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Short reports

Screening for bacterial vaginosis: a novel application of artificial nose technology

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Abstract

The AromaScan system was used to analyse vaginal swabs from 68 women attending a genitourinary clinic. Using clinical criteria, subjects were assessed for bacterial vaginosis. After training the AromaScan system to recognise patterns generated from four patients with and four patients without bacterial vaginosis, 16 of the 17 (94%) remaining subjects were correctly identified as having the condition. The positive predictive value of the test was 61.5%. These results indicate that the AromaScan technology may be of value as a screening test for bacterial vaginosis.

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Bacterial vaginosis is considered one of the most common causes of vaginal infection, and has recently become of considerable interest because of evidence linking it with preterm delivery and late miscarriage.[1] The most widely accepted diagnostic criteria are clinical, based on finding three or more of the following clinical signs of the vaginal discharge: a thin, homogenous appearance; an elevated pH; an amine odour after the addition of 10% KOH; and the presence of clue cells.[2] Testing for a fishy smell by sniffing, after adding potassium hydroxide to a vaginal swab (amine test), has been found to be sensitive and specific as a single test in diagnosing bacterial vaginosis in symptomatic patients.[3] Although these results demonstrate the potential for diagnosing bacterial vaginosis by smell, the traditional amine test is both subjective and arguably unpleasant to perform.

The AromaScan system (AromaScan plc, Crewe, Cheshire, UK) uses an array of 32 different conducting polymer sensors. Each sensor responds to a wide range of volatile chemicals exhibiting a reversible change of resistance. However, each sensor in the array has different sensitivity and selectivity characteristics, the highest sensitivity being to polar chemical substances. When the array is exposed to a mixture of volatiles that comprise an odour, a unique response pattern is produced. The relative responses of each sensor in the array produce a fingerprint that describes the particular odour.[4] To visually distinguish one set of patterns from many other sets of patterns is very difficult for the human eye because of the high dimensionality of the data involved. The human eye is good at differentiation of patterns in two or three dimensions using methods such as Sammon mapping that map high dimensional patterns to low dimensional space, on the bases of Euclidean distance, making no assumptions as to whether the data can be segregated into different classes.[5] If different clusters of points can be distinguished by eye, and these are associated with different odour samples, then automated classification of incoming odours is possible based on the previous experience of the system. Classification of odorous chemicals is one of the main functions that pattern recognition methods provide in an electronic nose system. The visualisation of sampled chemicals gives information on the relation between input patterns via human observation. However, it is important in an intelligent system that the ability to classify does not rely on human judgment, producing a system that can be truly automated. The AromaScan system makes extensive use of artificial neural networks to recognise incoming odour patterns to which descriptors have been previously assigned. Artificial neural networks were developed to provide models that could represent some aspects of the working principles of the brain, in particular, learning from experience. Thus, an artificial neural network has the ability to represent complex systems whose structural properties are unknown. In training an artificial neural network, the input represents an odour pattern, and the output represents a class descriptor supplied by the user for that odour pattern. A layer of processing elements lies between the input and output layers, and these encode discriminatory information. When trained, the artificial neural network is able to classify previously unseen patterns in terms of its previous learning experience.[6]

Because of the characteristic odour associated with bacterial vaginosis,[2] it appeared to be an ideal clinical condition to test the potential application of the AromaScan technology.

