# Evaluation of VEP Parameters in Patients Before and After Cardiopulmonary By-Pass Surgery

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**Research Article**

**Keywords:** Cardiopulmonary by-pass surgery, VEP P100 latency, systemic illnesses, aging, anemia, hypothermia

**Posted Date:** January 14th, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1156858/v1

# Abstract

**Introduction:** Coronary bypass surgery is emphasized in aetiology of ischemic optic neuropathy. Our aim in this study was to investigate the pattern visual evoked potentials (PVEP) in patients before and after coronary bypass surgery.

**Methods:** Thirty-one patients were included in the study. After a full ophthalmological evaluation, PVEP was assesed in the pre and postoperative periods. Operative times, hematological parameters, blood pressures, number of transfusions, body temperatures, anaesthetic drugs and systemic illnesses were recorded for each patient.

**Results:** The mean age of the patients were 59±10.4 years. There was 22 men and 9 women in the study. Only 3 of them needed transfusion during the surgery. The mean duration of the surgery was 3.2±0.7 hours. None of the patients had a history of visual disturbance or postoperative ischemic optic neuropathy. The mean VEP P100 amplitude was not statistically significantly different but the mean VEP P100 latency showed statistically significant difference between the preoperative and postoperative periods. ($p=0.014$) This significance was more appereant in patients with systemic illnesses. ($p= 0.023$) There was a positive correlation between the age and VEP P100 latency. ($r = 0.402$, $p< 0.05$)

**Conclusions:** Although surgical techniques and equipments are developing each day in the field of cardiopulmonary bypass surgery, the contributing factors such as hypothermia, anemia and diabetes still seem to affect neurophysiological functions even after a noncomplicated surgery.


# Introduction

Arterial system of the eye is an end-arterial system and the retinal and optic nerve vessels regulate the perfusion pressure changes by myogenic and metabolic processes instead of autonomic system. Extracorporeal circulation (ECC) during cardiopulmonary by-pass surgery (CPBS), may cause ischemia and infarction by hypoperfusion and microembolus formation.[1] Angiographical and postmortem studies have already shown the presence of microinfarcts in chorioretinal circulation during and after CPBS. [1, 2]

CPBS related ischemic optic neuropathy (ION) has a devastating course and visual deterioration is usually severe and persistent. Alterations in visual evoked potentials (VEP) after ION have been well established and it is known that pattern VEP (PVEP) amplitude decreases after acute ION. There are also reports about the elongation of PVEP latency in acute ION. [3] VEP is used to assess the functional disturbances from retina to visual cortex and intraoperative mesurement of VEP has been reported to be useful in monitoring neurophysiological functions as well.[4–6]

In this study, we aimed to evaluate the optic nerve involvement and the impact of contributing factors in patients with CPBS by assesing the PVEP in the pre and postoperative periods.

# Methods

Thirty-one patients were included in the study. Patients with glaucoma, arteritic or nonarteritic ischemic optic neuropathy, multiple sclerosis, alcohol and tobacco consumption, nonproliferative and proliferative diabetic retinopathy were excluded from the study.After a full ophthalmological evaluation, PVEP was assessed before and after the surgery. Duration of surgery, hematological parameters, blood pressures, number of the transfusions, body temperatures, anaesthetic drugs and systemic illnesses were recorded for each patient.

This study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. Written informed consent from all participants and institutional ethics committee approval was obtained.

PVEP was recorded within 10 days before and between the 7th and 10th days after the surgery when the patients were healthy enough for VEP assesment. During VEP recordings, all patients were seated comfortably in a semidarkened room, and exposed to the stimuli coming from a television monitor 1 m away from the tested eye. Vision was central and monocular. Patients were asked to keep their eye on the central fixation point and warned verbally whenever the fixation was lost or not. Recordings were performed using Medelec Synergy EMG machine with an analysis time of 500msec and a sweep speed of 50 ms/s. The mean luminance was 43.3 cd/$m^2$ and the the contrast was 100%. Low and high frequency filter settings were predetermined at 1.0 Hz, and 100 Hz, respectively. The international 10–20 system was used to insert electrodes. VEPs were recorded from 5 channels (T5-Cz, O1-Cz, Oz-Cz, O2-Cz, and T6-Cz). The ground electrode was attached on the forearm. Recordings were obtained by monocular checkerboard pattern reversal stimulation. An average of 200 runs were taken, and each run was checked for reproducibility by a second waveform stored in the memory system. For each eye, the first prominent positive (downward deflection) peak P100 was obtained. The latencies to the peak P100 and peak-to-peak amplitude of P100 in pre/postoperative periods were assesed by software and then controlled by a blinded researcher.

