SPACE LIFE SCIENCES SYMPOSIUM (A1)
Medical Care for Humans in Space (4)

Author: Dr. Ygal Rotenstreich
Sheba Medical Center, Tel Aviv University, Israel

Mr. Ron Chibel
Tel Aviv University, Israel
Dr. Soad Hajyahia
Sheba Medical Center, Israel
Mr. Daniel Benner
Sheba Medical Center, Israel
Dr. Mohamad Mahajna
Sheba Medical Center, Israel
Prof. Michael Belkin
Tel Aviv University, Israel
Dr. Yakir Berchenko
Gertner Institute for Epidemiology and Health Policy Research, Israel
Mrs. Bernice Oberman
Gertner Institute for Epidemiology and Health Policy Research, Israel
Prof. Laurence Freedman
Gertner Institute for Epidemiology & Health Policy Research, Israel
Dr. Ofra Kalter-Leibovici
Gertner Institute for Epidemiology & Health Policy Research, Israel
Dr. Ifat Sher
Sheba Medical Center, Israel

CHROMATIC MULTIFOCAL PUPILLOMETER FOR OBJECTIVE NON-INVASIVE DIAGNOSIS OF OPHTHALMIC PATHOLOGIES IN ASTRONAUTS

Abstract

Upon their return from long-duration space missions, astronauts often suffer from ophthalmic pathologies including optic disc edema, choroidal folds and hyperopic shifts. We developed a next generation, objective, visual field (VF) testing device for clinical diagnosis of VF defects, identification of damaged neuroretinal cells, as well as diagnosis and prognosis of defects in the optic nerve. The device comprises a multifocal chromatic pupillometer that enables accurate measurement of pupillary responses (PR) to short wavelength light stimuli (SWS, 485nm) and long wavelength (LWS, 625nm) light stimuli at 30 degrees of the VF, facilitating objective identification of damages in the neuroretinal pathways of rods (using LWS at intensity of 1000 cd/m2), cones (using LWS at intensity of 200 cd/m2) or intrinsically photosensitive Retinal Ganglion Cells (ipRGCs, using SWS at intensity of 5000 cd/m2). By categorizing damages of individual neuroretinal pathways, specific pathologies can be diagnosed. Thus, retinitis pigmentosa (RP) patients demonstrated statistically significant lower ($p<0.05$) PR in a vast majority of VF locations in response to SWS at intensity of 200 cd/m2 and mostly in peripheral targets in response to LWS. The time at which maximal pupil constriction velocity was measured at different VF locations in response to the LWS was significantly more dispersed in RP patients compared with controls (one-sided Wilcoxon

rank sum test, p-value<0.0001, area under the curve-0.97). These findings correlate with the pathology of RP that is characterized by degeneration of rods followed by cone degeneration. Macular dystrophy patients demonstrated significantly lower PR to LWS and nearly normal PR to SWS in majority of VF locations, correlating with pathology of macular cone deficit. Significantly reduced PRs were recorded in glaucoma patients under testing conditions that emphasized ipRGC and cone contribution in majority of perimetric locations ($P<0.05$). Under testing conditions that emphasized rod contribution, glaucoma patients demonstrated reduced PR in the center and 20 degree isopter ($p<0.05$), correlating with patient pathology of optic nerve defects. The device is predicted to indicate intracranial pressure and Papilledema, as specific cranial nerve compressions cause a reduction in pupillary responses for particular wavelengths and stimulus locations. In addition, general optical defects of the retina, can be objectively identified and lead to earlier detection of visual pathologies. Furthermore, pupil measurements can demonstrate refractive errors. A size-reduced, hand-held device is under development and is predicted to enable quick, easy to use, objective, noninvasive detection of VF defects in astronauts during space missions.