EXTENDED REPORT

Efficiency of Rarebit perimetry in the evaluation of homonymous hemianopia in stroke patients

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Aims To compare the efficiency of Rarebit perimetry and the Humphrey field analyser (HFA) in detecting the homonymous hemianopia in stroke patients with occipital lobe infarcts.

Methods: 40 patients who suffered from visual complaints caused by acute occipital lobe infarcts underwent visual field analysis on the same day, in random order—first with either Humphrey perimetry 30-2, SITA standard program (Zeiss Humphrey Systems) or Rarebit perimetry. A visual field was classified into four quadrants for right and left eyes: superior temporal, superior nasal, inferior temporal, and inferior nasal. The entire mean hit rate numbers (MHR) and mean deviation and pattern standard deviation (PSD) values were compared for each quadrant of each eye.

Results: The results of Rarebit MHR and HFA mean deviation values for each quadrant of the right and left eyes were highly correlated in all patients with homonymous hemianopia (Pearson's *r* correlation coefficients for superior temporal, superior nasal, inferior temporal and inferior nasal quadrants of right and left eyes were 0.827, 0.833, 0.843, 0.851 and 0.746, 0.821, 0.882, 0.824, respectively ($p < 0.001$ for all quadrants)). There was a strong correlation between Rarebit MHR and HFA PSD for each quadrant of both eyes.

Conclusions: Rarebit perimetry is rapid, reliable, and easily performed in patients with homonymous hemianopia. It can be done using a simple software program and simple hardware and it readily detects severe visual loss in patients with occipital lobe lesions.

Homonymous hemianopia is the visual field defect produced by lesions that develop posterior to the optic chiasm. It is caused by many different kinds of lesion that affect the retrochiasmal visual pathway, optic tract, lateral geniculate body, optic radiations, and occipital lobe.^{1,2} Lesions affecting the optic tract and lateral geniculate body tend to cause incongruous hemianopia, but the more posterior the site of a lesion in the optic radiation, the greater the congruity of the visual field defects. Ten per cent of patients with stroke (especially those with an occipital lobe lesion) are found to have homonymous hemianopia.²

Homonymous hemianopia can cause significant functional impairment—precluding driving, for example—and it is very important to identify the visual field defects in patients with this disorder. Automated perimetry is used extensively to identify visual field abnormalities in patients with neurological diseases. With the advent of newer generations of automated perimeters and the availability of more sophisticated software programs, automated perimetry is now often used for the detection and localisation of visual pathway damage.³ Humphrey perimetry, which is the type of threshold static perimetry used most often, is accepted as the gold standard for the diagnosis of visual field defects. With its advanced software program, it compares the patient's visual field data with age corrected normal values, corrects the visual field data of the patient for diffuse loss, and calculates the global indices that summarise the patient's data. Recently, new perimetric techniques such as Rarebit perimetry—which has been reported as a sensitive test for the evaluation of the neural structure of the visual system—have become available.⁴ In our study, we compared the efficiency of Rarebit perimetry with that of the Humphrey field analyser (HFA) (Zeiss Humphrey Systems, Dublin, California, USA) in detecting homonymous hemianopia in patients with an occipital lobe infarct.

METHODS

Forty patients with visual complaints, such as field defects caused by acute occipital lobe infarcts resulting from vascular disease, and who were referred to our service for visual field testing, were enrolled in the study. The local ethics committee approved the study, which was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all subjects before their enrolment. Patients without a well defined occipital infarct on magnetic resonance imaging (MRI) (fig 1) were excluded from the study.

All subjects underwent an ophthalmological examination, including an assessment of best-corrected visual acuity (BCVA) and an evaluation of the anterior and posterior segments by means of a slit lamp. Any patient who had a BCVA score lower than 20/30 because of a cataract or a pathological retinal or optic condition was excluded from the study.