Kolmogorov-Smirnov test was used to evaluate the normality of the distribution of variables. Accordingly, it was seen that all variables displayed a normal distribution ($p>0.05$ for all variables). Therefore, Mann-Whitney U t test was used to compare the VEP P100 latency values with small sample sizes, between independent groups. Paired sample t-test or Wilcoxon Rank Sum test (for small sample sized variables) were used to compare continuous variables between pre and postoperative periods. Pearson correlation coefficient was performed to assess correlations among variables. Continuous variables were presented as the mean ±standard deviation, and categorical variables as numbers. Categorical variables were presented as count and percentage. A p-value $<0.05$ was considered significant. Analyses were performed using a commercial software package (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Somers, NY)

# Results

Mean age of the patients were 59±10.4 years. There were 22 men and 9 women in the study. Eight subjects did not have a systemic disease. Only 3 of them needed transfusion during the surgery. The

details of the parameters evaluated were shown in Table 1. None of the patients had a history of visual disturbance or postoperative ION. Each patient anesthesized according to the principles of standardized anesthesia in these patients. The mean VEP P100 amplitude was not statistically significantly different but the mean VEP P100 latency showed statistically significant difference between the preoperative and postoperative periods. ($p=0.014$) (Table 2) This significance was more apparent in patients with systemic illnesses especially with diabetes. ($p= 0.023$)(Table 3) There was a positive correlation between the age and VEP P100 latency. ($r = 0.402$, $p< 0.05$)(Table 4)

Table 1
Demographic characteristics of the study patients

| **Age (years)** | | **59.03±10.43** |
|---|---|---|
| Gender | **Female** | 9 (29%) |
| | **Male** | 22 (71%) |
| **Associated Systemic Illness** | **NA** | 8 (25.8%) |
| | **DM** | 5 (16.1%) |
| | **HT** | 9 (29%) |
| | **Dyslipidemia** | 2 (6.5%) |
| | **CHD** | 1 (3.2%) |
| | **DM+HT** | 4 (12.9%) |
| | **DM+HT+ Dyslipidemia** | 1 (3.2%) |
| | **HT+CHD** | 1 (3.2%) |
| **DM** | **NA** | 21 (67.7%) |
| | **A** | 10 (32.3%) |
| **HT** | **NA** | 16 (51.6%) |
| | **A** | 15 (48.4%) |
| **Dyslipidemia** | **NA** | 28 (90.3%) |
| | **A** | 3 (9.7%) |
| **Systemic Illness** | **NA** | 8 (25.8%) |
| | **A** | 23 (74.2%) |
| **Blood Transfusion** | **NA** | 28 (90.3%) |
| | **A** | 3 (9.7%) |
| **Operative time (hour)** | | 3.17±0.77 |
| **Systolic blood pressure (mmHg)** | | 126.00±16.98 |
| **Diastolic blood pressure (mmHg)** | | 75.50±9.99 |

Data were shown as mean ±standard deviation and n (%).

DM:Diabetes; HT: Hypertension; Coronary heart disease:CHD,Hb: Hemoglobin; Htc: Hematocrit

NA: Not available, A: available

| | |
|---|---|
| **Age (years)** | **59.03±10.43** |
| **Intraoperative Hb (gr/dl)** | 8.5±0.8 |
| **Intraoperative Htc (%)** | 25.6±2.4 |
| **Postoperative Hb (gr/dl)** | 8,2±0.5 |
| **Postoperative Htc (%)** | 24,6±1.5 |
| **Intraoperative body temparature (ºC)** | 27,9±0.7 |
| Data were shown as mean ±standard deviation and n (%). | |
| DM:Diabetes; HT: Hypertension; Coronary heart disease:CHD,Hb: Hemoglobin; Htc: | |
| Hematocrit | |
| NA: Not available, A: available | |

Table 2
The mean VEP P100 amplitudes and latencies of patients in pre- and postoperative periods

| | n | Preoperative | Postoperative | p |
|---|---|---|---|---|
| **Latency (msec)** | 31 | 105.96±6.23 | 108.57±8.19 | **0.014** |
| **Amplitude (mv)** | 31 | 6.84±3.21 | 7.40±3.45 | 0.164 |
| Data were shown as mean ±standard deviation and n (%). | | | | |

