

**NEW METHOD FOR QUANTIFYING VISUAL FIELD DEFECTS IN
GLAUCOMATOUS PATIENTS**

Giancarlo Delvecchio, Alberto Brombin, Nikos Tsioumas, Lucia Bussolari, Roberto Guerra.

University of Modena - Institute of Ophthalmology. Modena, Italy.

Head: prof. Roberto Guerra

Dr. Giancarlo Delvecchio - Dr. Nikos Tsioumas
Dipartimento delle Scienze Neuropsicosensoriali
Clinica Oculistica
Policlinico di Modena
Via Del Pozzo 71
41100 Modena
ITALY
tel: 0039-59- 360309
fax: 0039-59-371532

SUMMARY

A new scoring system is introduced to obtain a visual field per centual score beginning from a threshold related automatic field chart, by which it is possible to quantify relative scotomata in proportion to their depth and their impact on everyday life.

Our interest is focused on the central 30 degrees visual field map of the C / 30 - 2 program of the Humphrey Field Analyser (Allergan), which actually is one of the most common perimetric records in clinical practice.

The new method is based on the Esterman's standard, which is worked out so as to ascribe a per cent value to each test point of the Central 30 - 2 program; this per cent value is differently weighed depending on the quadrant where each test point is inscribed, its eccentricity and its threshold value. The sum of the threshold-related per cent values of all the grid points is equal to the residual visual field functional score. The ratio of the residual visual field functional score to full score (50) rappresents a new perimetric index related to function.

In the case of glaucomatous eyes, a visual field efficiency index is calculated, which, together with visual acuity, rappresents the residual optic nerve function and consequently permits to quantify the optic nerve functional damage.

This scoring method has been tested on 15 glaucomatous visual fields.

Key words: glaucoma; visual field; threshold related perimetry; defect per cent quantification.

INTRODUCTION

The functional visual field scoring is based on the Esterman's theory of relative values which stresses that, for human activities,

- 1) the central part of the field is more valuable than the peripheral one,
- 2) the lower hemisphere is more useful than the upper one,
- 3) the "horizon" meridian is more important than the other meridians,
- 4) the 5 degrees central area is ignored, leaving macular and paramacular functions to be expressed by the Snellen visual acuity score.(1, 2).

In 1984 the American Medical Association (A. M. A.) adopted the Esterman's score system as the new standard for scoring the irregular visual field defects (3, 4, 5). The Esterman grid gives the whole visual field a 100 per cent value and defines a value respectively for each quadrant, hemisphere and concentric ring-area of the visual field starting from 5 degrees of eccentricity.

Originally, this grid was conceived for manual kinetic supra-threshold perimetry (stimulus III / 4) and was to be superimposed on the Goldman field charts.

Recently, a monocular Esterman grid adapted for static automated perimetry has become available (Esterman monocular program of Humphrey Field Analyzer). This program succeeds in dodging the errors due to the examiner's subjectivity, but it remains a supra-threshold test and thus not able to detect slight relative defects. Moreover, the Esterman monocular program consists of only 100 test points distributed all over the 60 degrees of

the visual field so that it appears inadequate for detecting small and irregular scotomata.

With regard to glaucomatous visual field records, though the global indices and probability maps have improved automated central 30 degrees field charts' analysis, a separate "efficiency index" for threshold-related perimetric tests is not yet available today. Consequently, a new method for scoring absolute and relative glaucomatous defects, beginning from an automated threshold-related test, is proposed.

SUBJECTS AND METHODS

Included in this study were 15 patients, 7 males and 8 females, aged from 27 to 75 (mean age 51), affected by glaucoma who received visual field testing at the Department of Ophthalmology of the University of Modena. Each subject had a history of an intraocular pressure above 21 mmHg with typical glaucomatous optic disc damage and with visual field changes. We excluded patients with extensive neurologic or retinal disease which might influence the visual field or those who were unable to complete perimetric testing. Only one eye from each subject was randomly selected to be tested.

