AFRICAN JOURNAL OF MEDICINE and medical sciences

VOLUME 34 NUMBER 2 JUNE 2005

ISSN 1116—4077

Afr J Med med Sci (2005) 34, 119-124

The motion sensitivity screening test in clinical practice in Abuja, Nigeria: affordable automated perimetry for the third world?"

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Summary

Perimetry is essential in the clinical management and evaluation of glaucoma patients and other patients with diseases impacting on visual fields, but automated equipment may be too expensive for many practitioners in the developing world. I have used the Wu-Jones automated motion sensitivity system in a medium sized practice in Nigeria, a developing country, and hereby present an audit of our experience with it. The Wu-Jones Motion Sensitivity screening test is a lap-top computer based test which integrates a number of components including a test program and reporting facility, a self organizing neural network, a database management mechanism, and a menu-mouse-windowing user interface. The test is available on the public domain and is small enough (194mb) to fit into a diskette. This test has been used at the Rachel Eye Center in Abuja since 1998, and has been applied to 339 individuals, 298 of whom are included in this analysis. Patients tested fell into four main groups: those with clinical glaucoma (intraocular pressure > 20mmHg on at least one occasion *and* optic cup/disc ratio of 0.5 or more), glaucoma suspects, (i.e. ocular hypertensives >20mmHg *or* c/d ratio of 0.5 or more and first degree relatives of glaucoma patients) patients undergoing routine tests for pre-employment ('normals'), and 'others'. These 'normals' were used as controls. Records are available for 531 eyes. It took an average of two minutes to complete the test. Significant field defects (Motion sensitivity less than 50%) were detected overall in 15.6% of tested eyes, 7.2% of normals but in 32.6% of glaucoma eyes. Using the 'normals' as controls, the sensitivity of the test in our hands varied from 33% to 72% and specificity from 57% to 93% at motion sensitivity cut off points from 50% to 97%. At the 83% cut off point, positive and negative predictive values were 86.0 % and 47.5% respectively. Reliability averaged 70%. I find the test easy to administer and understand by patients. Results can be recalled without difficulty, facilitating the longitudinal follow up process. This test will be of value to practices in the third world unable to afford more expensive equipment in the third world. The main investment would be in form of a laptop computer and a diskette. It can also be a useful adjunct for office practice in the western world.

Keywords: *Glaucoma, motion sensitivity, Wu-Jones, automated Perimetry.*

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Résumé

La périmétrie reste essentielle dans l'évaluation et le menagement clinique du glaucome et d'autres types de maladies affectuant le champ visuel aux patients; car les équipements automatiques sont trés chér pour le practiciens dans les pays sous developpés. Nous avons utilisé le test de mouvement de sensitivité de Wu-Jones à Rachel eye center à Abuja au Nigéria depuis 1998 sur 339 individus parmi lesquels 298 étaient analysés dans cette étude. Les patients étaient regroupés en 4 catégories: ceux ayant le glaucome clinique avec une pression intra-occulaire > 20 mmHg et une proportion de veree/disque optique > ou égale a 0.5, le glaucome suspecte, premier degreé de glaucome et les sujets sain. Sur 531 yeux testés avec un temps moyen de 2 munites par oeil. Un champ défectueux significatif (mouvement de sensivitité <50%) était observé chez 15.6% des eyes, 7.2% des eyes normaux et 32.6% de glaucome. En utilisant l'oeil "normal" comme "controle" la sensitivité du test variait de 33-72% et la spécificité de 57-93% avec un mouvement de sensitivité limite de 50-97%. A la limite de 83% les valeurs prédictives positive et négative étaient de 86% et 47.5% respectivement et une validité moyenne de 70%. La practicabilité de ce test, non chér est valeureuse et permet de bonne suivie longitudinale, mais d'autres équipements plus sophistiques seront necessaires pour aider les patients dans les pays sous-développés.

