Stethoscope: advances in sound chracterization and representation and perspective in teaching

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We read with interest the paper by Bank et al. entitled “The 200th anniversary of the stethoscope: Can this low-tech device survive in the high-tech 21st century?” published in the Journal (**1**). The stethoscope and the semantic of auscultatory findings were invented more than 200 years ago by the French Physician R.T. Laennec and over the years very few changes have been made to both the stethoscope itself and the way in which it is used. More recently, we have seen advances in the techniques used to process auscultatory signals, as well as in the analysis and clarification of the resulting sounds (**2**).

The physical characterization of physiological and pathological sounds in humans is still at a fledgling stage and has not yet resulted in reliable documentation, especially not in the field of pulmonary auscultation (**2**). The situation is somewhat similar in the field of cardiology. However in this latter, more precise data, essentially based on phonocardiography, are available, outdated as they may be (**3**). Analysis and characterization of auscultation sounds have been totally neglected by practicing physicians and any major improvements that have been made were primarily in auscultatory tools, i.e., the new intelligent communicating stethoscope systems (for review see the reference [**3**]).

In practice, auscultation diagnoses are often made based solely on past experience of the practitioners, and rely more on intuition than on rigorous and systematic classification systems. However in recent years, various studies have endeavored to characterize, identify and describe sounds in greater detail, especially in the respiratory field (for review see the reference (**3**). Whilst conventional stethoscope auscultation is subjective, hardly sharable, and interpreted by a single clinician, the characterization and identification of sounds by computer-based recording and analysis systems provide objective and early diagnostic help along with better sensitivity and reproducibility when interpreting findings (**2**). Thus, the availability of new technologies opens up interesting perspectives in the field of diagnostic tools, and also in education (**3**). The precise definition of these physical characteristics and the availability of new visual representations of sounds constitute exciting perspectives for teaching and pedagogy. The new intelligent communicating stethoscope systems could possibly contribute to a new auscultatory semiology, based on reliable methods of signal analysis and on visual display, and will be complementary to the acoustic signals perceived by the practitioner (**3**).

A study, conducted by our group, with a population of medical not graduate students allowed us to quantify better diagnostic "performance" with new auscultatory signal visualization tools in a setting of heart and lung disease assessment (**4**). We asked a cohort of medical graduate students (n = 30) to listen to 10 sounds in order to diagnose heart and lung pathology. Not graduate students (second cycle of the medical studies) in first heard 10 sounds, they were then asked to check the appropriate box corresponding to the diagnosis relative to the sound they had just heard, as with an acoustic stethoscope (Day 0). The same exercise was conducted by adding the visual representation of the sound with phonopneumogram or phonocardiogram and spectrograms (Day 28). At Day 0, the correct response rate was 40 to 51%. In the second instance at Day28, the rate of correct diagnosis reached 70 to 89%. *Table 1* and *Table 2* present the detail of these data. Analysis of this table shows that the improved performance (rate of correct diagnosis) is particularly significant for cardiac pathology. Thus in our experience, addition of visual representation of sounds has significant implications in terms of medical education, and also in term of decision-making, potential patient safety, and cost control.

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Figure 1. Representation of a recording of a lung auscultation in a normal subject in the form of a phonopneumogram (1a) and a spectrogram (1b) (*data collected in the ASAP and PRI projects*).

Table 1 and 2. Results of the use of new tools as phono- and spectrogram for visualizing sounds in 30 medical students

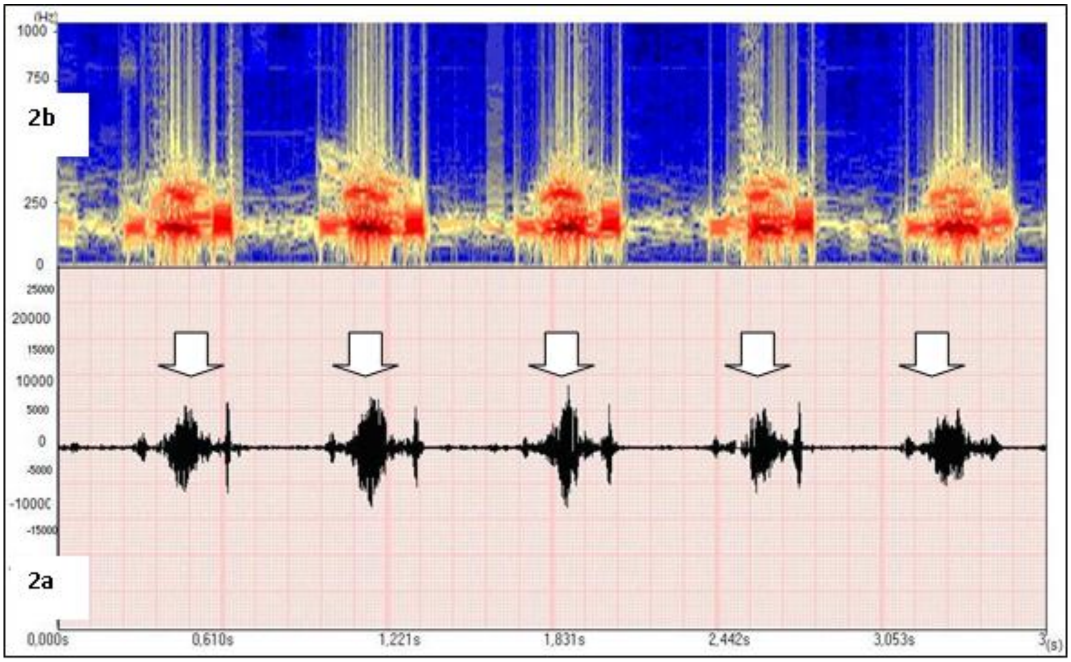

Figure 1. Representation of a recording of a cardiac auscultation in an individual with aortic stenosis with a systolic ejection murmur (indicated by a white arrow) in the form of a phonocardiogram (2a) and a spectrogram (2b) (*data collected in the ASAP project [Analysis of Auscultatory and Pathological Sounds) developed by the French national agency for research (ANR 2006 - TLOG 21 04]*).

Table 1 and 2. Results of the use of new tools as phono- and spectrogram for visualizing sounds in 30 medical students

	Day 0	Day 28 Without	Day 28 With tools	Comparison between Day 0 and Day 28 with tools
"Good" diagnosis	45% (136)	64% (191)	80% (239)	p <0,01
"Good" diagnosis in respiratory auscultation	51% (76)	61% (92)	70% (105)	p = 0,058
"Good" diagnosis in cardiac auscultation	40% (60)	66% (99)	89% (134)	p <0,009

	All students (n = 30)	
	Without tools	With tools
% of "Good" diagnosis	64% (191)	80% (239)
% of "Good" diagnosis in respiratory auscultation:	61% (92)	70% (105)
- normal respiratory auscultation	57% (17)	63% (19)
- crackles (chronic bronchitis)	57% (17)	60% (18)
- crackles (interstitial pneumonia)	53% (16)	70% (21)
- wheeze sibilants (acute crisis of asthma)	70% (21)	83% (25)
- stridor (lung carcinoma)	70% (21)	73% (22)
% of "Good" diagnosis in cardiac auscultation:	66% (99)	89% (134)
- normal cardiac auscultation	73% (22)	93% (28)
- aortic stenosis	60% (18)	100% (30)
- aortic regurgitation (minimal murmur)	30% (30)	70% (21)
- mitral stenosis	40% (12)	87% (26)
- arrhythmia (auricular fibrillation)	57% (17)	97% (29)