Both perimetry examinations were carried out with undilated pupils. Appropriate correction for the examination distance (for example, a 0.5 m viewing distance (which requires a near addition of +2.0 diopters) and a 1 m viewing distance (which requires +1.0 D)) was used for the Rarebit perimetry. On the day of testing, visual field analyses were done with either automated perimetry (Humphrey perimetry 30-2, SITA standard program) or Rarebit perimetry in random order by the same experienced technician. Rarebit perimetry, which does not monitor fixation, was carried out on a 15 inch liquid crystal display. The subjects were instructed to look at the fixation mark on the monitor and then to indicate the number of microdots seen during each presentation by not clicking, clicking, or double clicking a response button.⁴ The test was

Abbreviations: BCVA, best-corrected visual acuity; HFA, Humphrey field analyser; MHR, mean hit rate; PSD, pattern standard deviation

Figure 1 Magnetic resonance imaging in a 54 year old male patient showing acute ischaemia in the left occipital lobe, as demonstrated by hyperintense signalling in diffusion weighted images (A). T2 weighted axial magnetic resonance imaging also shows a focus of increased signal intensity in the same region (B).

first performed at a distance of 0.5 m and was then repeated at a distance of 1 m for the four central locations.

The central 30-2 threshold SITA standard program was used for the Humphrey perimetry, and all patients were tested with a white size III stimulus against background illumination. After both perimetric tests had been done, the patients were asked about their preference.

Because homonymous hemianopia occurs bilaterally, both eyes of each patient were evaluated. If the results of the perimetry tests were unreliable (for example, a high fixation loss (>20%) or a high rate of false positive or false negative results ($\geq 30\%$) for Humphrey perimetry, or if there was an error number >3 for Rarebit perimetry), the individual tested was excluded from the study.

The data collected included the patient's age and sex, the location of infarcts shown on brain MRI, the laterality of the visual field defects, global indices such as the mean deviation (MD) and the pattern of standard deviation (PSD), fixation loss, false positive and false negative errors, duration of the test, and mean hit rate (MHR), the number of locations tested with a hit rate of less than 90%, the error number, the time required to complete the test, and the mean reaction time (MRT) for Rarebit perimetry. The mean hit rate was determined by

dividing the sum of probes seen by the sum of the probes shown.⁴ The abbreviation "MD" cited above represents the mean value of the difference from the age adjusted value at every test point, and "PSD" refers to the pattern of standard deviation of the difference between the threshold value and the expected value at every test point.⁵

The visual field was divided into quadrants (superotemporal, superonasal, inferotemporal, and inferonasal) for the right and left eye. The HFA mean deviation and PSD values of each quadrant were calculated using the formulas described by Choplin and Edwards.⁶ The entire mean hit rate numbers, mean deviation, and PSD values were compared for each quadrant of each eye. The Pearson correlation analysis test was used for statistical analysis, and a probability (p) value of less than 0.05 was considered significant.

RESULTS

There were 40 patients with homonymous hemianopia (17 women (42.5%), 23 men (57.5%); mean (SD) age, 58.9 (14.5) years, range 26 to 90). Twenty patients had right sided hemianopia (fig 2a, b), and 20 had left sided. Thirty patients (75%) had complete homonymous hemianopia, and 10 (25%) incomplete. In the 10 patients with incomplete homonymous

Table 1 Right and left eye Rarebit and Humphrey field analyser indices in patients with right sided or left sided homonymous hemianopia

