Use of a portable head mounted perimetry system to assess bedside visual fields

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Abstract

Aim—This study was designed to test the ability of a portable computer driven, head mounted visual field testing system to perform automated perimetry on patients at their bedside and to compare these results with the “gold standard” for bedside examinations, confrontation visual fields.

Methods—The Kasha visual field system is a portable automated perimeter which utilises a virtual reality headset. 37 neurosurgery patients were examined at their bedside with a central 24 degree suprathreshold testing strategy after confrontation visual field testing. The patterns of visual field defects were categorised and compared with the results of confrontation testing.

Results—A total of 42 field examinations were completed on 37 patients, and the average testing time for both eyes was 4.8 minutes with the perimetry system. Each of the 11 fields (100%) classified with defects on confrontation testing was similarly categorised on head mounted perimetry. 26 out of 31 (84%) visual fields were normal on both confrontation and perimetry testing, while five out of the 31 fields (16%) which were full on confrontation had visual field defects identified by head mounted perimetry.

Conclusion—The head mounted, automated perimetry system proved easily portable and convenient for examining neurosurgical patients at their bedside in the perioperative period. The device demonstrated equal sensitivity to confrontation visual field testing methods in detecting field defects and offers the advantage of standardised, quantifiable testing with graphic results for follow up examinations.

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Visual field testing is an important adjunct to the ophthalmological and neurological consultative examination. Frequently, ophthalmologists, neurologists, and neuro-ophthalmologists are called upon for inpatient consultation, yet various factors preclude the examination of patients with formal, automated visual fields. Patients may be medically unstable and not permitted to be transferred off the floor for perimetry, while others may be unable to maintain their attention or head position as necessary for standard, formal visual field testing. The consultant is limited to careful confrontation methods in assessing the

visual fields. Confrontation testing, the most common manual visual field screening technique, is useful in detecting large dense visual field deficits.¹ Ideally, confrontation testing should be used as a tool for bedside examinations rather than as a substitute for standardised perimetry, whose superiority over confrontation is well established.²

In an effort to evaluate hospitalised inpatients with formal perimetry, a head mounted visual field analyser has been introduced. The goals of any diagnostic device are convenience, reliability, and superiority to clinical testing. The current study was designed to evaluate this new, PC driven head mounted visual field testing system in the consultative inpatient setting. Many features of this system facilitate its use for a bedside patient examination. This perimetry system does not require that a patient maintain a particular head position as the headset adjusts to fit comfortably on the patient's head. The field analyser reduces overall testing time by testing both eyes during the same field examination. Additionally, this new device performs a standardised, automated perimetry examination with a graphic output on a patient population that previously could only be examined by confrontation methods.

Methods

INSTRUMENTS

The Kasha visual field system was utilised for this study. The system, which contains a virtual reality headset, a laptop computer, visual field software, and a mouse, can be transported easily for bedside evaluations. Kasha visual field software Version 3.1, which runs on a Windows 95 platform, allows for the testing of a 24 degree field of 52 points with 6 degree spacing.³ The headset, which weighs a total of 8 ounces, consists of virtual reality glasses that connect to a band that adjusts to fit comfortably around the patient's head. A patient may wear his own glasses beneath the headset for refractive correction. The perimetry system uses two full colour, 0.7 inch × 0.7 inch liquid crystal display systems. Via the individual screens in front of each eye, the headset provides the patients with a binocular view (Fig 1).

The system and testing strategy allow for the testing of both eyes during the same visual field examination, thereby reducing the overall time and attention span required for automated perimetry. The patient fixates on a “cartoon” beetle that crawls along the outer edges of the viewing field. During the examination, light stimuli are randomly projected into the visual field of either eye via the individual viewing

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Figure 1 Head mounted perimetry test in progress with perimetrist monitoring examination on the computer screen.

screens. The subject holds a mouse during the examination and presses the button when a stimulus target of light is seen. The areas of the visual field being examined are determined by the location of the moving fixation point. For example, when the fixation point is along the left edge, the right upper and lower quadrants of both eyes are being examined, while the right and left lower quadrants of each eye are being tested as the fixation point moves along the top of the screen. The eye movements necessary for the patient to track the moving fixation target are minimal, with the eccentric gaze never exceeding 12 degrees in any direction.

The animation present in the screens of the headset can be viewed by the examiner on the computer monitor. Fixation losses are determined by projecting a stimulus into the physiological blind spot of the patient, estimated as a point 15 degrees temporal to the moving fixation point. The eye which is being tested, the number of correctly identified targets, as well as the number of fixation losses and false positive recordings, are all displayed on the computer monitor. Thus the perimetrist can monitor patient cooperation and can pause the examination if additional instructions are necessary. Variations can be made within the software in order to tailor the test to a particular group of patients. The system can be run in either full threshold or suprathreshold formats, and adjustments can be made to the intensity (brightness and size) of the stimulus, the time interval between stimuli, and the ratio of fixation checks. The luminance of the stimuli range from 1.3–500 asb, with numeric values calculated on a 13–39 dB scale of light attenuation similar to that used by Humphrey field analysers. Less sensitive retinal locations require brighter stimuli and are represented as lower decibel values.

