necropsy molecular tests can help diagnosis of an arhythmogenic disease, LQTS.

The LQTS family studied was the only one of the more than 250 such families who were followed up in Pavia, who have the C350T mutation on KVLQTI. The 14-year-old proband (QTc=500 ms) had a major syncopal episode at age 20 months, and is presently symptom-free on β-blocker treatment. Five other members of the family had the gene, with a penetrance of 50%, including the mother who had multiple syncopal attacks during pregnancy.

The identification of a mutation in the KVLQTI gene that is already associated with LQTS in a child who died from SIDS, suggested that the mutation causes the disease, and its presence was sufficient to explain the sudden death of the child. That some SIDS deaths could be attributable to LQTS has immediate implications for prevention of SIDS. Medically, despite the high death rate (50% within 10 years from the first syncope) in untreated asymptomatic patients with LQTS, and the 12% incidence (50% within 10 years from the first syncope) in untreated patients who are symptom-free. To implement rational preventive strategies, early identification of patients who are at risk is needed. To identify LQTS-related SIDS, an electrocardiogram can be done during the 2nd–3rd week of life, when the risk of SIDS and of spuriously long QT intervals (false positives) is extremely small. Although about 98% of children have normal QT intervals, most other infants will have borderline high QT intervals (between 440 and 469 ms) and a second electrocardiogram would be prudent. The best management for infants with borderline QT, intervals is still uncertain. The few infants with very long QT, intervals (>470 ms) should have β-blocker treatment until diagnosis of LQTS is confirmed by further analysis.

Implementation of widespread neonatal screening with electrocardiographs is controversial because the implications are not fully understood. Widespread screening would identify the few infants with LQTS who could die in infancy and be (mis)dianosed with SIDS, and could identify all infants with LQTS who remain at risk for sudden death as they get older. Early diagnosis would allow protection of children from life-threatening arrhythmias and identification of other family members who might be affected. Parents of children who have died from SIDS (in whom necropsy molecular tests show that the cause of death was LQTS) may ask why a simple, non-invasive, and inexpensive test, such as an electrocardiogram could not have been used.

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Department of Cardiology, Policlinico S Matteo IRCCS 19-27100, Pavia, Italy (Prof P J Schwartz MD); Department of Heart, Blood, and Lung Medical Sciences, University of Pavia, Pavia, Italy (Prof P J Schwartz, S G Priori MD); Molecular Cardiology and Electrophysiology Laboratory, Fondazione S Maugeri IRCCS, Pavia, Italy (S G Priori, R Biloise MD, C Napolitano MD, E Ronchetti MD, J Nastoli MD); Istituto di Medicina Legale, University of Milan, Milan, Italy (A Piccinni MD, C Goi MD); Department of Cardiology and Angiology, Hospital of the University of Münster, and Institute for Arteriosclerosis Research at the University of Münster, Münster, Germany (Prof G Breithardt MD, E Schulze-Bahr MD, H Wedekind MD)

Correspondence to: Professor Peter J Schwartz (e-mail: PJQT@compuserve.com)

Breath sounds, asthma, and the mobile phone

Kenneth Anderson, Yihong Qiu, Arthur R Whittaker, Margaret Lucas

The sounds generated by breathing in asthma are widely accepted as an indicator of disease activity. We have investigated the use of a mobile phone and electronic signal transfer by e-mail and voice mail to study tracheal breath sounds in individuals with normal lung function and patients with chronic or exercise-induced asthma. Spectrograms from patients with active asthma and impaired lung function were significantly different from people without asthma (p<0.0001). Our results suggest that mobile phone recordings clearly discriminate tracheal breath sounds in asthma and could be a non-invasive method of monitoring airway diseases.

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The interpretation of sound generated during the process of breathing is determined by the quality of the sound, the method of analysis, and the experience of the observer. The human ear is receptive to abnormal breath sounds, particularly to the pitches of wheezing and higher breath sound frequencies. Thus wheeze is frequently described as a symptom by patients with asthma and as a clinical sign by doctors. Although there is general acceptance that a stethoscope increases the sensitivity of wheeze detection, computer analysis of these sounds enables more advanced interpretation and can detect subtle prewheeze abnormailities that are not detectable by routine clinical examination. The benefits of mathematical analysis of breath sounds are widely accepted. However, the technique has only been used in highly specialised centres, where dedicated analytic tools and expertise are available. Given the incidence of chest disease (especially asthma) in the population, perhaps computerised analysis of breath sounds should be used in the general management of common lung disorders outside such centres.