Introduction

Central visual field assessment is essential to the management of glaucoma in clinical practice [1]. Visual field equipments vary in type and cost, and some of the more expensive ones such as Octopus, Humphrey's or even the Goldman's, may be out of the reach of many practices in the West African sub-region and indeed other developing countries. Some studies appear to suggest a 'high' sensitivity and specificity of Motion sensitivity testing using a laptop in measuring glaucomatous field loss [2,3]. A computerized Motion sensitivity screening test (MSST) has been developed by Wu and Jones [3] and field tested in rural settings especially in onchocerciasis endemic settings [4,5] as well as in certain limited Western settings [3]. Its acceptability, reproducibility and repeatability as a screening test to detect optic nerve disease and other causes of visual impairment has been demonstrated during the ivermectin drug trials for onchocerciasis because there was close inter-observer agreement (78%) and intra-observer agreement (98%) [4]. However, its use in ordinary clinical settings in West Africa has not been documented. Is the test useful in ordinary clinical practice es-

pecially in the detection of field loss from glaucoma?

This test has been employed since 1998 at the Rachel Eye Center in Abuja, Nigeria, and here is the researcher's experience with it.

Materials and methods

The tests were carried out at the Rachel Eye Center (REC) in Abuja, Nigeria. REC is a general ophthalmology private practice where between 150 to 250 new cases are seen every month. Subjects are drawn from the city of Abuja and environs, and are mostly but not exclusively Negroes of Nigerian-African descent.

Wu Jones MSST. This test has been described elsewhere [3]. Briefly, six points within the central 15° field of vision are repeatedly tested at 1/3 meter from the screen of a laptop computer in a darkened room. A tiny source of light is allowed into the room to enable the respondents and the computer operator observe the computer screen, the operator to record the results and the subject to move safely in the room. When the subject is comfortably seated in front of the computer, the test is explained to him/her in a language understood. The subject is then positioned approximately one third of a meter in front of the computer. At the computer prompting, the operator selects the eye to be tested first, usually the right eye. A series of vertical, illuminated white bars appears on the screen arranged in a 6 by 8 array (fig 1). The display is "paper-white" triple super-twist technology with backlighting, 16 shades of grey, 640-480 pixel resolution, VGA emulation. Six of these bars selected to coincide with critical points in the central field of vision would oscillate at random intervals. Each point is tested six or ten times, depending on whether a rapid or standard test was required. However I am limiting this analysis to the rapid tests. In a dark room situation, the maximal illuminance for the reference lines was 413 lux and the illuminance of the background was 200 lux. The contrast was 62% (Lmax-Lmin) / (Lmax+Lmin). The patient presses the space bar on the computer or clicks on a mouse when motion is detected. The stimulus was presented for a duration of 0.2 seconds. The presentation order of each location was randomized. The waiting time for response from the patient varies between 1.75- 2.2 seconds and is dynamically modified according to the patients response time. This response is recorded automatically in the computer system. Detection of motion only between 0-2 times out of six was categorized as a severe defect, 3-4 as a moderate defect and 5-6 as normal. A typical appearance of the result at the end of each test is found in (fig 2).

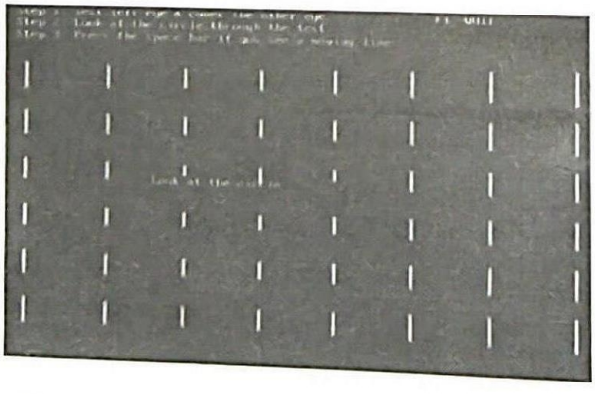

Fig. 1: *Bar array at beginning of test. Subject fixates on the circle and presses the space bar on detection of motion. Only six of the bars corresponding to critical points in the field of vision are programmed to move at random interval - two bars supero and infero temporal, and four bars two each supero and infero nasal as is evident in figure 2.*

