respiratory auscultatory skills of a large group of internal medicine and family practice residents of the Mid-Atlantic area, and compared their accuracy with that of a control group of medical students and pulmonary fellows.

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Correspondence and requests for reprints should be addressed to Dr. S. Mangione, Center for Research in Medical Education and Health Care, Jefferson Medical College, 1025 Walnut Street, Suite 121, Philadelphia, PA 19107. E-mail: mangione@auhs.edu.

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METHODS

Subjects

We assessed the auscultatory skills of 656 generalists-in-training. These participants comprised 404 trainees in internal medicine and 252 trainees in family practice, from 17 and 23 residency programs, respectively, in the Mid-Atlantic area. Ten of the 17 internal medicine programs were located in Pennsylvania (of these, nine were in Philadelphia); the remaining seven internal medicine programs were based in New Jersey, Maryland (two), Delaware, Washington, DC (two), and New York State. Eighteen of the 23 family practice residency programs were located in Pennsylvania. The remaining five were located in Maryland (two), Delaware, Washington, DC, and New York State. Twelve of the 17 internal medicine programs from which trainees were tested were based in university hospitals and five were in non-university hospitals. Thirteen of the 23 family practice programs tested were suburban and 10 were rural.

In addition to these generalists-in-training, we included in our study: (*1*) 194 third and fourth year medical students (whose proficiency provided a baseline comparison for the trainees' performance); and (*2*) 18 fellows in pulmonary and critical care medicine from six different training programs (whose proficiency provided a high-end comparison for the trainees' performance).

Proficiency Testing

The evaluation of auscultatory proficiency was arranged as a 1-h patient-management conference, incorporated into the teaching schedules of the various programs. The first half of the conference tested the trainees' proficiency and the second half didactically reviewed the various breath sounds and adventitious lung sounds used in the test. The evaluation instrument consisted of three modules. The first two modules tested the sound-recognition and clinicopathologic identification of 10 respiratory events directly recorded from patients. These events were selected from a pool of more than 100 sounds. Each was recorded analogically into a high-fidelity audiocassette player (PMD-430; Marantz, Chatsworth, CA), using an electret microphone encased in a Littmann Classic II stethoscope headpiece (3M Health Care, St. Paul, MN). Sounds were subsequently digitized into a microcomputer (MacIntosh SE30; Apple Computer Inc., Cupertino, CA), with which their waveforms were analyzed (MacRecorder; Farallon Computing, Berkeley, CA) and the final 10 events chosen on the basis of the purity of their sounds and good reproduction of findings typical of the corresponding disease process. Each selected event was subsequently recorded with a high-fidelity cassette deck (CR W85; Fisher Corp., Chatsworth, CA) and played back using a high-fidelity audiocassette player (PMD430; Marantz), an infrared wireless sound transmitter (SimulScope; Cardionics Inc., Houston, TX), and individual wireless infrared stethophones (HeartMan Infrared Stethophones, Model 718-7040; Cardionics, Inc.). A description of each sound sample, based on the interpretation of the waveform, and with the corresponding disease process, is reported in Table 1.

Participants listened to each event for little less than 1 min, although they had the opportunity to listen again as needed. After hearing the event, they answered a multiple choice questionnaire regarding all auscultatory findings. In a forced-response format, they put in a check-mark for whether a particular finding was present or absent, and then selected characteristics that best described it.

In addition to measuring the correct identification of each respiratory event, we also generated a series of scores. In this regard, the various items in our multiple choice questionnaire were scored as $+1$ (answered correctly) or -1 (answered incorrectly or left blank). A cumulative score (CS) was thus created by summing the individual scores and then expressing the result as a percentage of the highest allowed score. The CS ranged from 100 to -100, depending on whether all items were selected correctly or incorrectly. In addition, a diagnostic score (DS) was also generated for those items that were diagnostic of each of the 10 respiratory events. There were 12 such items in our test, and the DS was therefore expressed as the percentage of these 12 questions that was answered correctly. As a further step, for each auscultatory event participants were asked to select from a list of 10 diseases the one most likely to have been responsible for its generation. A disease recognition score (DRS) was then expressed as the percentage of these questions answered correctly.