Each subject was tested using the 30 - 2 program of the Humphrey Field Analyzer model 630, which examines 76 locations with a 6° grid within the central 30° of the visual field. Locations are offset symmetrically across the horizontal and vertical midline. This examination is performed in a staircase fashion to determine the subject's threshold level at each location.

In order to calculate a score for visual field defects detected by a threshold test, it has been necessary to give each test point a topographic value and, subsequently, to connect each topographic value with its corresponding threshold value.

Three concentric ring-areas are located all over the central 30 degrees visual field; according to eccentricity, a different percent value corresponds to each ring-area (table n. 1 e n. 2).

With reference to the per cent values of each quadrant (Q) and concentric ring-area (A) of the visual field, it is possible to calculate the corresponding per cent values of any segment of ring-area inscribed in a given quadrant (AI) by the following formula:

$$(A \cdot Q) : 100 = AI$$

A : per cent value of the selected ring area;

Q : per cent value of the selected quadrant;

AI : per cent value of ring area selected segment.

In table 3 the results obtained in each quadrant are shown. The grid test points located in each concentric ring-area are pointed out and all of them are considered to be at the same distance from the fixation point (approximation interval : + / - 5 degrees of eccentricity).

In a given quadrant, the score of each segment of ring-area (AI) is divided by the number of the test points inscribed (p) so that it is possible to give each grid point a topographic value which varies according to its eccentricity and its quadrant (T).

$$AI : p = T$$

AI : per cent value of the selected segment of ring area in a quadrant;

p : number of the segment test points;

T : topographic value of each segment test point

With regard to Esterman's theory of relative values, the four C / 30 - 2 grid test points inside the 5 degrees central area are excluded from calculation.

The topographic value of the two grid test points inside the blind spot is shared out among the remaining points of the same segment of ring area.

Once established the criteria for each grid point topographic value calculation (table 4), a threshold factor (C) is obtained for each tested point, that is the ratio of the recorded threshold (S) to mean reference threshold. In C / 30 - 2 program the mean reference threshold is directly obtained from the perimetric field chart summing up the recorded threshold and the respective "defect depth" value (D), so that it can be expressed by the following formula:

$$C = S / (S + D)$$

C : threshold factor of the tested point;

S : recorded threshold of the tested point;

D : defect depth of the tested point.

The threshold-related topographic value of a tested point (V) is calculated multiplying the topographic value (T) by the respective threshold factor (C), that is:

$$V = C . T \quad \text{or} \quad [S / (S + D)] . T$$

V = threshold-related topographic value of the tested point;

C = threshold factor of the tested point, that is: $S / (S + D)$;

T = topographic value of the tested point.

The sum of the threshold-related topographic values (V) of all the grid points (n) corresponds to the residual visual field functional score, that is:

$$V_1 + V_2 + \dots + V_n = RVFS$$

RVFS = residual visual field functional score

The ratio of the residual visual field functional score to full score (50) has been called visual efficiency index (VEI) and represents a new perimetric index related to function.

$$VEI = RVFS / 50$$

In order to speed up the score calculation we have set out a worksheet program so that the residual visual field score is automatically calculated by entering each grid point threshold and defect depth values.

RESULTS

We have examined 15 glaucomatous eyes, eleven were left eyes and four were right eyes. The global indices (MD, PSD, CPSD, SF) of each visual field have been recorded and the residual visual field functional score with its related visual field efficiency index were calculated.(Table 5). In order to classify the perimetric damage we have adopted the Glaucoma Staging System (GSS) so that it has been possible to ascribe an efficiency score to its respective stage of visual field damage.(Table 6) (6, 7, 8)

Our 15 glaucomatous eyes were arranged as follows: 1 eye at stage 0 (efficiency index: 0.93), 7 eyes at stage 2 (mean efficiency index: 0.86), 3 eyes at stage 3 (mean efficiency index: 0.75), 3 eyes at stage 4 (mean efficiency index: 0.63), 1 eye at stage 5 (efficiency index: 0.32). In particular, one eye with prevalently localized defect at stage 4 showed a higher efficiency index in comparison with another eye with mixed defect at stage 3.