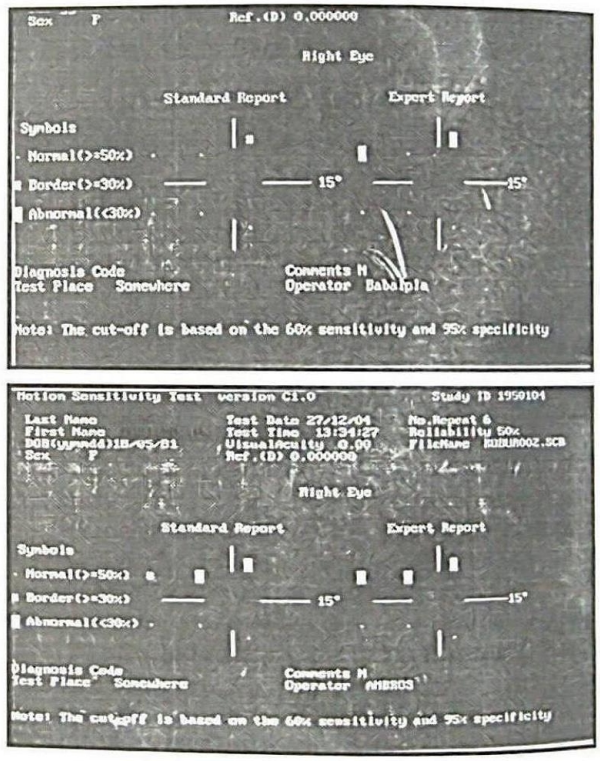

Fig. 2: *Typical motion sensitivity screening printout. Right eye Note that the expert report differs slightly from the standard report, especially for the infero-temporal sector. This results from automatic corrections by the program on the neural net. 2a. patient's findings January 2004. 2b. Same patient in December 2004, showing progression of field loss.*

A dot would represent normal responses for that position, while a hatch would represent moderate defect and a block would represent a severe defect. This could then be printed out and attached to the patient's case note as a ready reference for the doctor. There are two reports generated by the computer: a 'standard' report and an 'expert' report. The expert report factors in any detected instability in the neural net and summates this into a correction. The data is automatically recorded in another database on the pro-

gram and can be recalled easily at a later date, especially for the purpose of comparison or long term follow up. The actual scores give a more precise indication of the patient's performance and may be resorted to in borderline cases. These scores could be aggregated for each eye to give an overall impression of the visual field performance. In addition, motion sensitivity could be computed as a percentage of the maximum score of 36. The cumulative frequency scores for a given population can be plotted and compared with other populations of interest. Shifts in the curve to the right would connote an improvement in the overall visual field performance.

Members of our clinic population who have undergone this test have been divided into four groups for the purpose of this study:

1. *Normals* : patients for pre-employment and preschool tests etc. These were also used as controls in this study. They were only included as normals if other gross pathology had been ruled out.
2. *Glaucomas*: an intra-ocular pressure (IOP) measurement (Goldman applanation) >20mmHg on at least one occasion, and a vertical cup/ disc ratio(VCD) of >= 0.5 or asymmetry more than 0.2 between the two cups. Other minor criteria, which may accompany the high VC/D ratio, are pallor, notching of cup, nasal shift or acute entry of vessels into cup, and grooving of the nerve fiber layer. There must be no concomitant retinal disease, media opacity or other change that may account for field loss. If there is ametropia, glasses must be worn during the test.
3. *Glaucoma suspects*: Either an IOP > 20mmHg on at least one occasion, *or* a vertical cup/ disc ratio >=0.5 and first degree relatives of glaucoma patients. This group will thus include the 'low tension glaucomas' and the 'ocular hypertensives'. There must be no concomitant retinal disease.
4. *Others*. This includes all other pathologies, some of which may impact on visual fields, such as early cataracts, retinitis pigmentosa, diabetic neuropathy etc, but which are not considered glaucomatous.

Patients with significant refractive error used their corrections during the tests. Patients with significant media opacity such as early cataracts adjudged to possibly contribute to defect were excluded from this analysis.

The sensitivity and specificity of the test would depend on the motion sensitivity (%) cut off threshold adopted. In this communication, single author assessed these parameters at 50%, 66%, 70%,83% and 97% motion sensitivity cut offs.

The program itself is small enough to enter into a diskette (194 KB) but in its present form is not compatible with windows 2000 but is compatible with windows 98 and earlier. Analysis of results was carried out with the Statistical Package for the Social Sciences (SPSS 10.0) for windows program.

Results

This analysis is limited to patients tested between June 1998 and June 2004. Although 339 patients were tested during this period, only a total of 298 individuals are included in this analysis, others being excluded due to unreliability of test. The age of the subjects ranged from 5 to 98 years, average 34. Two hundred and two (202) subjects were male (67.3%) while 96 (32.7%) were female. 591 eyes were tested, 293 left, 298 right.