PATIENT POPULATION

After approval from the University of Pennsylvania's institutional review board, an 8 week prospective study was established in which automated head mounted visual field testing was performed on patients admitted to the

neurosurgery service at the hospital of the University of Pennsylvania. As a group, neurosurgery patients frequently have lesions or procedures that are likely to affect the visual pathways, and the majority still have the mental and physical capabilities necessary to perform an automated visual field examination. All patients on the neurosurgery service who had either undergone or were scheduled for craniotomies were considered eligible for the study, except for those being treated in the intensive care unit. Following written documentation of informed consent, patients willing to participate in the study were given by one of the authors the standard 30 point minimal status examination which provides a quantitative measurement of orientation, memory, and computation.⁴ A normal mental status is indicated by scores between 24 and 30, and any patient with a mini-mental status score <20 was considered ineligible for the study. Patients were then required to demonstrate both an understanding of the requirements of the examination and the ability to press and release the mouse button in response to the appropriate stimuli.

PROCEDURE

Visual fields were checked using confrontation methods by one of the authors (DAH, NJV) before perimetry in order to avoid any potential bias of confrontation testing. Furthermore, the examiner was also masked to both the diagnosis and the operative procedure that the patient had undergone, although in several cases the location of the surgery was apparent. Standard methodology for confrontation testing was employed, and the examiner's own visual field was utilised as a standard for comparison. The examiner faced the patient within arm's length and asked the patient to cover a particular eye and focus on the examiner's nose. The confrontation test involved the presentation of fingers within the boundaries of the four visual quadrants, followed by the double simultaneous presentation of fingers on either side of the vertical or horizontal meridians. The patient was asked to count the number of fingers presented in each field. Kinetic testing followed in which fingers were introduced from the periphery into the patient's field of view.

The same conditions and parameters were established for each patient in order to maintain uniformity in testing conditions. The patient was able to remain in his/her bed throughout the perimetric visual field examination. The light in the patient's room was dimmed, and the patient was fitted with the headset. A startup screen was shown to each patient in which objects appeared at the extreme corners of the field space to ensure that the headset was properly positioned. A sample test followed in which 10 points were shown to both familiarise the patient with the features of the examination and enable the examiner to evaluate the patient's mechanical ability to use the mouse button properly.

The visual field software was set to test both eyes. The program was run in a suprathreshold

Table 1 Distribution of pathologies and number of days following craniotomy in which visual field testing was performed for the total of 42 head mounted perimetry fields

Pathology	Preop	1–2 Days	3–4 Days	5–10 Days	>10 Days	Total fields
Gliomas	4	2	6	2	2	16
Pituitary adenomas	1	1	3	1	—	6
Meningiomas	1	1	—	—	3	5
Central nervous system metastases	2	1	2	—	—	5
Intractable seizures	—	1	1	—	1	3
Aneurysms	1	—	1	—	1	3
Hydrocephalus	—	2	—	—	—	2
Central nervous system sarcoid	—	1	—	—	—	1
Cranial fibrous dysplasia	—	—	—	—	—	—
Total fields						42

mode of 16 dB stimuli with a single retest at the same intensity of every missed stimulus target. The time interval between stimuli was roughly 1.5 seconds and the fixation check frequency was set at one in 10 targets. Visual field defects were assigned by the principal location within one of 11 categories.

CLASSIFICATION OF HEAD MOUNTED PERIMETRY FIELDS

The head mounted perimetry system generates results in numeric and grey scale formats. The grey scale fields were analysed, and the guidelines for defining visual field defects included three or more adjacent points missed upon retesting at the same stimulus intensity.² In order to minimise the potential influence of bias in interpretation, the perimetry fields were

Table 2 Distribution of the 37 of 42 fields with the same categorisation on confrontation and head mounted automated perimetry

Category	No of fields	% of fields	Test time (minutes)
Normal fields	26	61.9	4–5
Temporal defects	3	7.1	4–5
Bitemporal defects	2	4.8	6
Homonymous quadrant defects	3	7.1	5–6
Hemianopias	2	4.8	7–8
Four quadrant defects	1	2.4	7

Figure 2 Head mounted perimetry field of a 58 year old man 4 days after a transphenoid resection of a pituitary adenoma, with a classic bitemporal field defect consistent with chiasmal dysfunction.

