Clinical Neurophysiology Practice 2 (2017) 67–71

Contents lists available at ScienceDirect

Clinical Neurophysiology Practice

journal homepage: www.elsevier.com/locate/cnp

Research paper

Visual evoked potentials after hematopoietic allogeneic stem cell transplantation in childhood

Alba Lucia Törnquist [a], Thomas Andersson [b], Jacek Winiarski [c], Marita Andersson Grönlund [d], Kristina Teär Fahnehjelm [a,d,e,*]

[a] Department of Clinical Neuroscience, Karolinska Institutet and St Erik Eye Hospital, Polhemsgatan 50, SE 112 82 Stockholm, Sweden[1]
[b] Department of Clinical Neurophysiology, Karolinska University Hospital, Huddinge, Stockholm, Sweden
[c] Department of Clintec, Karolinska Institutet, and Department of Paediatrics, Karolinska University Hospital, Huddinge, Stockholm, Sweden
[d] Department of Clinical Neuroscience, Institute of Neuroscience and Physiology, Sahlgrenska Academy at the University of Gothenburg, Gothenburg, Sweden
[e] Department of Paediatric Ophthalmology, St. Erik Eye Hospital, Polhemsgatan 50, SE 112 82 Stockholm, Sweden

ARTICLE INFO

Article history:
Received 13 January 2017
Accepted 5 February 2017
Available online 2 March 2017

Keywords:
Hematopoietic stem cell transplantation
Visual acuity
Visual evoked potentials

ABSTRACT

Objective: To study visual pathway pathology detected by visual evoked potentials (VEPs) in patients treated with hematopoietic stem cell transplantation (HSCT) in childhood and to determine the impact of adverse ocular findings, somatic diseases, and conditioning regimens on the VEP results.
Methods: Ophthalmological assessments including pattern VEPs were performed in 47 of 79 patients at a median age of 15 years (range 3–21 years) in median 6 years (1–17 years) after HSCT. Somatic data were extracted from medical records.
Results: Eight patients of 47 (17%) demonstrated pathological VEPs with prolonged latencies bilaterally (n = 3) or unilaterally (n = 5) at their latest VEP test at an age of 12–18 years. A subnormal visual acuity was present in 8/11 eyes with pathological VEPs: one eye had cataract, six eyes had cataract surgery where of two had developed secondary cataracts. One eye had residual retinopathy of prematurity. Pathological VEPs were associated with decreased visual acuity ($p = 0.00019$) but not linked to gender, malignant diagnosis or conditioning.
Conclusion: VEP recordings showed an association with decreased visual acuity but no relationship with irradiation or chemotherapy in the present study.
Significance: VEP recordings might be of clinical value for children with an unexplained subnormal visual acuity undergoing HSCT.

1. Introduction

Transplantation of allogenic hematopoietic stem cells (HSCT) is a recognized treatment for children with severe diseases like leukaemia, other haematological malignancies or non-malignant haematological diseases, immuno-deficiencies, and or inborn errors of metabolism. HSCT offers children who do not respond to conventional treatment a chance. In HSCT the child receives a human leukocyte antigen (HLA) matched, or sometimes mismatched, graft from a sibling, other family member or an unrelated individual. The five-year probability of survival in children diagnosed with malignant and non-malignant disease is now between 60–90% (Remberger et al., 2011; Locatelli et al., 2015; Rousso et al., 2015).

Before the transplant a conditioning regimen is given, to eradicate the disease or to reduce it to a minimal state and to suppress the patient's immune system to allow the engraftment. In general, a standard conditioning regimen for malignant and non-malignant diseases historically has included total body irradiation (TBI), systemic chemotherapy or both. After the HSCT, cyclosporine A (CyA) is used to prevent rejection and graft versus host disease

Abbreviations: BCVA, best corrected visual acuity; CI, cranial irradiation; CNS, central nervous system; CT, computerized tomography; CyA, cyclosporine A; f-TBI, fractionated total body irradiation; GVHD, graft versus host disease; HLA, human leukocyte antigen; HSCT, hematopoietic stem cell transplantation; IOL, intra ocular lens; MRI, magnetic resonance imaging; ROP, retinopathy of prematurity; s-TBI, single fractio total body irradiation; VEP, visual evoked potentials; TBI, total body irradiation.

* Corresponding author at: Department of Paediatric Ophthalmology, St. Erik Eye Hospital, Polhemsgatan 50, 112 82 Stockholm, Sweden.
E-mail address: kristina.fahnehjelm@ki.se (K.T. Fahnehjelm).
[1] At the time of the study.

http://dx.doi.org/10.1016/j.cnp.2017.02.001
2467-981X/

(GVHD) during approximately the first year after HSCT. GVHD is usually treated with corticosteroids.

The conditioning regimen and treatment after HSCT may inflict detrimental effects on the central nervous system (CNS). TBI has been described as damaging the developing brain and causing different neurological and cognitive complications (Phipps et al., 2008; Willard et al., 2014) as have busulfan and CyA (Barba et al., 2009; Azik et al., 2014). Cyclosporine A has been linked to increased intracranial pressure, visual disturbances, papilloedema (Tear Fahnehjelm et al., 2016) and encephalopathy (Shah, 1999; NOE et al., 2010) as well as CNS abnormalities visible on magnetic resonance imaging (MRI) or computerized tomography (CT) scans (Trullemans et al., 2001; Bartynski et al., 2004).