These were all categorized into four groups as indicated above with the following distribution: Glaucomas (194 eyes), Glaucoma suspects (143 eyes), Normals (110 eyes), Others (144). 'Others' included incipient cataracts, retinal detachments, retinitis pigmentosa, high myopia, diabetic neuropathy and amblyopia. There is no statistically significant difference in sex distribution between the normals and the controls (F:M 1:3 for glaucomas and 1:2.8 for the controls).

Table 1: Proportion of 'Failed' motion sensitivity tests at various cut off levels according to patient group.

MS cut-off Patient group	50%	66%	70%	83%	97%
Glaucomas	32.6%	34.7%	36.7%	45.0%	72.0%
Glaucoma suspects	6.3%	8.4%	9.1%	13.9%	62.2%
Normals	7.2%	9.1%	9.0%	13%	42.7%
Others	8.2%	9.7%	11.0%	17%	62.7%
All	15.6%	17.4%	18.6%	24.5%	62.1%

Table 1 is a summary of these categories and their performance on the Wu-Jones motion sensitivity field test at various levels of motion sensitivity cut off. Taking the 83% cutoff point as a reference for instance, it will be seen that, overall, 25% 'failed' the test i.e. had significant field defects. The failure rates were 45% for glaucomas, 14% for glaucoma suspects, 13% for 'normals' and 17% for others. At a cut off point of Motion sensitivity less than 50%, significant field defects were detected overall in 15.6% of tested eyes, 7.2% of normals but in 32.6% of glaucoma eyes.

Using the 'normals' as controls, the sensitivity of the test to detect field loss in glaucomas would again vary with the cut off point for normal versus disease. At the 83% motion sensitivity cut off point, the sensitivity was 45%, while specificity was 87%. The positive predictive value was 86% while the negative predictive value was 48%.

Variations in sensitivity and specificity with cut off points are summarized in Table 2. As expected the sensitivity of the test increases as the Motion Sensitivity cut off points is raised, while the specificity drops. For instance, the sensitivity of the test increases to 72% for the detection of 'any' loss of motion sensitivity, (i.e. the 97%

cut off point) but this is inevitably associated with a drop in specificity to 57%.

Table 2: Sensitivity and specificity of motion sensitivity (MS) tests at various cut off points

MS Cut off	Sensitivity	Specificity
50%	33%	93%
66%	35%	90%
70%	37%	90%
83%	45%	87%
97%	72%	57%

For the purposes of comparison to other studies and also between various groups in our clinic population, percentage motion sensitivity was calculated and a cumulative frequency graph was generated for the glaucomas, the glaucoma suspects and the 'normals' (figure 3). From this curve, it is apparent that the overall performance of the glaucoma group was worse than the glaucoma suspects and the 'normals'. There is a 'shift to the right' for the latter two groups. However, the glaucoma suspect group is just marginally worse than the 'normals'. The difference becomes most noticeable as the motion sensitivity exceeds 80%. This difference becomes statistically significant only at the 97% cutoff point. (Pearson Chi square = 9.52, $P < 0.002$)

The proportion of patients scoring equal to or below 50% and 70% respectively was computed to enable direct comparisons with other populations that had undergone the test. The results are shown in Table 3. Within our overall clinic population, 14% scored less than or equal to 50%, while 19% scored less than 70%. This compares with 14% and 24% respectively in oncho-endemic Kaduna, and only 2% and 5% respectively in the normal UK and USA populations. The time taken to complete the test ranged from a minimum of 39 seconds to a maximum of 4466 seconds, mean 162, Standard deviation 269.