The third module of our test was based on a 21-item multiple choice questionnaire of participants' knowledge of lung auscultation. A knowledge score (KS), expressed as the percentage of all questions answered correctly, was then generated for each participant.

The internal reliability of the DRS and KS was estimated by determining a coefficient alpha. The coefficients (0.41 for DRS and 0.46 for KS) were low enough as to suggest considerable heterogeneity among the items.

Attitudes Survey

Participants also completed a one-page attitude questionnaire. This component of our study was administered prior to the proficiency testing. This 13-item questionnaire assessed the residents' self-motivated learning and personal interest in pulmonary auscultation. Items included the importance attributed to lung auscultation, the need to devote more time to its teaching during medical training, the amount of auscultatory instruction received during medical school or residency, and the respondent's confidence with his or her own pulmonary auscultatory skills. Other variables assessed whether respondents had any special interest in music and whether they could play a musical instrument. We included these two items to determine whether any "training of the ear," independent of the motives for pursuing it, might have helped achieve a greater auscultatory proficiency.

Statistical Analysis

Two major questions were addressed, as follows: (*1*) At each level of training (from medical school to pulmonary fellowship), is there an improvement in trainees' proficiency with lung auscultation? (*2*) To what degree do trainees improve in their proficiency over the 3 yr of internal medicine or family practice residency? Each question was analyzed by a trend-analysis chi-square across the three categories of interest (students, residents, and pulmonary fellows) and across the 3 yr of residency (both for internal medicine and family practice). In addi-

TABLE 1

DESCRIPTION OF THE VARIOUS RESPIRATORY EVENTS USED FOR THE TEST AND THEIR CORRESPONDING DISEASE PROCESSES

Event No.	Breath Sound	Adventitious Lung Sounds/Transmitted Voice Sounds	Clinicopathologic Correlation
Event 1	Bronchial	None	Consolidation (alveolar collapse/patent bronchi): atelectatic lung overlying a pleural effusion
Event 2	Vesicular	Late inspiratory crackles	Pulmonary fibrosis
Event 3	Vesicular	Panexpiratory polyphonic wheeze	Bronchospastic airways
Event 4	Vesicular	None	Normal lung
Event 5	Vesicular	Expiratory rhonchus	Bronchospastic airways
Event 6	Vesicular	Pleural friction rub	Pleuritis
Event 7	Bronchial	Late inspiratory crackles	Consolidation (alveolar filling/patent bronchi): lobar pneumonia
Event 8	Vesicular	Late inspiratory crackles/late inspiratory squeak	Pulmonary fibrosis
Event 9	Bronchial (amphoric variety)	Late crackles/expiratory rhonchus	Cavitary pneumonia
Event 10	None	Whispered pectoriloquy	Consolidation

tion, chi-square tests were used to compare medical students with residents, residents with fellows, and first-year residents with third-year residents. Trainees' attitudes toward lung auscultation were analyzed with Student's *t* test and chi-square tests.

RESULTS

Twenty-nine generalists-in-training were excluded from analysis because they either did not indicate their year of residency (n = 20) or were of a postgraduate year greater than 3 (n = 9). The remaining 627 residents (387 of 404 for internal medicine and 240 of 252 for family practice), 194 medical students, and 18 pulmonary fellows represented our final study sample (Table 2). Although the fellows we tested were fewer in number than either residents or medical students, we still opted to include them in our final analysis because they provided a valuable "high-end" comparison for the residents' performance. Because our study assessed both proficiency in and attitudes toward pulmonary auscultation, we shall discuss these two points separately.