CONCLUSIONS

The threshold-related scoring system of the visual field gives an accurate quantitative information because of the great number of grid points and because it is able to give a score to slight relative defects, otherwise not valuable.

Our results show that our visual field efficiency index decreases with the advancing of the perimetric damage. Taking into consideration visual fields at the same stage our results suggest that mixed visual field defects could have a stronger impact on everyday life than pure localized defects.

Although, there is some kind of correlation between GSS and visual efficiency index, it can be concluded that patient's perceived visual field disability does not strictly fit with the sharp demarcation of a clinical staging system.

The clinician should always have an idea of the patient's perceived visual field disability. Our threshold related scoring system makes possible to quantify relative scotomata in proportion to their depth and their functional importance.

| | | | | |
|-----------|---------|-------------|-------|-----|
| Ring Area | between | 5° and 10° | | 6% |
| Ring Area | between | 10° and 20° | | 22% |
| Ring Area | between | 20° and 30° | | 22% |

Table 1: values of the ring areas depending on eccentricity.

| | Nasal | Temporal | Horizontal total |
|--------------------------|-------|----------|------------------|
| Superior | 14% | 19% | 33% |
| Inferior | 27% | 40% | 67% |
| Vertical total | 41% | 59% | 100% |

Table. 2: Quadrant and hemifields' values.

TEMPORAL SUPERIOR QUADRANT (value: $19 / 2 = 9,5$ %)

between $5^\circ - 10^\circ$ of eccentric.: $(19 \times 6): 100 = 1,14$ %

between $10^\circ - 20^\circ$ of eccentric.: $(19 \times 22): 100 = 4,18$ %

between $20^\circ - 30^\circ$ of eccentric.: $(19 \times 22): 100 = 4,18$ %

TEMPORAL INFERIOR QUADRANT (value: $40 / 2 = 20$ %)

between $5^\circ - 10^\circ$ of eccentric.: $(40 \times 6): 100 = 2,4$ %

between $10^\circ - 20^\circ$ of eccentric.: $(40 \times 22): 100 = 8,8$ %

between $20^\circ - 30^\circ$ of eccentric.: $(40 \times 22): 100 = 8,8$ %

NASAL SUPERIOR QUADRANT (value: $14 / 2 = 7$ %)

between $5^\circ - 10^\circ$ of eccentric.: $(14 \times 6): 100 = 0,84$ %

between $10^\circ - 20^\circ$ of eccentric.: $(14 \times 22): 100 = 3,08$ %

between $20^\circ - 30^\circ$ of eccentric.: $(14 \times 22): 100 = 3,08$ %

QUADRANTE NASALE INFERIORE (value: $27 / 2 = 13,5$ %)

between $5^\circ - 10^\circ$ of eccentric.: $(27 \times 6): 100 = 1,62$ %

between $10^\circ - 20^\circ$ of eccentric.: $(27 \times 22): 100 = 5,94$ %

between $20^\circ - 30^\circ$ of eccentric.: $(27 \times 22): 100 = 5,94$ %

Table 3: Topographic values of the three annular segments inscribed in each visual field quadrant.

| Eccentricity | Inscribed Points | QTS | QTI | QNS | QNI |
|---------------------|------------------|-------|-----|-------|-------|
| between 5° and 10° | (2 points) | 0,57 | 1,2 | 0,42 | 0,81 |
| between 10° and 20° | (4-5 points) | 1,045 | 2,2 | 0,616 | 1,188 |
| between 20° and 30° | (11 points) | 0,38 | 0,8 | 0,28 | 0,54 |

QTS = temporal superior quadrant.

QTI = temporal inferior quadrant.

QNS = nasal superior quadrant.

QNI = nasal inferior quadrant.