Table 3: Motion Sensitivity in various populations

Population	Motion sensitivity <= 50%	Motion sensitivity <= 70%
REC patient population	14%	19%
REC glaucomas	33%	37%
REC glaucoma suspects	6%	9%
REC Normals	7%	9%
*[1]Kaduna Onchocerciasis	15%	25%
*[2]Nigeria Normals	5%	11%
*[3]USA Normals	2%	6%
*[4]UK Normals	2%	6%

**1 Kaduna Mesoendemic Onchocerciasis population, Ivermectin (1201 subjects)*
**2 Nigeria Normals: 74 control subjects from non-omchoendemic Fatika, Kaduna state. *3USA Normals: 74 volunteers from ARVO meeting 1991.*
**4UK Normals 91 staff and students and 121 spouses of Glaucoma patients.*
Data from Wu X et al [4]

For all tested individuals on our record, reliability ranged from 0 to 100%, with a mean at 70% and standard deviation at 34.64%. However, results of patients with reliability less than 50% are normally rejected and do not form part of this analysis. There is a slight tendency for those who have field defects to take a longer time at the tests. (Regression analysis Standardized coefficient - 0.380 significant at 0.01). There is also a weak tendency for performance at the test to reduce with age (Standardized coefficient 0.227, significant at 0.01 level) but one must bear in mind the presence of confounding variables such as presence of concomitant disease.

Discussion

The diagnosis of 'glaucoma' is not easy or straightforward. Foster *et al* [8] have attempted to define what glaucoma is and what it is not, based on percentiles in various populations for C/D ratios (>=97.5th percentile that also show a definitive field loss consistent with glaucoma or IOP > 99.5th percentile if the disc cannot be seen.). They also include a neuroretinal rim <= 0.1 CDR between 11 to 1 o'clock or 5 to 7 o'clock. In other words, VC/D ratios up to 0.9 in the designated areas. As we do not have population figures for C/D ratios in normal in Nigeria for now, it is difficult to adopt this definition. I have however deliberately used cut off points which are low for this study so that we will tend to be over-inclusive of normals rather that exclusive. This means that sensitivity for the test is bound to be lower than if stricter criteria were used for C/D ratio and intraocular pressure. The problem with the Foster definition is that it insists that the stringent criteria must be established beyond reasonable doubt before a diagnosis can be entertained. I beg to differ. In black populations, I feel it is better to err on the side of caution in the management of glaucoma, and my selected cut off reflects clinical practice, because as other studies have eminently demonstrated, black race is the most important risk factor in the development of Primary Open Angle Glaucoma [9]. Further, it is generally agreed that any cup/disc ratio greater than 0.3 should be viewed with suspicion, as well as any asymmetry greater than 0.1 [10]. Also, the normal range of intra ocular pressure is generally accepted as varying between 10-21mmhg with an average of 16mmhg. Levels above this must be viewed with suspicion. However it is also known that glaucomatous damage may occur when IOP is less than 21mmhg, while sustained IOP greater than 21 may not be associated with any damage [10]

There are two important objectives to clinical perimetry. The first is to identify an abnormality in the field of vision, and the second is to follow it up before, during and after intervention [1]. To some extent the Wu- Jones MSST attempts to meet both objectives. It may be argued, that the MSST is not likely to be as sensitive as other automated perimeters such as the Octopus and the Humphrey's, especially since the number of tested sites are much fewer. I would have loved to do a direct comparison with any of these two analysers, but these are not

available in my center at this time, being too expensive. An Humphrey's visual system costs at least US $25,000 dollars and by the time freight and installation is factored in, the cost could be approaching $30,000. This is equivalent to about N4.5 million.(Four and a half million Naira). The Japanese KOWA perimeter is less expensive, but will still cost about US$15,000.00. Apart from the Wu-Jones software which is available on the public domain and should thus be technically free, investment in a laptop is necessary. But the advantage is that the lap-top can be used for other purposes and need not be dedicated to the Perimetry.

However, the six sites tested for the Wu-Jones perimeter have been carefully chosen to coincide with the areas of the visual field most likely to be affected by glaucomatous damage – i.e. the arcuate scotoma sweep. In all probability however, the sensitivity of the test may be enhanced by increasing the number of tested loci. Secondly, the relative advantage of 'motion sensitivity' tests in general over other forms of automated Perimetry has been highlighted [11,12]. These include the fact that the peripheral visual field is optimized for motion perception rather than differential light sensitivity which is measured by other forms of automated Perimetry. Also, using a 'size threshold method', Wall was able to demonstrate better sensitivity of motion detection Perimetry over the Humphrey's visual field analyzer. The Wu Jones test was performed on a cohort of subject who also had Friedman's Mark I visual anlyser test and unpublished data tended to suggest that the sensitivity of the two techniques was similar. That said, the Wu Jones test retains the advantages of other automated perimeters namely that the findings are automatically recorded and easily recalled, making temporal longitudinal follow up that much easier. This is enhanced greatly by the fact that actual numeric scores are available on the database, beyond the pictorial representation of performance which is based on a 60% specificity and 95% sensitivity. This is particularly important for glaucoma suspects in whom loss of sensitivity tends to be marginal. As can be seen from the sensitivity curves (fig 3), the difference between glaucoma suspects and 'normals' do not become evident until motion sensitivity exceed 80%.