The Proficiency Test

Table 3 outlines the various scores of our test. Internal medicine and family practice residents' DSs were significantly higher than medical students', but lower than those of fellows. Family practice residents had higher DRSs than did internal medicine residents, but lower KSs. Pulmonary fellows had the highest DSs and KSs of all groups. There were no significant differences in any of the four scores when comparing first and third year residents, regardless of the program type.

When analyzing improvement from third to fourth year medical students, we found a significant increase in both the DS and DRS ($p = 0.001$ and 0.002, respectively) and in the CS ($p = 0.02$). There was, however, no significant improvement in the KS.

Figure 1 indicates the frequency of identification for the various auscultatory events in our test, based on participants' level and type of training. There was never a significant improvement, as a result of training, from medical students to internal medicine or family practice residents. The only exception was in the identification of the vesicular breath sound, which family practice residents recognized significantly more often than medical students, at 48.3% versus 38.1%, respectively ($p = 0.04$). There was, however, a significant improvement from family practice residents to pulmonary fellows in three of the 10 events tested, and from internal medicine residents to pulmonary fellows in five of the 10 events tested. Similarly, there was significant improvement from medical students to pulmonary fellows in six of the 10 events tested.

There was no significant improvement across the 3 yr of internal medicine or family practice residency (Figure 2). On the other hand, there was a significant improvement from third- to fourth-year medical students in recognition of the bronchial breath sound (45.1% versus 69.4%, respectively, $p = 0.001$), and in recognition of the vesicular breath sound with late-inspiratory crackles (13.1% versus 25%, respectively, $p = 0.035$).

The Attitudes Survey

Overall, internal medicine and family practice trainees did not differ significantly in the importance they attributed to pulmonary auscultation (mean $\pm$ SD $= 5.5 \pm 0.9$ and 5.6 ± 0.9, respectively, on a scale of 1 to 6, with 6 indicating the highest importance). Family practice residents, however, had both sought and received significantly more teaching of this skill than had their internal medicine colleagues. For example, they had used pulmonary audiotapes significantly more often (68.9% versus 17%, $p < 0.001$); they had also received significantly more training in pulmonary auscultation during both medical school and residency training (89.6% versus 67.1% and 43.2% versus 15.9%, respectively, both $p < 0.001$). Yet family practice trainees felt less confident than internal medicine residents about their own auscultatory skills (mean $\pm$ SD $= 2.8 \pm 1.1$ versus 3.3 ± 1.1, respectively, $p < 0.001$ on a scale of 1 to 6, with 6 indicating the highest confidence). They also wished more time to be devoted to auscultatory teaching during medical school (mean $\pm$ SD $= 5.5 \pm 0.9$ and 5.2 ± 1.0, respectively, on a scale of 1 to 6, both $p = 0.001$).

When comparing all internal medicine and family practice trainees who had received auscultatory teaching during residency with those who had not, we found that trainees with teaching had a significantly greater confidence in their own auscultatory skills (mean $\pm$ SD $= 3.7 \pm 1.2$ versus 3.2 ± 1.1, respectively, $p = 0.01$ on a scale of 1 to 6). This confidence (which was significantly greater than that of trainees for their own cardiac auscultatory skills, as reported in our previous study [9]), did not, however, translate into a much greater accuracy. Only the DS was significantly higher as a result of the teaching received (42.9 ± 16.8 versus 38.4 ± 14.9, $p = 0.04$). All other scores were not significantly different for the two groups.

TABLE 2

NUMBER AND PERCENTAGE OF PARTICIPANTS IN THE PROFICIENCY TEST, DISTRIBUTED BY PROGRAM AND YEAR OF TRAINING*

Year of Training	Medical Students	Internal Medicine	Family Practice	Pulmonary Fellows	Total†
Medical students					
MS3	122 (62.9)	—	—	—	122 (14.5)
MS4	72 (37.1)	—	—	—	72 (8.6)
Residents					
First year	—	179 (46.3)	86 (35.8)	—	265 (67.6)
Second year	—	108 (27.9)	80 (33.3)	—	188 (22.4)
Third year	—	100 (25.8)	74 (30.8)	—	174 (20.7)
Fellows					
First year	—	—	—	9 (50.0)	9 (1.1)
Second year	—	—	—	3 (16.6)	3 (0.4)
Third year	—	—	—	4 (22.2)	4 (0.05)
Fourth year	—	—	—	2 (11.1)	2 (0.02)
Total	194 (100.0)	387 (100)	240 (100)	18 (100)	839 (100)