analysed by an author who was unaware of the results of confrontation testing. Each quadrant of each eye field was assessed for a visual field defect and compared with the results of confrontation. Visual field defects were assigned by the principal location within one of 11 categories based on relevant classifications defined in the Optic Neuritis Treatment Trial.^{5,6} The categories of defects included the following: (1) hemianopia, (2) quadrant, (3) temporal, (4) bitemporal, (5) arcuate, (6) nasal step, (7) peripheral rim, (8) multiple foci, (9) three quadrant, (10) four quadrant, and (11) enlarged blind spot. The grey scale results were then compared with the findings of confrontation testing. Lower patient reliability was ascribed to those with greater than 25% fixation losses or greater than 10% false positives. These parameters were designed to parallel the reliability indices established for Humphrey visual fields, which assign low patient reliability to fields with greater than 20% fixation losses or more than 33% false positive recordings.⁷

Results

During the course of 8 weeks, 77 individuals were admitted to the neurosurgery service at the hospital of the University of Pennsylvania for craniotomies. The visual fields of 74 eyes from 37 different patients were tested on the portable, head mounted perimeter. Five of the 37 patients had testing performed both preoperatively and postoperatively to assess possible changes in visual fields following various neurosurgical procedures. The 37 patients (48%) encompassed a cross section of the neurosurgery service with a diverse set of pathologies (Table 1). The ages of the patients ranged from 21 to 75 years, with a mean age of 46.9.

Forty out of the 77 patients (52%) on the service did not undergo perimetry testing. Seventeen patients (22%) were excluded because of a low mini-mental status score (<20), and two patients (3%) were unable to press and release the mouse button appropriately. Eighteen (23%) patients refused to participate in the study. The visual field program for testing both eyes during the same examination was utilised for this study, and therefore three patients (4%) with strabismus were excluded.

TESTING TIME

The average total testing time for both eyes using the head mounted automated perimeter was 4.8 minutes. Those with abnormal fields by confrontation required an average of 5.8 minutes, 1.3 minutes longer than the average testing time of those with full fields by confrontation. The suprathreshold examination was completed on both eyes and identified hemianopias in 7–8 minutes, homonymous quadrant defects in 5–6 minutes, and temporal and bitemporal defects in 4–7 minutes (Table 2).

FIELD CLASSIFICATION

A total of 42 head mounted perimetry fields were completed on the 37 patients. Eleven fields (26%) on 10 different patients were considered

Figure 3 Head mounted perimetry fields of a 37 year old man taken preoperatively (A) and 2 days following a right temporal lobe resection for an anaplastic astrocytoma (B). The left superior homonymous quadrant defect is consistent with the right temporal lobe resection.

to have field defects by confrontation, while 31 (74%) of the completed fields were classified as normal by confrontation. The results of confrontation testing and perimetry received the same categorisation on 37 of the 42 (88%) examinations (Table 2). Each of the 11 fields with defects on confrontation were similarly categorised on the perimetry examination, and 26 out of the 31 full fields on confrontation were also identified as full by perimetry.

The 11 fields with similar defects detected on confrontation as well as on head mounted perimetry (Figs 2, 3) had visual field defects which correlated with predicted abnormalities based on the pathology and operative procedures.⁸ The patients with pituitary adenomas produced temporal or bitemporal lesions consistent with masses compressing the chiasm. The patients who had resections of occipital lobe lesions produced complete hemi-

anopias, and lesions and resections of tumours in the parietal and temporal lobes led to the identification of inferior or superior quadrant anopic defects, respectively.

Five of the 42 completed perimetry fields did not have corresponding defects on confrontation visual field testing. Two of the five fields contained peripheral rim defects in both eyes consistent with patient fatigue. One field contained a three quadrant defect in the left eye and an enlarged blind spot in the right eye, despite normal confrontation results. However, the head mounted visual fields were similar to the field results from a Humphrey field analyser examination performed several months earlier (Fig 4). The remaining fields, which contained an arcuate defect and a nasal step defect, may represent true false positives or unrelated optic neuropathies.

RELIABILITY

Patient cooperation was assessed by monitoring fixation losses and false positive recordings. Fixation checks were performed roughly 12–20 times per examination. Using the standard for a reliable field as fixation losses less than or equal to 25% with less than 10% false positives, 69% (29/42) of the head mounted perimetry fields met the standards of reliability, including 82% (9/11) of the similarly categorised abnormal fields. False positives were rare and every patient had less than 5% false positive recordings.

Discussion

This study demonstrated the ability of a portable, head mounted automated perimetry system to obtain visual fields at a patient's bedside. The testing of this population of hospitalised neurosurgery patients has previously been limited to confrontation testing. In a study of confrontation visual field techniques, Trobe *et al* concluded that confrontation methods should not be the only form of visual field testing for chiasmal hemianopic defects, but rather should serve to alert the perimetrist to the presence of gross field defects.⁹ The head mounted perimetry system allowed for a standardised, automated test to be utilised for visual field examination at a patient's bedside.