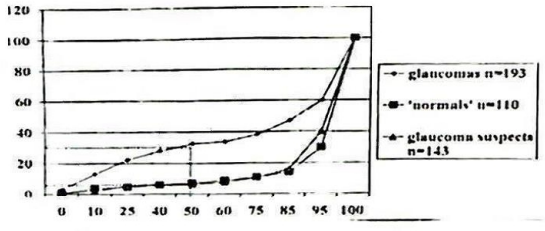

Fig. 3: *Cumulative motion sensitivity curve for various groups of patients. Note the distinct difference bewteen 'glaucomas' on the one hand and the 'normals' and 'glaucoma suspects' on the other. Note also the gap that opens up between the 'glaucoma suspects and 'normals' when motion sensitivity exceeds 85%.*

In this study, the sensitivity of the test for detection of defects in glaucomas as defined, varied between 33-72% depending on the motion sensitivity cut-off adopted. The lower the cutoff, the lower the sensitivity of the test and the higher the specificity. Of necessity, the cutoff needs to be high for the detection of early glaucomatous damage, especially with regard to 'glaucoma suspects', though this will be at the expense of specificity. My experience with the test would suggest that a cut off point of 83% motion sensitivity would be a suitable compromise because in our hands, this gives a sensitivity of 45% and a specificity of 87%. However, especially in borderline cases, an evaluation of actual scores beyond the pictorial representation becomes critical for decision making as regards what constitutes 'glaucomatous damage'.

The database management system conforms to dBase.dbf format and is compatible with Windows Microsoft Excel. Secondly, the reliability of the test is easily established and displayed, based on stability of the neural net. There is a self-organizing neural network to analyze the stability of the test. If a test is judged unstable, the operator is advised to conduct a repeat test. This instant stability analysis together with the test control net provides a way for obtaining more reliable test results.

Overall impressions are that the test is easy to administer, easy to understand and generally takes a shorter time than other field analyzers such as Friedman's with which this author is reasonably familiar. One main advantage is that it does not require electricity supply and is thus ideal for many West African nations where steady electricity is a problem. It is particularly useful for fieldwork in rural settings. The other limitation of the study worthy of mention is that the normative data used is determined by the manufacturers rather than data generated locally. There is a need to build normative databases based on the Nigerian/African eye not just for the Wu Jones MSST but also for other automated visual field tests.

Comparison of the overall clinic population with other populations for which a record is available, shows that the proportion with detectable field defects is similar to (14% versus 15%, table 3) the results obtained in an enriched sample within an oncho-endemic community in Nigeria with optic nerve disease. (Enriched in the sense that patients for this test in the field had been selected as Optic nerve disease suspects based on preliminary tests for optic nerve disease such as confrontation field tests, colour tests, and optic disc appearance, as well as a random sample of 'normals' [4].) In a sense therefore, the demographic characteristics of the two populations are similar, being a mix of optic nerve disease patients, optic nerve disease suspects and 'normals'. REC normal population seems to have more motion sensitivity failures than normals form Fatika, Nigeria as well as the USA and the UK (7% REC, compared with 2% for the USA and UK and 5% for Fatika Nigerian normals.) This may be due to a selection bias on the part of organizations that send patient for pre-

employment tests but we have no evidence to back this up at the moment.

Only first day tests have been included for the purposes of this analysis, but this author's observation agrees with that of Wu *et al* [3,4] that the test is reproducible and repeatable. Patients seen on longitudinal follow up after an interval of treatment have sometimes demonstrated a worsening of field defects or stability.

In conclusion therefore, the author feels that the Wu-Jones test can be of value to practices in the third world which is unable to afford more expensive equipment. Certainly it can find a place as a portable quick test adjunct for office work even in western countries, especially when there is some pressure of time on the part of patient or physician.

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Received: 18/08/04
Accepted: 27/01/05