* MS3 indicates third-year medical students; MS4, fourth-year medical students, and —, not applicable.
† Because of rounding, percentages do not total to 100%.

TABLE 3

DIAGNOSTIC AND CUMULATIVE SCORES FOR THE VARIOUS AUSCULTATORY EVENTS, DISEASE RECOGNITION SCORE, AND KNOWLEDGE SCORE OF MEDICAL STUDENTS, INTERNAL MEDICINE AND FAMILY PRACTICE RESIDENTS, AND PULMONARY FELLOWS

Scores for All 10 Events	Students (*n* = *194*) Mean (SD)	IM Residents (*n* = *387*) Mean (SD)	FP Residents (*n* = *240*) Mean (SD)	Fellows (*n* = *18*) Mean (SD)
DS*	34.9 (16.8)	38.2 (15.3)	39.8 (15.6)	56.1 (12.5)
CS†	36.8 (18.1)	38.4 (17.7)	40.2 (14.8)	44.9 (16.3)
DRS‡	8.6 (11.3)	10.1 (11.8)	15.0 (11.6)	12.8 (22.2)
KS§	37.7 (17.6)	44.1 (17.6)	38.7 (17.19)	51.9 (11.3)

Definition of abbreviations: CS = cumulative score; DRS = disease recognition score; DS = diagnostic score; FP = family practice; IM = internal medicine; KS = knowledge score.

Scores were expressed as mean ± SD of the percentage of diagnostic findings recognized (DS), of the total number of acoustic findings recognized (CS), of the percentage of disease processes accurately matched to each event (DRS), and of the percentage of knowledge questions answered correctly (KS). For more information on the characteristics and calculation of the various scores, refer to the METHODS section.

* IM Residents versus Students, $p = 0.02$; FP residents versus students, $p = 0.002$; fellows versus students, $p < 0.001$; fellows versus IM residents, $p < 0.001$; fellows versus FP residents, $p < 0.001$.

† FP residents versus Students, $p = 0.032$.

‡ FP residents versus students, $p < 0.001$; IM residents versus FP residents, $p < 0.001$.

§ IM residents versus Students, $p < 0.001$; IM residents versus FP residents, $p < 0.001$; fellows versus FP residents, $p = 0.002$; fellows versus IM residents, $p = 0.01$; fellows versus students, $p = 0.001$.

Trainees who could play a musical instrument had significantly higher DSs than those who could not (43.4 ± 16.4 versus 38.6 ± 11.2, respectively, $p = 0.01$), although this difference did not persist when a self-declared "special interest in music" became the only discriminating variable. No other scores were significantly different for the two groups.

DISCUSSION

This study was part of a two-pronged investigation by the American Academy of Family Physicians, aimed at assessing the status of two very important bedside skills: cardiac and pulmonary auscultation. Proficiency data relative to cardiac auscultation were reported in a previous publication (9).

Time-honored skills such as chest auscultation are essential filters for a more intelligent use of diagnostic technology (10–12). As a result, they have become the focus of recent attention since the advent of managed care and its renewed emphasis on more ambulatory and cost-effective medical care. Yet bedside skills such as auscultation still remain largely ignored in residency curricula. Structured teaching of lung auscultation, for example, is almost absent during primary-care training (7). The teaching of cardiac auscultation is also very much underrepresented (8). A decreased emphasis during training and the ever increasing reliance on technology-based diagnosis are probably responsible for the poor auscultatory proficiency we found among trainees.