Ocular complications reported in children treated with TBI and or chemotherapy are cataract (Locatelli et al., 1993; De Marco et al., 1996; Suh et al., 1999; Holmstrom et al., 2002; Fahnehjelm et al., 2007; Tear Fahnehjelm et al., 2016), and dry eyes (Locatelli et al., 1993; Fahnehjelm et al., 2008; Ayuso et al., 2013; Kinori et al., 2015). Retinal haemorrhages, optic disc oedema, and chorioretinal lesions have also been described in children receiving TBI (Ayuso et al., 2013). Abnormalities described in the posterior visual pathways or visual cortex are more rarely reported (Gurney et al., 2006; Gong et al., 2011).

Visual evoked potentials (VEPs) are a gross electric potential of the visual cortex in response to visual stimulation and depend on the functional integrity of central vision at all levels of visual pathways including the retina, optic nerve, optic radiations, and occipital cortex.

VEP examinations were used as routine after HSCT in our clinic but the results have previously not been evaluated. The aims of the current study were to determine the frequency of visual pathway disturbances detected by VEPs in patients after HSCT in childhood and to determine the impact of ocular disease, underlying somatic diagnosis, conditioning regimens and or immunosuppressive drugs on the VEPs. A further aim was to evaluate the clinical benefits of regular VEP assessments post HSCT.

2. Materials/subjects

Seventy-nine patients were originally invited to participate in a larger study when they come for regular annual follow-ups after HSCT. Forty-seven of these 79 patients underwent VEPs. Data on demographics, cataract development, dry eye complications, visual fields results, and optic nerve morphology among the patients in the cohort has previously been reported (Fahnehjelm et al., 2007; Fahnehjelm et al., 2008; Tornquist et al., 2011).Patients were at a greater risk of developing cataract if conditioned with single fractio TBI (s-TBI) or fractionated TBI (f-TBI) when compared to busulfan or other chemotherapeutic drugs (Fahnehjelm et al., 2007). Poorer visual fields outcomes were found in patients who had undergone HSCT compared with normal controls (Tornquist et al., 2011) and long term results have been published (Tear Fahnehjelm et al., 2016).

3. Methods

Most of the patients came for annual examinations more than once during the study period and the findings of the latest VEP assessment with its corresponding ocular examination are presented as well as links to conditioning regimen and somatic diagnoses. Only patients who had corresponding VEP results and ocular examination during the same time period were included. The results were compared with VEPs obtained before HSCT.

4. Ocular assessment

Clinical ocular assessments included best corrected visual acuity (BCVA), slit lamp examination and funduscopy. Refraction under cycloplegia was measured by retinoscopy after a single instillation of a mixture of cyclopentolate (0.85%) and phenylephrine (1.5%). Lens opacities were graded 1–3 where grade 1 was defined as minor/minimal opacities, grade 2 as cataract with slight impact on BCVA or normal BCVA with subjective symptoms, and grade 3 as cataract with pronounced impact on BCVA (Fahnehjelm et al., 2007). The ocular fundii were examined first with indirect ophthalmoscopy and then with biomicroscopy in the vast majority of the children.

5. Visual evoked potential (VEP)

Visual evoked potentials were recorded with a Nicolet Viking Select (Nicolet Biomedical Inc. Madison, WI, USA). The patients were seated comfortably in a darkened room and were instructed to fixate the centre of a reversing checkerboard pattern displayed on a monitor placed 1.3 meters in front of the eyes (Fig. 1). Gold-pleated electrodes were attached across the scalp. The active electrode was placed at Oz (occipital midline), the reference electrode at Fz (frontal midline) and a vertex (Cz) electrode acted as ground. The impedance was maintained below 5 kOhm. Each eye was examined separately with the other eye covered with a black patch. Care was taken to keep the patients as relaxed as possible to minimize artefacts and the cooperation of the subjects (fixation of the pattern) was monitored by the technician.

The field size of the checkerboard pattern was $12^\circ \times 16^\circ$, each individual square subtended 30 min of arc, the contrast of the pattern was approximately 87% and the reversal rate 1 Hz. Filter settings were 1 Hz and 100 Hz respectively. The average response to at least 100 reversals was recorded, the number of reversals was increased if the VEP was poorly defined and, in most cases, each eye was examined at least twice to confirm reproducibility.

The latency and amplitude of the P100 potential were determined with help of cursors and the values were compared with the department's reference values which were based on bilateral examinations of 31 healthy individuals aged between 13 and 66 years. A latency of >2.5 SD of the normal mean (>126 ms), or an inter eye latency difference exceeding 6 ms, was regarded as an abnormal response. VEPs were rated as either normal or pathological/abnormal (Fig. 2). All VEPs were analysed by the same neurophysiologist (T.A.), who was unaware of the illness, therapy and other results of outcome measures.

6. Statistics

The Fisher exact two-tailed test was chosen for comparison between VEP results and abnormal BCVA, presence of cataract, presence of an intraocular lens (IOL) or posterior pole abnormalities, malignant diagnosis, somatic diagnosis, gender, prematurity, conditioning regimen, corticosteroid treatment for more than six months and chronic GVHD. The Mann-Whitney test was used to compare the VEP results among patients who had more than seven occasions of trough levels >250 ng/ml of CyA. A p-value of <0.05 was regarded as significant.

The study was approved by the Regional Ethics Committee in Stockholm and performed according to the Helsinki Declaration. Written informed consent was signed by all participants and or parents before enrolment in the study.