The head mounted perimetry system proved portable and was easy to set up at a patient's bedside. The headset adjusted comfortably over the patients' bandages and none of the patients stopped the examination or complained of any discomfort. The ability to test both eyes during the same examination limits the total testing time, which was further reduced in this study by employing a suprathreshold format. This new device offers the advantage of providing a graphic result to allow for comparisons upon follow up examinations. One of the patients preoperatively was found to have normal visual fields, yet was identified with homonymous quadrant defects following a temporal lobe resection (Fig 3).

The results of head mounted perimetry correlated with clinical testing on 37 of the 42 completed fields. Each of the visual field defects detected by confrontation was con-

Figure 4 Head mounted perimetry field of a 34 year old woman 3 days following a craniotomy for central nervous system sarcoid (A). The three quadrant defect in the left eye (B) and enlarged blind spot in the right eye correlated well with the results of a Humphrey field examination performed 3 months earlier (C).

firmed by head mounted automated perimetry, and 26 out of 31 full fields on confrontation were similarly identified on perimetry. A key in evaluating this device for the patient population is looking at those fields which had different results. Of the five of 42 fields which had different classifications, two had peripheral rim defects detected on perimetry which were considered the result of patient fatigue.¹⁰ One of the fields which was full on confrontation had a three quadrant defect in the left eye and an enlarged blind spot in the right eye on head mounted perimetry. The results of a previous Humphrey field examination on this patient correlated well with the perimetry examination and supported these results over confrontation testing (Fig 4). The remaining two fields which did not correspond to confrontation showed an arcuate defect and a nasal step defect, but these patients had no previous or follow up testing with Goldmann or Humphrey visual field analysers. These fields suggest optic neuropathies or represent true false positives.

Our goal was not to compare this device other forms of formal perimetry, but rather to introduce a form of bedside automated perimetry that would be complementary to and more quantifiable than confrontation methods. The validity and reliability of this device compared with other forms of automated perimetry is unknown. We have performed some early trials comparing this new head mounted perimetry device with the Humphrey field analyser, and have found comparable results in terms of field classifications. Previous trials evaluating all equivalent points between the head mounted perimetry fields of 48 people (24 normal, 24 abnormal fields) and those produced by a Humphrey field analyser demonstrated a mean difference of 4 dB at each point.¹¹ Further trials are necessary in order to more fully evaluate this new device relative to the standard perimetry tools such as the Humphrey or Goldmann field analysers.

The disadvantages of the head mounted perimetry system are similar to those of any automated perimetry system. Given the preset testing program of automated perimeters, patient cooperation and concentration are vital during the head mounted perimetry visual field examination. Unlike standard Humphrey field analysers, the head mounted perimetry system incorporates the use of a moving fixation target. Studies comparing the Humphrey field analyser and the Dicon TKS 4000 perimeter demonstrated that there is no overall difference in diagnostic value between perimeters using static fixation points and those which utilise moving fixation targets.¹⁰ Perhaps the greatest limitation observed in this study was the high number of fixation losses. Based on the reliability criteria for the number of allowable fixation losses, 69% of the completed fields were considered reliable. Though the fraction of reliable fields is less than ideal, it may be the result of patients' inexperience with automated visual field testing or their initial difficulty adjusting to a moving fixation target. Only 11 of the 37 patients had been tested previously with any form of perimetry, and we would have expected a steep learning

curve upon retesting with automated perimetry. The reliability findings for the head mounted perimetry study are similar to those of other clinical studies utilising various forms of automated perimetry. Studies of reliability indices for the Humphrey visual field analyser have shown that only 55–65% of baseline automated perimetry examinations on glaucoma patients satisfy reliability criteria, most commonly the result of fixation loss.^{12 13}

This study featured the use of suprathreshold static perimetry to allow for reduced testing times. Siatkowski *et al* demonstrated that suprathreshold automated perimetry is nearly as effective as full threshold testing in detecting visual field abnormalities due to neuro-ophthalmic disease and suggested that more quantitative full threshold perimetry should be performed on equivocal cases.¹⁴ The suprathreshold mode of this device seems especially conducive for screening or examining patients with reduced attention spans. A full threshold perimetry field examination remains a more appropriate test for quantifying defects or following chronic diseases such as glaucoma.¹⁴

The head mounted perimetry system allows for a standardised test to be utilised on hospitalised inpatients who previously could only be tested with confrontation testing. This head mounted perimetry system appears to offer an alternative to confrontation for consultants evaluating the visual fields of patients who are unable to be tested by current perimetry techniques.

The authors have no financial or proprietary interest in the system described in this paper

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