EVALUATION OF TRANSCRANIAL DOPPLER SPECTRAL (TCD) SIGNATURES AND ASSESSMENT OF CEREBRAL OXYGENATION USING NEAR-INFRARED SPECTROSCOPY (NIRS) IN PATIENTS UNDERGOING NEUROSURGICAL PROCEDURES AS A NOVEL MARKER FOR CLINICAL OUTCOME AND PROGNOSTICATION - AN OBSERVATIONAL STUDY.

DR JEEVA GEORGE

DM NEUROANAESTHESIA

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM

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EVALUATION OF TRANSCRANIAL DOPPLER SPECTRAL (TCD) SIGNATURES AND ASSESSMENT OF CEREBRAL OXYGENATION USING NEAR-INFRARED SPECTROSCOPY (NIRS) IN PATIENTS UNDERGOING NEUROSURGICAL PROCEDURES AS A NOVEL MARKER FOR CLINICAL OUTCOME AND PROGNOSTICATION - AN OBSERVATIONAL STUDY.

A THESIS SUBMITTED BY

DR JEEVA GEORGE

TO

SREE CHITRA TIRUNAL INSTITUTE FOR

MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE AWARD OF

DM NEUROANAESTHESIA

2022

DECLARATION BY THE STUDENT

CERTIFICATE

I, Dr Jeeva George. hereby certify that I had personally carried out the work depicted in the thesis titled, "**EVALUATION OF TRANSCRANIAL DOPPLER SPECTRAL (TCD) SIGNATURES AND ASSESSMENT OF CEREBRAL OXYGENATION USING NEAR-INFRARED SPECTROSCOPY (NIRS) IN PATIENTS UNDERGOING NEUROSURGICAL PROCEDURES AS A NOVEL MARKER FOR CLINICAL OUTCOME AND PROGNOSTICATION-AN OBSERVATIONAL STUDY.**" No part of this thesis has been submitted for the award of any other degree or diploma prior to this date.

Date: 12/08/2022

Place : TRIVANDRUM

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*Clearance was obtained from the Institutional Ethics Committee and CTRI for carrying out the study.

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DR JEEVA GEORGE

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1.	ABP	Arterial blood pressure
2.	ACA	Anterior cerebral artery
3.	ASA	American society of Anaesthesiology
4.	AUC	Area under the ROC curve
5.	BP	Blood pressure
6.	CA	Cerebral autoregulation
7.	CBF	Cerebral blood flow
8.	CBFV	Cerebral blood flow velocity
9.	COx	Cerebral oximetry index
10.	CPP	Cerebral perfusion pressure
11.	CVR	Cerebrovascular resistance
12.	EDV	End diastolic velocity
13.	fNIRS	Functional near-infrared spectroscopy
14.	GCS	Glasgow coma scale
15.	GOS	Glasgow outcome scale.
16.	HR	Heart rate
17.	ICA	Internal carotid artery
18.	ICP	Intracranial pressure
19.	LF	Low frequency
20.	MAC	Minimum alveolar concentration
21.	MAP	Mean arterial pressure
22.	MCA	Middle cerebral artery
23.	MFV	Mean flow velocity
24.	Mx	Mean flow index
25.	NIRS	Near-infrared spectroscopy
26.	NSOT	Neuro-surgical operation theatre

27.	ONSD	Optic nerve sheath diameter
28.	PaCO2	Partial pressure of carbon dioxide
29.	PCA	Posterior cerebral artery
30.	PI	Pulsatility index
31.	PICC	Peripherally inserted central catheter.
32.	PRx	Pressure reactivity index
33.	PSV	Peak systolic velocity
34.	PVV	Pulse velocity variation
35.	RAP	Correlation coefficient between mean ICP and AMP.
36.	RI	Resistivity Index
37.	ROC curve	Receiver operating characteristic curve
38.	rSO2	Regional cerebral oxygen saturation
39.	SAH	Subarachnoid haemorrhage
40.	SVV	Systolic velocity variation
41.	TBI	Traumatic brain Injury
42.	TCD	Transcranial doppler
43.	THx	Total haemoglobin reactivity index.
44.	TOI	Tissue Oxygenation index
45.	TOxA	Coefficient between arterial blood pressure and tissue oxygenation index

ABSTRACT

Background: Transcranial Doppler (TCD) monitoring non-invasively measures cerebral blood flow (CBF) velocity. Peak systolic flow velocity(PSV), and Pulsatility index (PI) have been used as a tool for indirect intracranial pressure (ICP) measurements. The sequential evolution of distinct patterns of TCD waveforms with an increasing degree of raise in ICP in a spectrum of neurological conditions is described. Optic nerve sheath diameter (ONSD) has been increasingly used as a bedside screening tool for raised ICP. Our primary aim was to study the spectral velocity variations in the TCD and to correlate that with the clinical outcome of neurosurgical patients. We hypothesised that variation in transcranial Doppler velocity in the spectral pattern and optic nerve sheath diameter can be used to indirectly measure intracranial compliance and predict the outcome of neurosurgical patients.

Materials and Methods: After IEC approval we performed the prospective observational pilot study. We included a total of 56 patients, aged 18 to 65 years after obtaining informed consent from patients/relatives as appropriate, undergoing neurosurgical procedures. We categorized the patients into four groups based on preoperative GCS scores. Group A, B, C, and S for 13-15, 9-12, <8 respectively and spine patients who were taken as controls. TCD variables and spectrum, bilateral near-infrared spectroscopy (NIRS) and ONSD measurements were recorded preoperatively, postoperative period at 24 hours and discharge.

Results: There was a statistically significant difference between groups concerning mean flow velocity and PI in the preoperative period. along with that, there was a

significant change in the pulse velocity variation(PVV) among the groups. We could correlate the PVV with the outcome of patients, mean PVV value of 2.5% gave a predictive value with a sensitivity of 91.7% and specificity of 34%. With a value of less than 2.5% predicting good outcomes and a value of more than 2.5% predicting poor outcomes in different patients. Correlating with ONSD with a cut-off of 5mm, the PVV value of 2.5% gave a predictive value with a sensitivity of 84.6 % and specificity of 42.2 %. NIRS values did not vary among the groups.