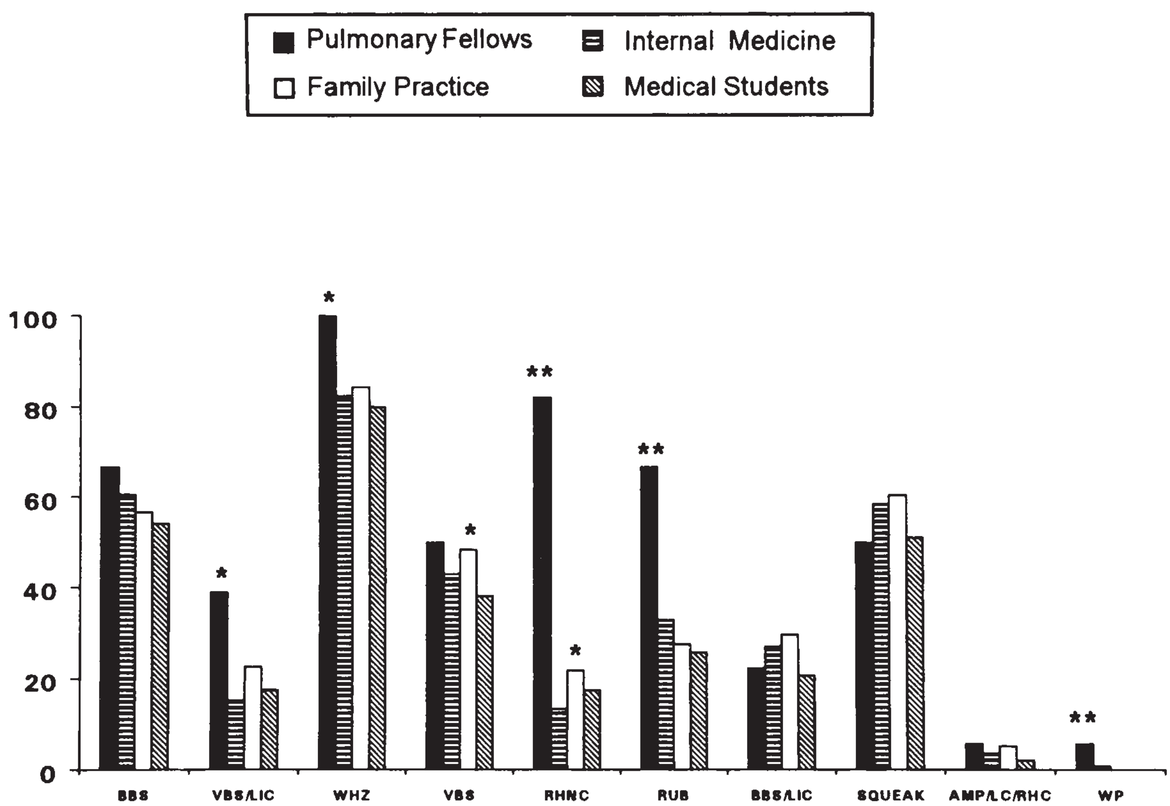

Figure 1. Identification rates according to type of training. Accuracy in identifying the ten respiratory events is reported as a percentage of correct answers and shown for medical students, internal medicine and family practice residents, and pulmonary fellows. BBS, bronchial breath sounds; VBS/LIC, vesicular breath sounds and late-inspiratory crackles; WHZ, expiratory wheeze; VBS, vesicular breath sounds; RHNC, expiratory rhonchus; RUB, pleural friction rub; BBS/LIC, bronchial breath sounds and late inspiratory crackles; SQUEAK, late inspiratory squeak; AMP/LC/RHC, amphoric breath sounds, late-inspiratory crackles and expiratory rhonchus; WP, whispered pectoriloquy. Significance is reported for differences in proficiency among the participating groups when compared to each other (*p value < 0.05; **p value < 0.005)