Table 4: percentual topografic value of each test point in program C/30-2

| <u>patient</u> | <u>eye</u> | <u>residual s.</u> | <u>defect s.</u> | <u>eff. index</u> | <u>MD</u> | <u>PSD</u> | <u>CPSD</u> | <u>SF</u> |
|----------------|------------|--------------------|------------------|-------------------|-----------|------------|-------------|-----------|
| B. F. | OS | 46,53 | 3,47 | 0,93 | 0,09 | 2,57 | 1,95 | 1,5 |
| C. A. | OS | 45,48 | 4,52 | 0,90 | -5,01 | 2,3 | 1,45 | 1,6 |
| C. G. | OD | 45,45 | 4,55 | 0,90 | -3,85 | 5,53 | 4,92 | 2,2 |
| B. F. | OD | 44,34 | 5,66 | 0,88 | -3,79 | 3,37 | 2,95 | 1,4 |
| G. T. | OS | 44,28 | 5,72 | 0,88 | -4,17 | 3,2 | 2,62 | 1,6 |
| R. A. | OD | 43,22 | 6,78 | 0,86 | -1,75 | 5,01 | 4,24 | 2,3 |
| C.M. | OS | 42,75 | 7,25 | 0,85 | -1,39 | 6,9 | 6,69 | 1,5 |
| D. M. | OD | 40,60 | 9,40 | 0,81 | -4,98 | 5,63 | 4,58 | 2,9 |
| M. N. | OS | 39,29 | 10,71 | 0,78 | -6,78 | 8,76 | 8,2 | 2,7 |
| G. C. | OS | 38,80 | 11,20 | 0,77 | -7,45 | 4,78 | 3,82 | 2,5 |
| A. C. | OS | 36,90 | 13,1 | 0,73 | -10,83 | 12,9 | 12,46 | 2,9 |
| C. B. | OS | 36,46 | 13,54 | 0,72 | -10,13 | 8,14 | 7,57 | 2,7 |
| B. R. | OS | 30,32 | 19,68 | 0,60 | -14,89 | 8,35 | 7,69 | 2,9 |
| V. G. | OS | 28,25 | 21,75 | 0,56 | -16,32 | 13,7 | 10,94 | 7,3 |
| C. C. | OS | 16,32 | 33,68 | 0,32 | -16,64 | 15,2 | 14,78 | 3,1 |

residual s.= residual visual field score; defect s.= defect visual field score; eff. index = efficiency visual field index; MD = mean deviation; PSD = pattern standard deviation; CPSD = corrected pattern standard deviation; SF = short term fluctuation.

Table 5. List of the 15 tested glaucomatous eyes and their perimetric results

| Patient | Stage | Visual Field Efficiency Index |
|----------------|---------------------------------------|--------------------------------------|
| B.F. | Stage 0: | 0,93 |
| C.A. | Pure Generalized Defect Stage 2: | 0,90 |
| C.G. | Prevalently Localized Defect Stage 2: | 0,90 |
| B.F. | Mixed Defect Stage 2: | 0,88 |
| G.T. | Mixed Defect Stage 2: | 0,88 |
| R.A. | Pure Localized Defect Stage 2: | 0,86 |
| C.M. | Pure Localized Defect Stage 2: | 0,85 |
| D.M. | Mixed Defect Stage 2: | 0,81 |
| M.N. | Prevalently Localized Defect Stage 3: | 0,78 |
| G.C. | Mixed Defect Stage 3: | 0,77 |
| A.C. | Prevalently Localized Defect Stage 4: | 0,73 |
| C.B. | Mixed Defect Stage 3: | 0,72 |
| B.R. | Mixed Defect Stage 4: | 0,60 |
| V.G. | Mixed Defect Stage 4: | 0,56 |
| C.C. | Mixed Defect Stage 5: | 0,32 |

Table 6. Visual field efficiency index correlation with Glaucoma Staging System classification.