Conclusion: Our study results showed that the transcranial doppler spectral waveform and derived new non-invasive TCD variables namely SVV and PVV variations are useful in assessing intracranial compliance. We found that these variables can give useful information on the changing conditions of intracranial compliance in patients with acute neurological disorders like SAH, acute stroke, etc. Computing these variables can identify patients at varying points in the intracranial compliance curve non-invasively at the bedside. These variations could be used to prognosticate patients and identify the point of surgical intervention. Also, multimodal neuromonitoring can help in serial monitoring and understanding the changing intracranial hemodynamics so that focused and early interventions can be done to facilitate better outcomes.

INTRODUCTION

1. INTRODUCTION

Transcranial doppler is a non-invasive tool for assessing cerebral blood flow based on ultrasound doppler. The advantage of TCD is the low cost of imaging, ease of repeatability, and excellent safety and tolerability. Studies have correlated the importance of Peak systolic velocity(PSV), Pulsatility index (PI) and resistivity index (RI) as a marker for severely raised intracranial pressure (ICP) in traumatic brain injury (TBI)and brain dead patients. (1)

However, most studies have been done based upon the derived values of PSV, End diastolic velocity (EDV), PI and RI. They have been extensively studied to be correlated with standard ICP measurement and used as a surrogate for non-invasive ICP monitoring, especially in TBI patients. The detailed spectral analysis of the transcranial doppler has not been studied and parameters of flow reversal, systolic spikes, tardusparvus waveform, absence of diastolic flow or absence of flow are correlated with raised ICP and loss of intracranial compliance. (2,3)

The analysis of the TCD spectral waveform in terms of variation in the systolic and diastolic velocity peaks in the spectrogram is similar to the pulse pressure variation in the arterial waveform and the correlation of these variations with intracranial pressure and intracranial compliance of the patient has not been previously described in the literature.

The variables that have been employed to predict patient outcomes are clinical variables for evaluating the degree of raised ICP like GCS and pupil size. Other systemic parameters such as mean arterial pressure, heart rate, and respiratory rate along with CT findings. (4)GCS is an easy bedside tool for neurological assessment,

but it comes with a lot of fallbacks of not being able to assess verbal response in the intubated patient, inter-observer variability, not reliably reproducible and it's only grossly predictive of the outcome. We expect that using this scale will predict clinically significant outcomes in acute care settings, such as the presence of brain injury, the requirement for neurosurgical intervention, and overall mortality. Although each of these events is statistically, the predictive value of the GCS is insufficient to reliably predict outcomes for specific patients. (5)There comes the role of multimodal monitoring in accurately predicting the changes in intracranial compliance and assisting in targeting interventions that can lead to better outcomes.

The sequential evolution of distinct patterns of Doppler waveform with an increasing degree of raise in ICP in a spectrum of neurological conditions has been described by Mangalore, et. al which could act as a quick screening tool in neurocritical care units and also help to stratify patients for treatment and prognostication.(2)

Assessment of cerebral autoregulation has been done by tests of carbon dioxide reactivity, stress tests relying on mechanical or pharmacological alteration of arterial pressure, and the transient hyperaemic response test after carotid artery compression. All these use TCD to assess the dynamic response of cerebral flow velocities to various stimuli. . The averaged flow velocity values encompass a complex array of factors, making interpretation of abnormalities difficult. (6) Here we try to assess the changes in intracranial compliance in nontraumatic elective neurosurgical patients and using a group of patients undergoing spine surgery as controls to identify whether the variations in the TCD spectrum can be used to indirectly measure

intracranial compliance pre and postoperatively and could this be correlated with the outcome of patients.

The serial TCD examinations in elective neurosurgical patients with intracranial space-occupying lesions and aneurysmal subarachnoid haemorrhage with clinical features of raised ICP in a broad range of GCS from good GCS of 15 to poor GCS <8 and sequential evaluation of change in the intracranial compliance from the presurgical period to postoperative period till the time of discharge or end of care during the hospital stay and use of TCD spectral changes to predict the prognosis and outcome has not been described in the literature previously.

Optic nerve sheath diameter (ONSD) measurement using ocular ultrasonography being a safe, quick, reliable and reproducible technique for the assessment of ICP has now emerged as a promising technique. The normal cut-off range for ONSD in adults is 4.9 mm. More than 5 mm has been considered as raised intracranial pressure.(7)(8) ONSD can be used to measure indirectly the changes in intracranial pressure, and here we tried to correlate the changes in ONSD pre and postoperatively in different GCS group patients along with the changes in TCD values.

Near-infrared spectroscopy (NIRS), is an indirect monitor of cerebral perfusion, it uses non-invasive optical technology. The frontal cortex's regional cerebral oxygen saturation (rScO2) is determined by comparing the specific absorbance patterns of oxygenated and non-oxygenated haemoglobin to near-infrared light. When CBF decreases, tissue oxygen extraction will increase to maintain cerebral metabolism with an eventual decrease in haemoglobin saturation. In the

presence of a stable metabolic rate, rScO2 is an indirect measure of CBF and provides information on organ ischemia.(9)

In our study, the patients were divided into four groups. A control group of patients with normal intracranial compliance, Group S - Patients undergoing spine surgery, Group A-patients with GCS 13 to 15, Group B-Patients with GCS 9 to 12 and Group C- patients with GCS 3-8 undergoing supratentorial craniotomy for various major neurosurgical procedures like brain tumour resection, clipping for intracranial aneurysm, and decompressive craniectomy for malignant stroke. The preoperative NIRS values, ONSD values and TCD spectral indices were observed along with postoperative values till the time of discharge. The spectral changes in TCD were measured serially to note the change in the intracranial compliance correlating with the change of intracranial pressure with ONSD measurement along with cerebral oxygenation values by NIRS and the interrelationship with the clinical outcome of the patients.