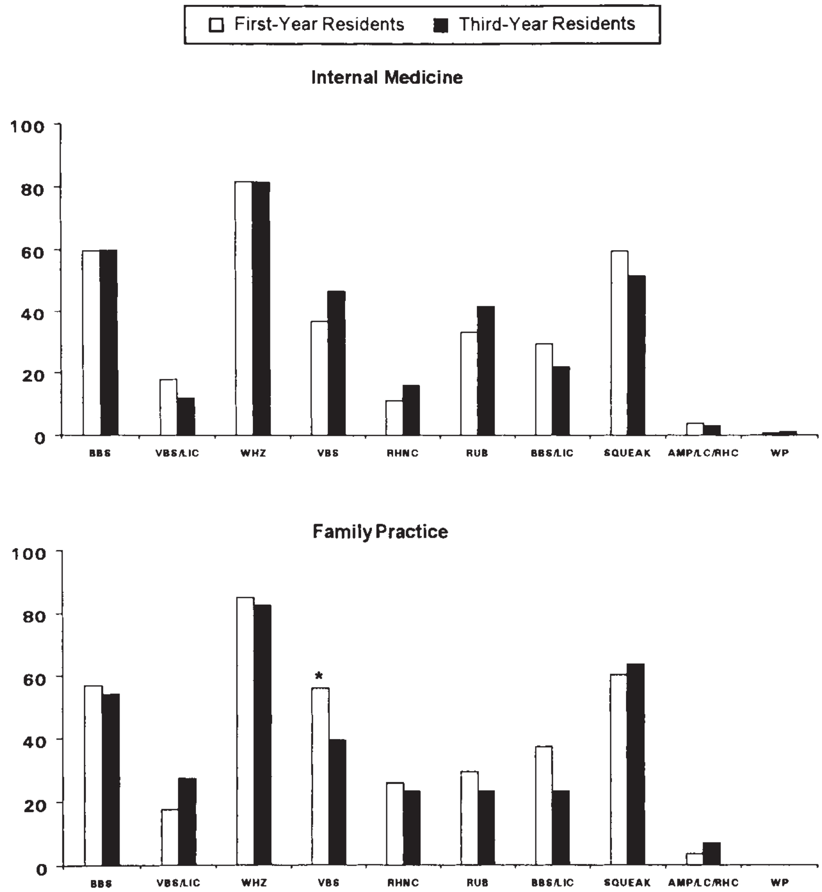

Figure 2. Identification rates according to year of training. Accuracy in identifying the ten respiratory events is reported as a percentage of correct answers and shown for internal medicine and family practice residents. BBS, bronchial breath sounds; VBS/LIC, vesicular breath sounds and late-inspiratory crackles; WHZ, expiratory wheeze; VBS, vesicular breath sounds; RHNC, expiratory rhonchus; RUB, pleural friction rub; BBS/LIC, bronchial breath sounds and late inspiratory crackles; SQUEAK, late inspiratory squeak; AMP/LC/RHC, amphoric breath sounds, late-inspiratory crackles and expiratory rhonchus; WP, whispered pectoriloquy. Significance is reported for change over time across internal medicine or family practice training (*p values < 0.05)

Although trainees' proficiency was generally poor, we did find a significant difference between accuracy in pulmonary auscultation (40% on average) and accuracy in cardiac auscultation (20% on average). This difference occurred, paradoxically, despite the lesser extent of teaching devoted to lung auscultation during residency training. A probable reason for the difference is that lung sounds are easier to identify. This may also be the reason why trainees had greater confidence in their respiratory auscultatory skills as opposed to their cardiac auscultatory skills.

Lung auscultation is easier than cardiac auscultation because it allows more time for the identification of less numerous and more easily audible acoustic signals. Sounds of the lungs are: (*1*) higher-pitched; (*2*) scattered across a longer time interval (2 to 3 s for the average respiratory cycle, as compared with 0.8 s for the average cardiac cycle); and (*3*) rarely present as more than two or three acoustic findings per event (whereas in cardiac auscultation, there may be as many as four to five findings in a cardiac cycle of only 0.8 s). Not surprisingly, our trainees had the greatest difficulty when challenged by respiratory events containing two or more acoustic findings.