Parameters	Patients with right sided HH		Patients with left sided HH	
	Right eye, mean (SD), minimum–maximum	Left eye, mean (SD), minimum–maximum	Right eye, mean (SD), minimum–maximum	Left eye, mean (SD), minimum–maximum
Rarebit MHR (%)	49.70 (15.89), 11 to 69	47.30 (14.50), 23 to 67	44.10 (16.02), 21 to 85	50.00 (17.90), 26 to 84
Hit rate number <90%	22.00 (4.66), 14 to 29	23.90 (4.77), 14 to 29	24.7 (4.7), 10 to 29	23.00 (5.02), 15 to 29
Error	0.70 (0.73), 0 to 2	0.25 (0.44), 0 to 1	0.25 (0.44), 0 to 1	0.50 (0.94), 0 to 3
Test duration (min)	4.21 (0.51), 3.06 to 5.31	4.23 (0.35), 3.43 to 5.16	4.18 (0.54), 3.44 to 5.13	4.10 (0.65), 3.16 to 5.34
MRT (s)	0.97 (0.17), 0.69 to 1.5	1.06 (0.29), 0.61 to 1.68	0.98 (0.29), 0.65 to 1.90	0.95 (0.26), 0.65 to 1.47
HFA MD (dB)	–13.75 (4.21), –21.42 to –6.26	–17.11 (4.47), –25.57 to –9.04	–15.52 (4.78), –22.19 to –7.21	–12.75 (5.25), –26.67 to –4.71
HFA PSD (dB)	14.50 (4.5), 10.71 to 17.12	14.58 (2.12), 10.90 to 18.04	14.49 (2.73), 6.99 to 18.10	12.47 (3.72), 6.48 to 17.32
FL	0.40 (0.59), 0 to 2	2.9 (3.9), 0 to 15	3.70 (4.78), 0 to 15	0.90 (1.07), 0 to 3
False positive (%)	2.30 (2.00), 0 to 8	1.40 (1.60), 0 to 5	2.15 (1.72), 0 to 6	2.25 (2.51), 0 to 8
False negative (%)	10.30 (10.17), 0 to 30	8.30 (8.80), 0 to 29	5.50 (6.10), 0 to 22	6.80 (9.09), 0 to 28
Test duration (min)	7.16 (1.48), 4.36 to 9.52	6.90 (1.32), 5 to 10	7.60 (2.41), 4.01 to 12.39	7.34 (2.40), 4.31 to 13.07

FL, fixation loss; HFA, Humphrey field analyser; HH, homonymous hemianopia; MD, mean deviation; MHR, mean hit rate; MRT, mean reaction time; PSD, pattern standard deviation.

Figure 2 Humphrey field analyser (A) and Rarebit perimetry (B) in the same patient with a right homonymous hemianopia.

hemianopia, eight (20% of all patients studied) had homonymous sectoranopia, and two (5% of all patients studied) had partial homonymous hemianopia. Visual field defects were congruous in 36 (90%) of the patients and incongruous in only four (10%).

In patients with right sided homonymous hemianopia, the mean Rarebit MHR of the right eye was 49.7% and that of the left eye, 47.3%. In patients with left sided homonymous hemianopia, the Rarebit MHR value of the right eye was 44.1% and of the left eye, 50%. Right and left eye Rarebit parameters (mean hit rate, hit rate number <90%, error number, test time, and mean reaction time) and HFA

parameters (mean deviation, PSD, fixation loss, false positive and false negative percentages, and test duration) in patients with right sided or left sided homonymous hemianopia are shown in table 1.

The results of Rarebit MHR and HFA mean deviation values for each quadrant of the right or left eye were highly correlated in all patients with homonymous hemianopia. There was also a strong correlation between Rarebit MHR and HFA PSD for each quadrant of the right or left eye. The Rarebit MHR, HFA MD, and HFA PSD values for all quadrants in patients with right sided or left sided homonymous hemianopia with Pearson's correlation coefficient and p values are shown in fig 3.

Figure 3 Rarebit mean hit rate and Humphrey mean deviation and pattern standard deviation values and Pearson's correlation coefficients and p values according to the quadrants in patients with right homonymous hemianopia (A), and left homonymous hemianopia (B).

In the patients with homonymous hemianopia, the mean test time for the Rarebit perimetry was 4.19 minutes for the right eye and 4.18 minutes for the left eye; the mean test time for HFA was 7.38 minutes for the right eye and 7.14 minutes for the left eye. Rarebit perimetry took significantly less time than HFA ($t = -10.26$ for the right eye and -10.04 for the left eye;

$p < 0.001$ for both). The difference between the Rarebit test duration and the HFA test duration for the right and the left eye in patients with right sided or left sided homonymous hemianopia was also significant ($t = -8.795$ for the right eye and -9.227 for the left eye in patients with right sided homonymous hemianopia, and $t = -6.499$ for the right eye and

–6.233 for the left eye in patients with left sided homonymous hemianopia; $p < 0.001$ for all). Because of the brief duration of Rarebit perimetry, this form of evaluation was found to be easier and more comfortable to undergo than HFA by the study subjects.