HYPOTHESIS

2. HYPOTHESIS

We hypothesize that variation in transcranial Doppler velocity in the spectral pattern and optic nerve sheath diameter can be used to measure intracranial compliance indirectly and also to predict the outcome of neurosurgical patients.

AIMS AND OBJECTIVES

3. AIMS AND OBJECTIVES

AIM

The primary aim is to assess the impact of different spectral TCD waveforms on different preoperative GCS scores of patients and to correlate these spectral changes with the outcome of patients at hospital discharge.

OBJECTIVES

Our objectives of the study are:

1. To correlate the different spectral TCD waveforms as a marker of cerebral blood flow with NIRS values, an indicator of cerebral oxygenation.
2. To correlate the TCD spectrum velocity variations with GCS scores, ONSD values and NIRS values between preoperative and postoperative values at 24 hours and at hospital discharge.
3. To find the correlation between TCD velocity variations and ONSD values.
4. Correlation between TCD spectral waveform variations and outcome of patients.

REVIEW OF LITERATURE

4. REVIEW OF LITERATUE

NORMAL CEREBRAL PHYSIOLOGY

The brain consumes 20% of the total body's oxygen uptake while it weighs only 2% of body weight. The brain needs a continuous blood supply to support its metabolic functions. The metabolism and blood flow to the brain are closely interrelated and the brain is sensitive to changes in blood flow.CBF is defined as the blood volume that flows per unit mass per unit time in brain tissue and is expressed in units of ml/100-gram tissue per minute. Cerebral perfusion pressure is the driving pressure of blood flow to the brain and it is measured as the difference between mean arterial pressure(MAP) and intracranial pressure(ICP).(10)(11)

Cerebral autoregulation is the ability of cerebral vasculature regulation of CBF in response to changes in cerebral perfusion pressure(CPP) and encompasses the integrated myogenic, metabolic, and neurologic adjustments made to maintain steady cerebral blood flow(CBF). It is mainly achieved by modulating the cerebrovascular resistance(CVR), which is brought about by changing the radius of cerebral arteries. In intact autoregulation with an increase in MAP, the constriction of vessels occurs increasing the resistance to CBF thereby maintaining the CPP. In the scenario of low MAP, the opposite happens to balance the CBF.

METHODS TO MEASURE CEREBRAL AUTOREGULATION

Static autoregulation- Baseline pressure is recorded, manual or pharmacological manipulation of blood pressure is undertaken and the relationship between mean CPP and CBF under steady-state conditions is measured.

Dynamic autoregulation- refers to short-term, fast responses of the brain's blood flow to changes in systemic blood pressures.

TCD measures CBF velocity as a surrogate although it cannot measure the CBF directly. Pressure changes can be induced using stimuli such as body tilt, thigh-cuff release, or lower body negative pressure. (12–14)There is a multitude of indices derived to measure cerebral autoregulation Mx derived from TCD, PRx from the ICP, and COx from NIRS.

TRANSCRANIAL DOPPLER MEASUREMENT

Transcranial doppler (TCD) is used to measure the velocities in the intracranial arteries non-invasively. It is used to measure cerebrovascular haemodynamic changes and in conditions that need monitoring of cerebral blood flow(CBF).(15)

TCD examination is done by using a 2 MHZ ultrasound and a sweep speed of 3-5 seconds. The acoustic window is the area receiving the ultrasound and this can be a transtemporal, transorbital,suboccipital, or submandibular window.The transtemporal window allows inspection of the terminal internal carotid artery (ICA), middle cerebral artery (MCA), anterior cerebral artery (ACA), posterior cerebral artery (PCA), and communicating arteries.

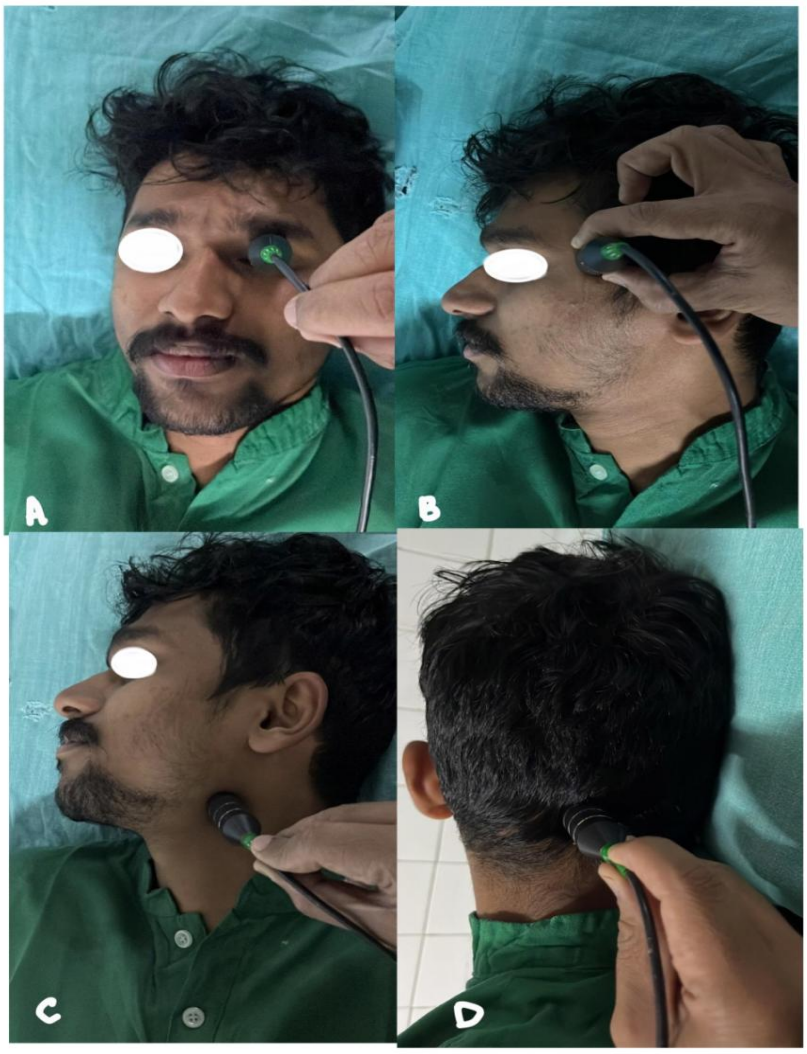


FIGURE 1: DEMONSTRATION OF ACOUSTIC WINDOWS USED FOR TRANSCRANIAL DOPPLER - TRANSORBITAL (A), TRANSTEMPORAL (B), SUBMANDIBULAR (C) AND SUBOCCIPITAL (D) WINDOWS.