REFERENCES

- 1) Esterman B.: Grid for scoring visual fields. I Tangent screen. Arch. Ophthalmol. 77: 780 - 786, 1967.
- 2) Esterman B.: Grid for scoring visual fields. II Perimeter. Arch. Ophthalmol. 79: 400 - 406, 1968.
- 3) A.M.A. Committee on Medical Rating of Physical Impairment. Guide to the evaluation of permanent impairment; the visual system. J.A.M.A. 168: 475 - 485, 1958 (Sept. 27).
- 4) A.M.A. Committee on Rating of Mental and Physical Impairment. Guides to the evaluation of permanent impairment. Chicago: American Medical Association, 93 - 101, 1971.
- 5) A.M.A. Guides to the evaluation of permanent impairment, 2nd ed. Chicago: American Medical Association, 141 - 151, 1984.
- 6) Brusini P.: Un nomogramma per la classificazione dei difetti del campo visivo nel glaucoma. XI Riunione AISG. Rapallo, 24 marzo 1995. Boll. Ocul. 1996; 75, Suppl. 2: 33 - 38.
- 7) Brusini P.: Un nuovo metodo per la suddivisione in stadi del danno perimetrico nel glaucoma cronico semplice. XI Convegno SOT, Trieste, 26 - 27 maggio 1995. In corso di stampa.
- 8) Brusini P. Clinical use of a new method for visual field damage classification in glaucoma. X Congr. SOE, Milano, 23 - 29 giugno 1995. In corso di stampa

ΝΕΑ ΜΕΘΟΔΟΣ ΕΚΤΙΜΗΣΗΣ ΤΩΝ ΕΛΛΕΙΜΜΑΤΩΝ ΤΟΥ ΟΠΤΙΚΟΥ ΠΕΔΙΟΥ ΣΕ ΓΛΑΥΚΩΜΑΤΙΚΟΥΣ ΑΣΘΕΝΕΙΣ.

Giancarlo Delvecchio, Alberto Brombin, Νίκος Τσιουμας, Lucia Bussolari, Roberto Guerra.

Οφθαλμολογικό Ινστιτούτο Πανεπιστήμιο της Μοντενα. Ιταλία.
(Διευθ: R.Guerra).

ΠΕΡΙΛΗΨΗ

Προτείνεται ένα καινούργιο σύστημα υπολογισμού της ποσοστιαίας εκτίμησης της βλάβης του οπτικού πεδίου, ξεκινώντας από τα αποτελέσματα προγραμμάτων προσδιορισμού του ουδού ευαισθησίας της αυτοματικής περιμετρίας. Το ενδιαφέρον μας είναι εστιασμένο στο πρόγραμμα C/30-2 του αυτοματικού περιμετρου Humphrey 630 Analyser Allergan, που είναι το πιο κοινό πρόγραμμα αυτοματικής περιμετρίας που χρησιμοποιείται στην κλινική πράξη.

Η νέα μέθοδος είναι βασισμένη στη σταθερά του Esterman, η οποία χρησιμοποιείται με τρόπο ώστε να αποδοθεί σε κάθε εξεταζόμενο σημείο του προγράμματος προσδιορισμού του ουδού ευαισθησίας μια ποσοστιαία τιμή, εξαρτώμενη από το τεταρτημόριο που ανήκει, από την εκκέντρωση του και από τον ουδό ευαισθησίας του. Το άθροισμα των τιμών του κάθε σημείου αντιπροσωπεύει την υπολοίπη βαθμολογία του οπτικού πεδίου. Η σχέση της υπολοίπης λειτουργικής βαθμολογίας του οπτικού πεδίου προς την ολική βαθμολογία (50) αντιπροσωπεύει έναν νέο περιμετρικό δείκτη σχετιζόμενο με την λειτουργία.

Στην περίπτωση γλαυκωματικών οφθαλμών, υπολογίζεται ένας περιμετρικός δείκτης αποδοτικότητας, που μαζί με την οπτική οξύτητα, αντιπροσωπεύει την λειτουργία του οπτικού νεύρου και κατά συνέπεια επιτρέπει την εκτίμηση της λειτουργικής βλάβης αυτού.

Αυτή η μέθοδος υπολογισμού χρησιμοποιήθηκε στην μελέτη 15 γλαυκωματικών οπτικών πεδίων. Παρουσιάζουμε τα αποτελέσματά μας.

Λεξεις ευρετηριασης: γλαυκωμα,
αυτοματη περιμετρια, προγραμμα προσδιορισμου ουδου ευαισθησιας, ποσοστια
ια εκτιμηση ελλειμματων.