DISCUSSION

Homonymous hemianopia is usually caused by stroke, and most stroke associated cases are secondary to an occipital infarct.¹ The representation of the visual field in the occipital striate cortex was initially described by Inouye and then by Holmes and Lister.⁷ Because the contralateral hemifield of vision is demonstrated in each cerebral hemisphere, superior quadrantic defects may be associated with inferior calcarine lesions, and inferior quadrantic defects usually evolve secondary to superior calcarine lesions.⁷ Although medial occipital lesions cause highly congruous homonymous field defects, if both the upper and lower calcarine cortices are affected a complete homonymous hemianopia may develop.

Visual field defects such as homonymous hemianopia may be overlooked in patients with stroke. Patients with stroke must be evaluated for such defects because they can cause severe impairment of driving ability and the performance of daily activities. Several perimetric techniques have been described for detecting visual field abnormalities in patients with ischaemic stroke.³ To date, Humphrey perimetry, tangent screen, and Goldmann perimetry have been used to detect homonymous hemianopia caused by occipital lobe lesions, and all of these perimetric techniques have been found to be satisfactory screening tests for the detection of occipital lesions.³

Rarebit perimetry has been used in patients with glaucoma or vigabatrin associated vision loss and also in healthy children and young adults.^{8–11} However, to our knowledge, our study is the first report of the use of Rarebit perimetry for the evaluation of homonymous hemianopia in patients with stroke. Rarebit perimetry, which was developed by Frisen, is a simple, fast, and user friendly perimetric method which provides accurate preliminary results in the early detection of visual field damage in patients with neurological disorders.⁴ Rarebit perimetry primarily targets the ganglion cells (especially the midgrid cells) which enable detailed vision and resolution. During Rarebit perimetry, the visual information is carried by minuscule bright dots and is presented against a dark background to maximise image contrast. Test dots are contained in 5° circular areas that are separated centre-to-centre by approximately 10°, and 30 areas are tested. Because Rarebit perimetry traverses the 26 peripheral test locations about once a minute, it is very fast and can be easily conducted, even in older patients with neurological complaints. Rarebit perimetry requires Windows 95/98/2000/NT and needs only a thin film transistor and a liquid crystal display with a resolution of 1024×768 picture elements. As a result, it is possible to conduct the test at the bedside.

In our study, MHR was selected for Rarebit perimetry and the mean deviation and PSD values were selected for HFA perimetry in the comparison of these two tests. The MHR values and the mean deviation and PSD values were significantly correlated in all four quadrants of both eyes. MHR was found to be a reliable index of visual field defects in patients with homonymous hemianopia.

Brusini and colleagues found that Rarebit perimetry, when conducted in patients with glaucoma, was slightly faster than the HFA 30-2 SITA test.⁸ In our study, the difference between the time required for Rarebit perimetry testing and the duration of the HFA test was more obvious (the mean Rarebit test times for the right and left eye were 4.19 and 4.18 minutes, respectively, while for HFA perimetry the values were 7.38

and 7.14 minutes for the right and left eye, respectively). The short time required to carry out Rarebit perimetry is important, especially in patients with severe neurological illness. Our test time results were similar to those found in healthy and glaucoma subjects.¹² Martin and Wanger reported a median reaction time of 0.7 seconds in 18 year old subjects (shorter than our mean reaction times of 0.98 and 1.01 seconds for the right and left eye, respectively)¹²; however, our study was conducted in an older patient population (mean age, 58.9 years) and all our subjects had experienced an ischaemic stroke. We conclude that the longer mean reaction time in the Rarebit perimetry in our study was probably caused by the older age and the poor general health of the subjects.

In our study, the mean number of errors made was 0.47 (range 0 to 3), which was similar to the findings of Malmer and Martin (0, range 0 to 2) in patients younger than 65 years, and 0 (range 0 to 5) in patients older than 65 years.¹¹ We believe Rarebit perimetry to be a simple and user friendly test that can easily be performed by patients, even those who have experienced a stroke.

We conclude that Rarebit perimetry is reliable and easily performed and that it is the preferred test for use in patients with homonymous hemianopia. It can be conducted with a simple software program and standard computer hardware. Rarebit perimetry saves time and is easily carried out at the bedside in neurologically disabled patients. Other prospective studies must be done to establish the effectiveness of this technique in the evaluation of visual field defects caused by neuro-ophthalmological disorders, especially in patients with stroke.

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