Transtemporal TCD procedure:

- The ultrasound probe is placed on the zygomatic arch anterior to the tragus and directed toward the contralateral side.
- If the probe is turned slightly superoanteriorly, the ICA bifurcation blood-flow signal should be detected at a depth of approximately 65 mm. The toward- and away- flow signals are from the MCA and ACA, respectively.

- The MCA flow is insonated at depth of 50mm(45-65mm), and ACA at a depth of 62-75m.
- The machine generates the waveform for the intended vessel and the velocities can be measured using the software provided with the USG machine.

ANALYSIS OF SPECTRAL WAVEFORM

The spectral waveform changes according to the systolic and diastolic phases of the heart:

1) The systolic phase begins, the aortic valve closes, the heart contracts and the aortic valve opens;
2) The peak systolic velocity (PSV) is measured;
3) The aortic valve is closed by the dicrotic notch; and
4) The end-diastolic velocity (EDV) is measured.

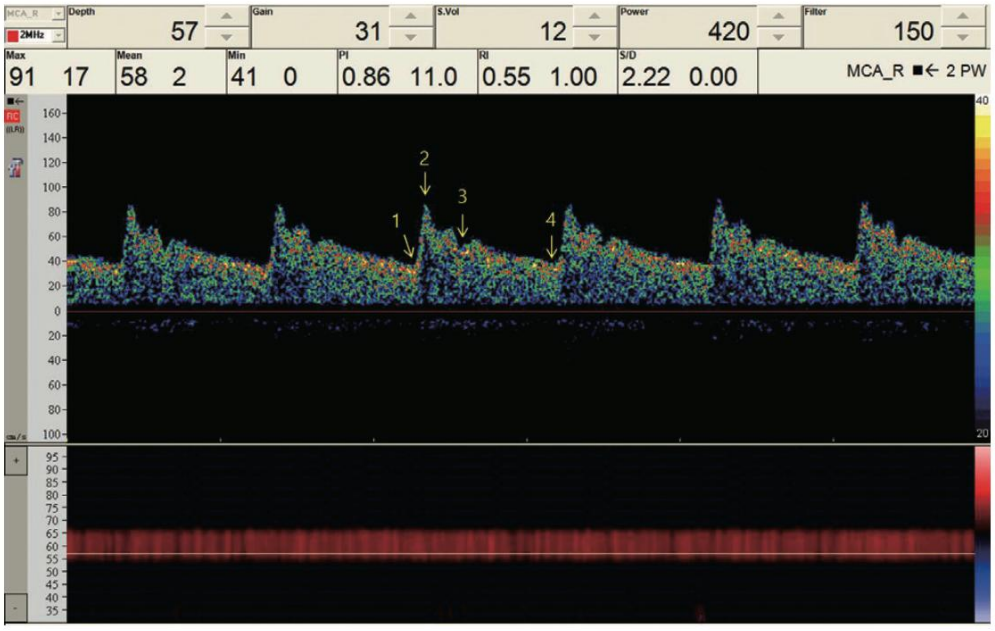


FIGURE 2: DEMONSTRATION OF NORMAL TRANSCRANIAL DOPPLER SPECTRAL WAVEFORM OF THE MIDDLE CEREBRAL ARTERY.

The interval from phase 1 to phase 2 is referred to as systolic acceleration and reflects the resistance from the heart to the artery of interest. The diastolic phase, which occurs between phases 3 and 4, reflects the resistance of the target artery to the periphery.

Interpretation of TCD values

EDV usually is around 30% of PSV, and the difference between PSV and EDV divided by the mean flow velocity (MFV) is the **pulsatility index (**PI).

$$PI = \frac{PSV\text{-}EDV}{MFV}$$

PI is normally 0.5 to 1.19(16)Proximal stenosis or occlusion may lower the PI below 0.5 due to downstream arteriolar vasodilation whilst distal occlusion or constriction may increase the PI above 1.19.(17)

There is a progressive increase in PI and a positive correlation with an increase in Intracranial Pressure (ICP) as well diagnosis in the peri agonal period helping in the management and diagnosing brain death. (18)(19)

Resistivity index

Pourcelot resistivity index (RI) is equal to (PSV-EDV)/PSV with values of 0.8 indicating increased downstream resistance. (20)

SPECTRAL ANALYSIS OF TCD

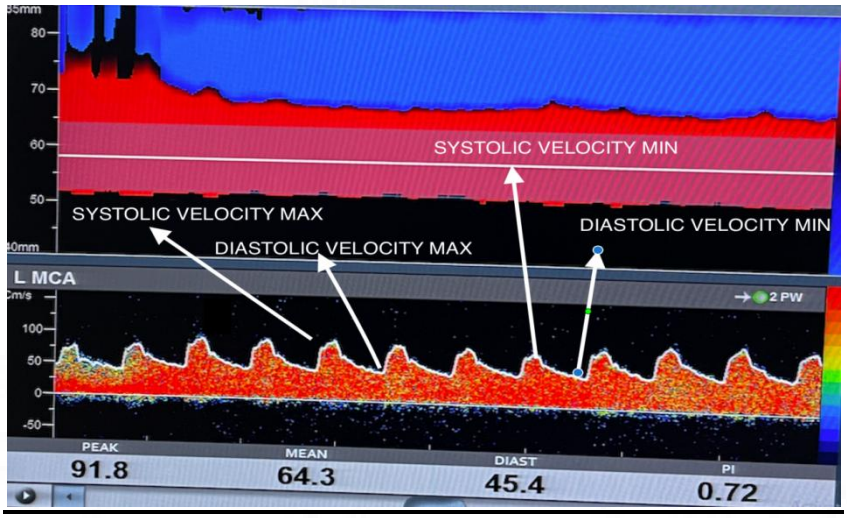


FIGURE 3 : LEFT MCA FLOW VELOCITY SHOWING FLUCTUATIONS IN THE WAVEFORM IN A PATIENT WITH REDUCED INTRACRANIAL COMPLIANCE.