Table 3
Comparision of VEP P100 latencies of patients with systemic ilnesses and diabetes

| | | Preoperative | Postoperative | p* |
|---|---|---|---|---|
| **DM** | **NA (n=21)** | 106,47±4,94 | 107,90±7,89 | 0.231 |
| | **A (n=10)** | 104,88±8,57 | 109,99±9,04 | **0.016** |
| | **p**** | 0.516 | 0.516 | |
| **Systemic Illness** | **NA (n=8)** | 105,75±6,80 | 108,41±11,82 | 0.323 |
| | **A (n=23)** | 106,03±6,18 | 108,63±6,85 | **0.023** |
| | **p**** | 0.915 | 0.950 | |
| Data were shown as mean ±standard deviation and n (%). | | | | |
| *: p values of comparisons between pre and postoperative periods (Wilcoxon Rank Sum Test). **: *: p values of comparisons between NA and A groups (Mann Whitney U test). DM: Diabetes Mellitus, NA: Not available, A: available | | | | |

**Tablo 4.** The correlations between PVEP parameters and age, blood pressures and operative

times

| | Preop latency | | Preop amplitude | | Postop latency | | Postop amplitude | |
|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p |
| **Surgery duration** | -0.206 | 0.267 | -0.155 | 0.404 | -0.011 | 0.954 | -0.201 | 0.278 |
| **Systolic BP** | 0.354 | 0.125 | -0.208 | 0.379 | 0.320 | 0.169 | -0.202 | 0.392 |
| **Diastolic BP** | 0.213 | 0.367 | -0.272 | 0.246 | 0.206 | 0.383 | -0.288 | 0.219 |
| **Age** | 0.352 | 0.052 | -0.260 | 0.158 | **0.402*** | **0.025** | -0.156 | 0.401 |

r: Correlation coefficient, BP: Blood pressure

# Discussion

Ischemic optic neuropathy is characterised by acute onset painless visual loss. Crowded disc, diabetes, hypertension and anemia are among the risk factors. Also it may be a devastating complication of CPBS. [7] Hypothermia, hemodilution, microembolus formation and prolonged extracorporeal operativel times as well as the advanced age and vascular impairment are well known risk factors for its development after this major surgery. [8]

Evaluation of evoked potentials is a noninvasive method of assesment of neuronal conduction and central nervous system functions.[9] VEP has been used as an effective method in monitoring neurophysiological functions during surgical procedures and it is the gold standard electrophysiological method for evaluating the visual pathways. [5, 6]

The postoperative elongation of VEP P100 latency in our patients may be multifactorial. Keenan et al. observed elongation of PVEP latency in patients during CPBS and circulatory arrest and found a negative correlation between the hypotermia and latency.[5] They explained this finding by progressive slowing of axonal conduction and increased synaptic delay. The same findings were also reported and the hypothermia related prolonged latency were found to be independent of anesthetic drugs. [10]

Iron deficiency has been shown to affect PVEP latency in the chilhood group. [9, 11] Iron (Fe), is the cofactor of the enyzme involved in ATP synthesis. ATP is crucial in maintenance of synaptic and axonal conduction in the central nervous system. It is also essential in the synthesis of the dopamine and myelin synthesis.[12] Dopamine is an important neurotransmitter in the visual and auditory pathways. Iron deficiency anemia related latency delay has been explained both with hypoxia and the requirement of Fe in these critical biochemical reactions .[9, 10] Hemoglobin decrement up to the 10th postoperative day in CPBS patients has been reported as an outcome of bleeding and liquid shift out of the vascular bed.[13] Also changes in Hb concentrations mentioned were reported as a cause for tissue hypoxemia. The

recommended Htc concentration is 25% for extracorporeal circulation and tissue oxygenation, and also blood flow can be successfully maintained by Htc concentrations of 35%.[14] Since, our patients experienced mild anemia and related decreases in Htc concentrations during and after the surgery, anemia may be a contributing factor for latency delay in our patients.

Postoperative ischemic optic neuropathy has been shown to be more frequent in diabetics with Htc concentraions lower than 22%. It has been also emphasized that uncontrolled diabetics demonstrated VEP latency elongation.[15, 16] In our study, the pre- and post operative latencies showed statistically significant difference in patients with systemic illnesses (p= 0.023) and especially the patients with diabetics. (p=0.016) (Table 3) Lower Htc concentrations and diabetes- related microvascular complications may contribute to the latency elongation as well.

We found a positive correlation between latency and age. As shown in various investigations optic nerve and cortical conduction velocities decreased with aging. [17] Aging may also be a contributing factor in the latency difference in our study.

As a result, the well -controlled blood pressures and mild anemic course during the surgery might prevent the development of ION in our study patients. Although surgical techniques and equipments are developing each day in the field of cardiopulmonary by-pass surgery, the contributing factors such as hypothermia, anemia and especially diabetes still seem to affect the neurophysiological functions even after a noncomplicated surgery.

# Declarations

This paper has not been published anywhere previously and that it is not simultaneously being considered for any other publication. The authors have no financial interest in any of the products identified herein. None of the authors have any proprietary interests or conflicts of interest related to this submission. The authors alone are responsible for the content and writing of the paper.

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