That recognizing lung sounds might be easier than recognizing cardiac sounds was confirmed by a recent study that we conducted among a group of third-year medical students (13). Students had higher identification scores for pulmonary than for cardiac sounds. Moreover, supplementary auscultatory teaching led to higher recognition and disease identification scores for cardiac but not for pulmonary sounds. This suggests that additional teaching of chest auscultation is beneficial in improving the identification of heart sounds and murmurs, but may have little impact on pulmonary auscultatory proficiency.

Despite being easier than cardiac auscultation, pulmonary auscultation remains hampered by a descriptive and confusing terminology, often relying on onomatopoeic words, and greatly modified since the original classification by Laennec. These limitations were not entirely resolved by the standardization done in 1976 by the ILSA and immediately adopted by the American Thoracic Society (14, 15). Indeed, various subsequent studies have shown that pulmonary auscultatory terminology remains widely variable and often outdated (16, 17). Thus, the low identification rate of the rhonchus in our study might have reflected not only trainees' difficulty with sound recognition, but also a problem with terminology. This conclusion is supported by a study conducted in 1988 among a large group of physicians, which showed that more than 50% of all participants could not accurately describe the rhonchus (18), and who in a "free form" questionnaire instead used various other terms for this sound.

The "forced-response" format of our multiple choice questionnaire, on the other hand, might have paradoxically favored the recognition of the late-inspiratory squeak, a finding described only recently in the pulmonary literature (19). Indeed, it might have been easier for our trainees to match the questionnaire item "late-inspiratory squeak" with a "squeaky" inspiratory sound. That this might have been the case was confirmed by the finding that on average, only 5% of these same trainees could properly interpret the squeak as a sign of pulmonary fibrosis. In fact, trainees' ability to recognize the various sounds of our test did not translate into an ability to clinically interpret them. This discrepancy might also have reflected the lesser time and importance devoted to lung auscultation (as opposed to cardiac auscultation) during residency.

Thus, problems with terminology probably explained some but not all of the inaccuracies demonstrated by our trainees. Individual skill and knowledge still played a role in accuracy. It is of interest, for example, that in the study by Wilkins and colleagues only 32% of pulmonologists and 11% of nonpulmonary physicians were able to accurately identify a pleural friction rub (18), an accuracy even lower than that found in our study. This suggests once again that difficulty in properly interpreting the various respiratory events remained an important factor in the individual performance of our subjects.

One of the limitations of our study is that we used recorded sounds without providing any historical information about their sources. It can be argued that physicians' ability to recognize electronic sounds may correlate poorly with bedside skills, and that subtracting clinical history from physical examination eliminates an important guide toward accurate diagnosis. We tried to overcome this possible limitation by using only high-quality sounds, and by relying on stethophones and cassette decks of high fidelity. The validity of our method was demonstrated by the greater auscultatory accuracy of pulmonary fellows than of other subjects, indicating that each trainee's performance more strongly reflected the skills of the individual than the limitations of the test.

In summary, this study indicated some degree of difficulty among generalists-in-training in properly identifying 10 commonly encountered respiratory events. Trainees were incorrect in more than half of their identifications, improved little with higher year of training, and were not more accurate than a group of medical students. Thus there is a need for revisiting this skill during residency, although this is not as strong as the need to revisit cardiac auscultation. To rekindle interest and proficiency in chest auscultation will probably require a substantial effort at the bedside, as well as a considerable shift in attitudes about the teaching and testing of these skills among trainees. Achieving proficiency may still be difficult, however, even after considerable investment of time and effort. The challenge to educators is whether such investment is still warranted, particularly in our times of increasingly sophisticated diagnostic technology.

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