Mangalore et al did a TCD spectral analysis of MCA vessels on patients with different GCS and pupillary reactivity and found different patterns in patients with varying GCS and varying range of ICP. Given below are some of the spectral findings in their study.

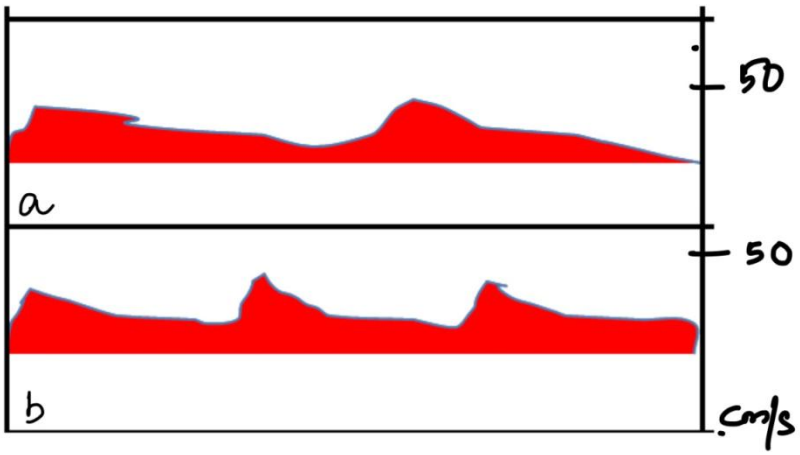


FIGURE 4: TCD DEMONSTRATES A DECREASED END-DIASTOLIC VELOCITY WHEN INTRACRANIAL PRESSURE IS MILDLY RAISED. TWO WAVEFORMS WERE NOTED.

a) Both peak systolic velocity and end-diastolic velocity is in the normal range - Pattern I – Blunted.

b) Peak systolic velocity is normal and end-diastolic velocity is reduced - Pattern II – Dampened. In order to maintain brain perfusion, this waveform is consistent with low resistance flow.

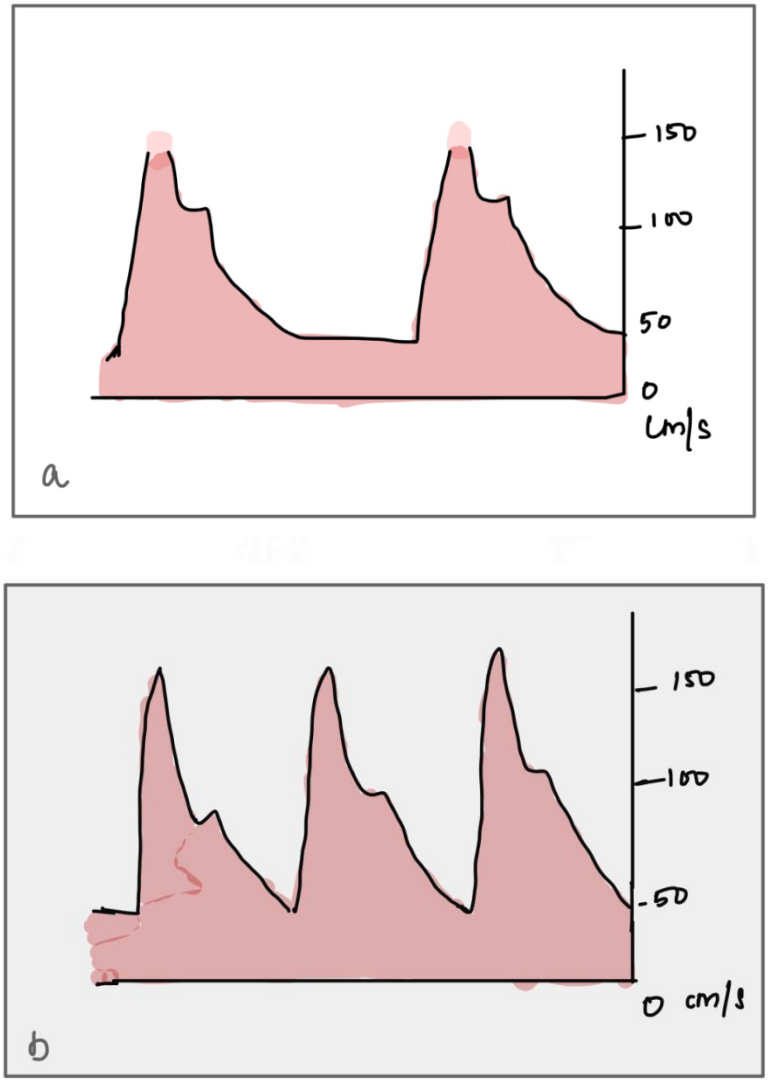
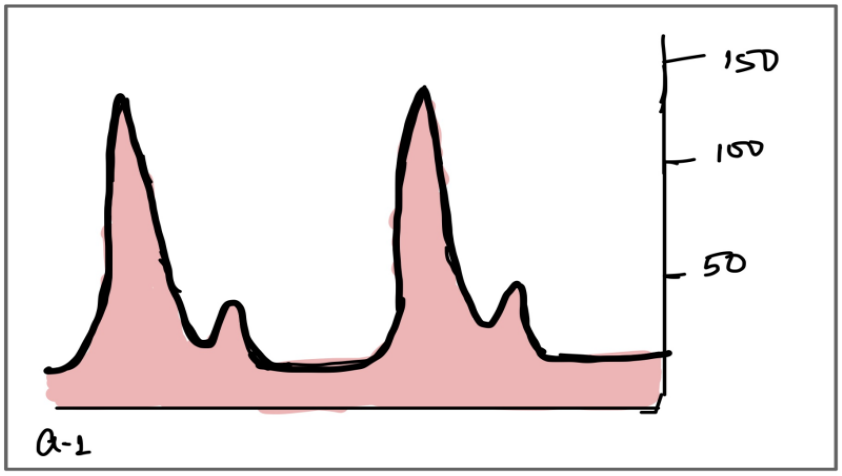
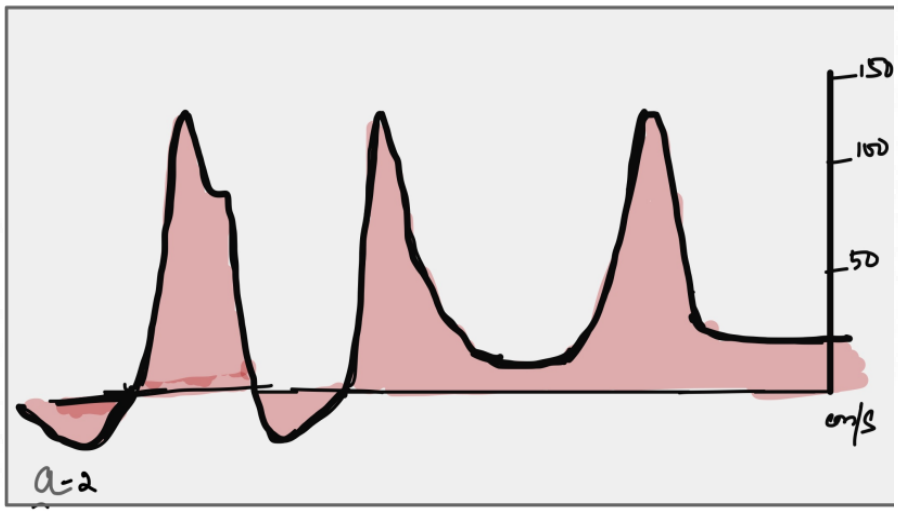