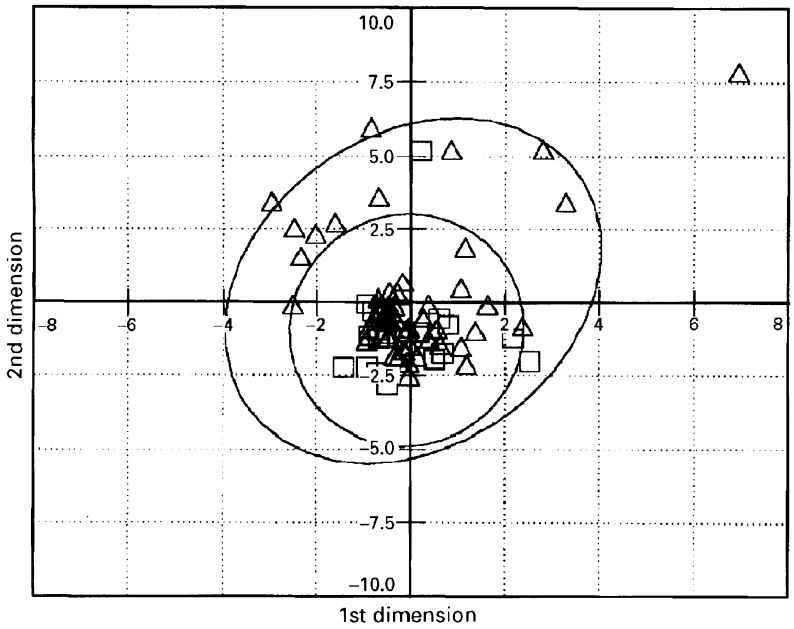

Figure 1 Cluster analysis using Sammon mapping technique with 95% confidence boundaries around positive (inner) and negative (outer) clusters. Squares, positive; triangles, negative.

Subjects and methods

Sixty eight women attending a genitourinary clinic were entered into this pilot study. Clinical diagnosis of bacterial vaginosis was made using the four standard criteria.[2] A high vaginal swab was taken and placed directly into a sampling pouch, labelled, sealed, and sent to the laboratory. On arrival the bag was unsealed and attached to a header that was attached to the bagfill outlet port of the AromaScan instrument, the bag was then inflated. The bag was detached and conditioned in a hot room for 30 minutes at 37°C, and was then attached to the sampling port of the AromaScan for analysis.

Using Sammon mapping the samples were compared on a two dimensional plot. In this case the 32 dimensional data of each pattern was reduced to a single point on a two dimensional plot. The distances between points are dependent on how different one pattern is from the next. No assumptions are made about whether patterns belong to different classes. The appearance of clusters of points signifies that groups of patterns are very similar to each other.

The artificial neural network was also trained to recognise positives and negatives.[6] Four samples that had three positive criteria and where no other pathogen was found were used to train the system for positive recognition. Four samples that had no positive criteria and no other pathogens found were used to train the system for negative recognition.

Results

Figure 1 shows a Sammon map of odour patterns from 68 cases, initially analysed without making any assumptions about classification of the data. Twenty one cases (31%) had three or four positive criteria and these were generally well clustered. Forty seven (69%) had two or fewer clinical criteria of bacterial vaginosis and patterns were much more scattered. Ninety five per cent confidence boundaries are shown for each of the two classes, the positive cases were found to be much more tightly clustered than the negative cases, although some of the negative case patterns overlapped with the positive case patterns.

Following training with the four positive and four negative cases, 60 cases (43 negative and 17 positive) were available for testing by the artificial neural network. Sixteen of the 17 positive cases (94%) were recognised as positive. Of the 43 negative by clinical criteria, 33 were recognised as negative (76.7%) and 10 (23.3%) as positive. The positive predictive value for the test was 61.5%.

Discussion

This small pilot study suggests that the AromaScan technology may be of value as a screening test for bacterial vaginosis, particularly in settings where assessing the clinical criteria objectively may be difficult. Once the equipment is set up, the test is quick and simple, and gives an easy to understand answer. In our study the AromaScanner failed to identify only one of the positive samples and this could have been caused by a technical problem early on in the study. The AromaScanner identified 10 of the cases negative by clinical criteria as positive, and it would be of interest to follow subjects with this mismatch to see whether frank bacterial vaginosis subsequently developed. The utility of the AromaScan technology to screen for bacterial vaginosis needs to be fully evaluated in larger studies of both symptomatic and asymptomatic (for example, antenatal) women, and the potential application of the technology for diagnosis of other clinical conditions associated with a characteristic odour should be assessed.

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Conflict of interest: Dr K C Persaud, Senior Lecturer, UMIST, is a consultant to AromaScan plc.

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