We aimed to establish whether breath sounds can be recorded by mobile phone, and if this method can discriminate between patients with asthma and those without. Such devices are now widely available (there are about 40 million in use in the UK) and might, according to the technical specification standard (Global System for Mobile Communications) for the equipment, produce a signal which could be analysed in much the same way as a laboratory recording. We applied the microphone of a telephone (purchased in a high street shop) to the neck.
over the trachea and asked the patient, who was situated elsewhere, to breathe through the mouth for a minimum of five breath cycles. We recorded the signals with a free internet voice-mail service (http://www.yac.com) which, for each recording, sends a date-stamped audio file (GSM 6.10 format, 16 bit resolution, 8 kHz sampling frequency) to a standard computer in the laboratory. When the wave file is replayed in the laboratory, using a standard sound card, the breath sounds are of a quality which might be expected by direct auscultation with a stethoscope. Using standard techniques of lung-sound analysis,2 spectrograms can be calculated and viewed in less than 5 min from the initiation of breath recording. We recorded tracheal breath sounds from 20 patients (age range 12–61 years; ten women; seven with asthma on treatment) without communicating to the central computer whether there was any history of asthma. We selected the patients with asthma on the basis of lung function, history, response to treatment, and long-term peak flow recordings. A patient was assumed healthy if there was no given history of illness and if lung function was normal. Normal lung function was assessed by measurement of peak flow, forced expiratory volume in 1 s (FEV1), and forced vital capacity using a handheld portable spirometer (Vitalograph 2120, Vitalograph, Ireland). We could detect a significant difference in lung function between patients with healthy lungs and those with asthma (median FEV1, 3·55 L [IQR 3·07–4·16] vs 1·43 L [1·3–1·7]; p=0·0004, Mann-Whitney U test). Clearly distinct breath sounds were shown in all recordings, which were abnormal in five patients and contained audible wheeze and abnormal sound frequencies. Figure 1 shows spectrograms for three of the patients with abnormal breath sounds and the frequency characteristics associated with wheeze. These three patients had poorly controlled asthma and were wheezy, had peak flow rates of less than 50% of normal, and had spectrograms which were different in pattern from patients without asthma. However, one of the patients with asthma but no audible wheeze had a spectrogram with a similar pattern to someone with normal lung function, a peak flow at 74% of normal, and well controlled symptoms. Two patients with a history of predominately exercise-induced wheeze and normal lung function and breath sounds at rest, developed wheeze after exercise with measurable airflow obstruction (FEV1, pre-exercise 3·77 L and 2·99 L, postexercise 1·94 and 1·43 L) and similarly abnormal spectrograms (figure 2). The presence of linear-frequency abnormalities on the spectrograms was strongly associated with asthma (p<0·0001, Fisher’s exact test). For all patients, the mobile phone preprocessing did not alter interpretation of the results, which are available as sound recordings on the internet at www.lungsounds.org.uk. These results show that breath sounds can be effectively recorded outside a laboratory and produce satisfactory sound reproduction and rapid spectral analysis. Our findings suggest that a method of accurately recording breath sounds in the community is now available in a manner which allows wide access to the general population. The overall scientific and practical benefits offered by this technique for patients and their medical supervisors will depend on rigorous prospective study. However, our results do suggest that the mobile phone, as well as being an attractive and successful technological development, has, largely by serendipity, a potential use in the understanding and monitoring of asthma and other respiratory disorders. The immediate benefit of mobile-phone recordings includes accurate timing of the measurement which might, for instance, improve compliance with an associated peak-flow measurement. Such a recording would be particularly relevant in the assessment of occupational asthma or in larger populations during in-lement environmental conditions. The ease of measurement could even encourage self-monitoring. In addition, a record of symptoms or inhaler use could be included in the voice mail message.

![Figure 1: Breath-cycle spectrograms from three patients with asthma and from a patient with normal lung function](image1)

Linear abnormalities representing wheeze are seen, which are polyphonic in patient 1 and 2, and monophonic in patient 3.

![Figure 2: Breath cycle spectrograms from two patients before and after exercise](image2)


**Department of Respiratory Medicine, Level 3 Eastwing, Crosshouse Hospital, Kilmarnock KA2 0BE, UK (K Anderson FRCP) and Department of Mechanical Engineering, University of Glasgow, Glasgow, Scotland (Y Qiu BSc, A R Whittaker PhD, M Lucas PhD)**

**Correspondence to:** Dr Kenneth Anderson (e-mail: kenneth.anderson@aaaht.scot.nhs.uk)