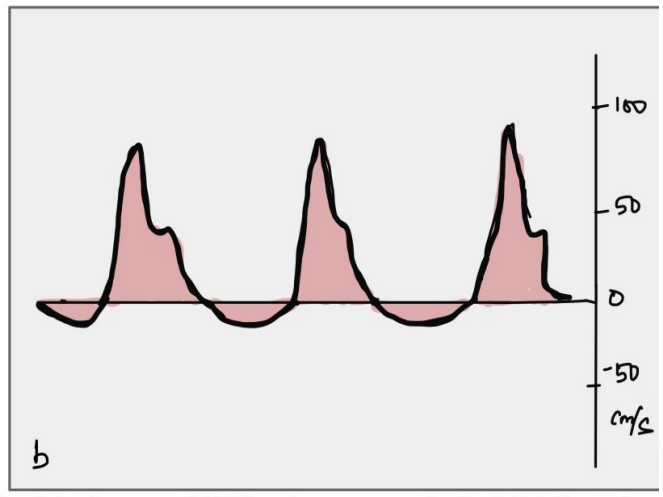
FIGURE 5: TCD DEMONSTRATES AN INCREASED PEAK SYSTOLIC VELOCITY WHEN INTRACRANIAL PRESSURE IS MODERATELY RAISED. TWO WAVEFORMS WERE NOTED.

(a) Peak systolic velocity is increased and end-diastolic velocity is in the normal range - Pattern I - prominent systolic peak without a Doppler window.

(b) Peak systolic velocity and end-diastolic velocity is increased – Pattern II - prominent systolic peak with Doppler window. This waveform is consistent with the setting in vasoconstriction as maximum vasodilatory capacity is reached.



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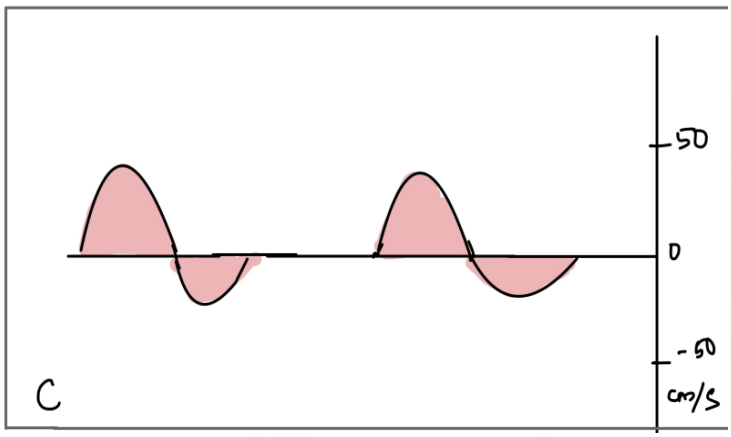
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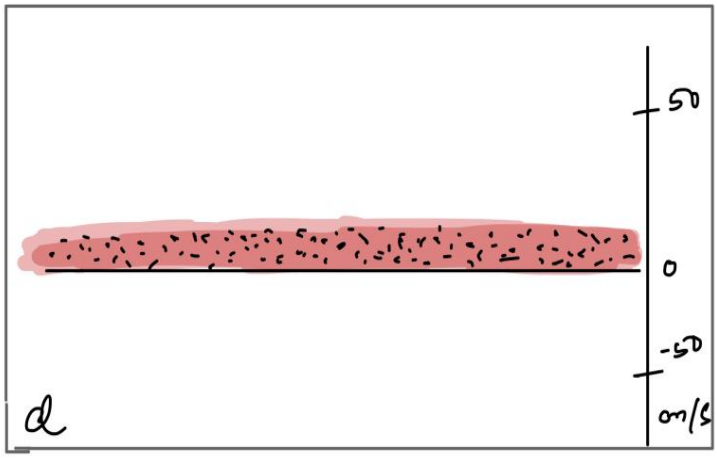
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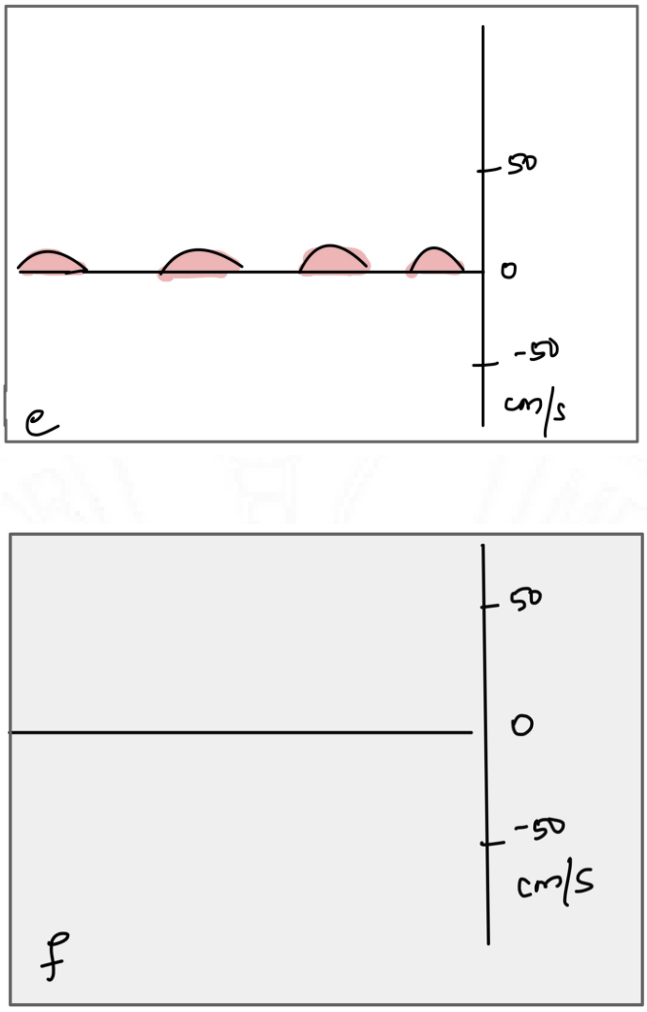


FIGURE 6: (A-F) TCD DEMONSTRATES SEQUENTIAL CHANGES IN PEAK SYSTOLIC VELOCITY AND END-DIASTOLIC VELOCITY, WHEN INTRACRANIAL PRESSURE IS SEVERELY RAISED SIX TYPES OF WAVEFORMS, ARE NOTED. ALL THESE WAVEFORMS ARE CONSISTENT WITH LOSS OF CEREBRAL AUTOREGULATION IN MAINTAINING CEREBRAL PERFUSION.

(a) Peak systolic velocity is increased and end-diastolic velocity reduced to <12 cm/s (topmost row) with intermittent flow reversal (middle row) - Pattern I - sharp wave with or without flow reversal.

(b) Peak systolic velocity is in normal range with flow reversal in diastolic phase - Pattern II - systolic spike with flow reversal (bottom row).

(c) Peak systolic velocity is reduced and diastolic wave shows reverse flow and continuity between waveforms is lost (decoupling) - Pattern III - systolic and diastolic spike.

(d) Prolonged systolic acceleration with diminished amplitude with a total absence of

(a) diastolic flow Pattern IV - tardusparvus waveform.

(e) Peak systolic velocity is decreased with discontinuity of waveform Pattern V - systolic spike with absent diastolic.

(f) Total absence of systolic and diastolic flow Pattern VI - no flow waveform (2)

Assessment of cerebral Autoregulation by TCD

Cerebral Autoregulation is the tendency of CBF to remain approximately constant when mean arterial blood pressure (MAP) changes over a wide range, typically from 60 to 150 mmHg.(21)Dynamic autoregulation can be effectively measured by using TCD, transient response of CBF velocity to a sudden change in BP induced by the release of inflated thigh cuffs. Mx index is a correlation coefficient that has been used for the correlation between CBF velocities (CBFV) and mean BP using 60 values averaged every 3-4 seconds. The normal value of Mx = 0 with intact autoregulation and increase to 1 with impairment reflects the direct relation of CBFV to BP. (22)

The autoregulatory index (ARI) is based on the CBFV oscillatory amplitude changes during and after Valsalva manoeuvres. ARI ranges from 0 (absence of autoregulation) to 9(best measurable autoregulation).In Intact cerebral autoregulation, when BP is reduced it is compensated by reductions in CVR

constantly maintaining CBF approximately .when autoregulation is impaired it leads to passive changes in CBF mirroring changes in the BP. (23)

Clinical testing of autoregulation is done by observing the phase relationship between the CBFV and BP, which predicts positive phase shift angles between CBFV and ABP oscillations. significant decreases in phase shift angles are observed in patients with autoregulatory disturbances. The correlation between CO_2-induced vasomotor reactivity and autoregulation is proved. (24)

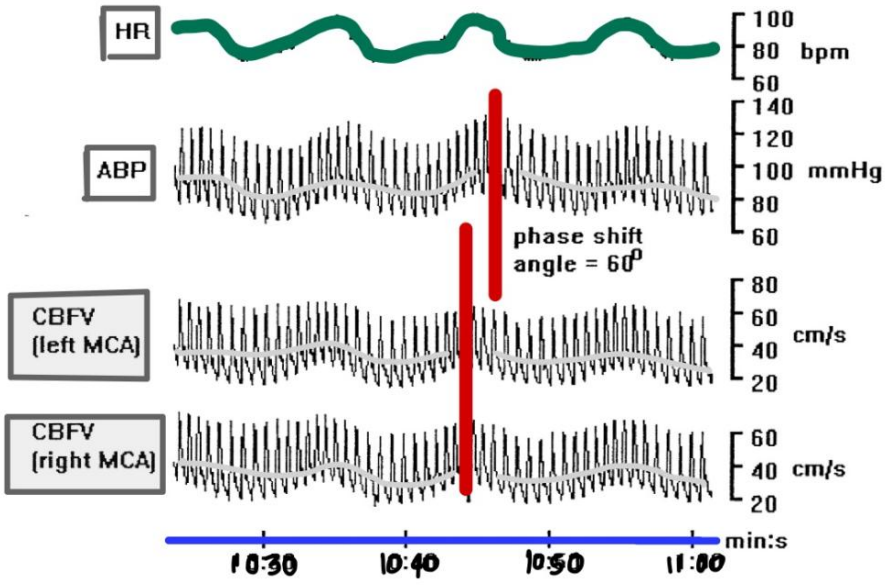


FIGURE 7 : RECORDINGS OF HEART RATE (HR) IN BEATS PER MINUTE (BPM), ABP, AND CBFV OF BOTH MCAS IN A HEALTHY SUBJECT DURING FORCED BREATHING AT 6/MIN. BARS INDICATE THE POSITIVE PHASE SHIFT ANGLE BETWEEN OSCILLATIONS IN CBFV AND ABP.(24)

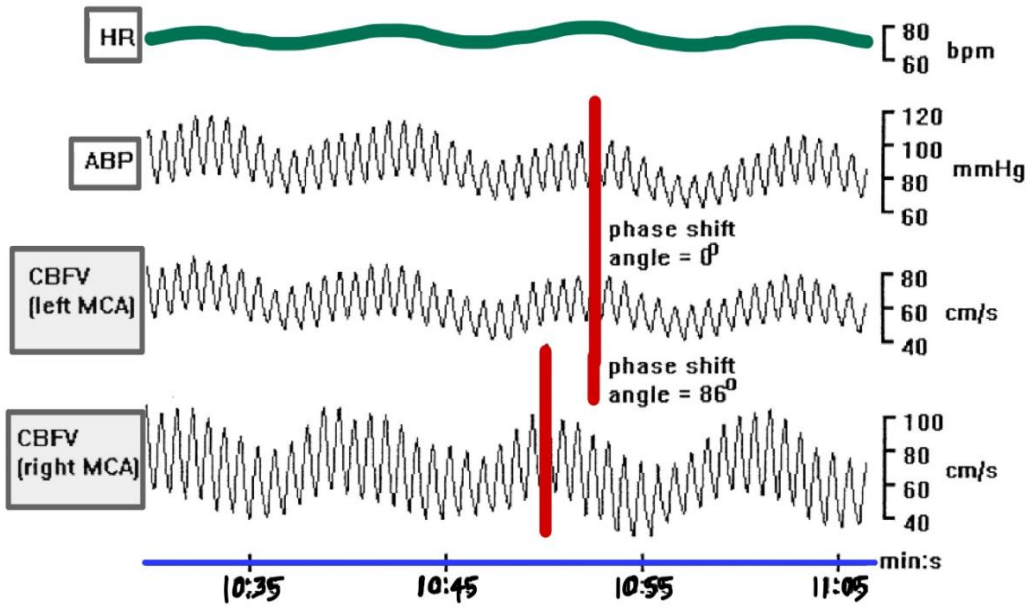


FIGURE 8 : RECORDINGS OF HEART RATE (HR) IN BEATS PER MINUTE (BPM), ABP, AND CBFV OF BOTH MCAS IN A SUBJECT WITH SEVERE STENOSIS OF THE LEFT MCA DURING FORCED BREATHING AT 6/MIN (POST STENOTIC INSONATION OF LEFT MCA). BARS INDICATE THE MISSING PHASE SHIFT ANGLE BETWEEN OSCILLATIONS IN CBFV OF LEFT MCA AND IN ABP (CBFV FOLLOWS PASSIVELY ABP AND THE POSITIVE PHASE SHIFT ON THE NORMAL SIDE. (24)

NONINVASIVE ASSESSMENT OF CEREBRAL AUTOREGULATION

The use of Mx has been validated in traumatic brain injury and subarachnoid haemorrhage. It uses the continuous measurement of ICP and ABP. The need to continuously assess cerebral autoregulation occurs in a multitude of conditions that do not use ICP monitoring. Hence nMx (non-invasive Mx) has been studied. The study by Lavinio et al suggested that the correct use of the Finapres accurately replicated ABP slow waves, supporting the strong correlation between nMx and Mx and this could be in research and clinical practice and hemispheric difference in autoregulation also can be acceptably detected by this method. (25)

There are non-invasive methods that quantify cerebral autoregulation (CA) from the CBFV response to spontaneous BP fluctuations originating from short-term BP control by the sympathetic nervous system. But these cannot be used in anaesthetized patients because sympathetic outflow is suppressed by sevoflurane. so intraoperative non-invasive assessment of CA is impossible. The CBFV changes to BP change spontaneously around 2 frequencies, a high frequency around 0.25Hz and a low frequency around 0.1Hz. The low frequency is attributed to sympathetic activity mediated by the baroreceptor-mediated system and high frequency to respiration. The CA needs 5s to react to BP fluctuations hence the high-frequency fluctuations are passed unaltered while LF BP oscillations are counter-regulated and damped by CA. In the'frequency domain' analysis, the relative power (or amplitude) of these fluctuations can be calculated and analysed to determine CA efficacy. (26,27)

Weiland et al proposed a novel method using paced breathing with BP oscillations magnified with positive pressure ventilation.They continuously monitored BP non-invasively and CBF velocity (CBFV) derived by transcranial Doppler before surgery during 3 min of paced breathing at 6, 10, and 15 bpm and during surgery from mechanical positive pressure ventilation at identical frequencies. Frequency domain analysis was used to analyse data to obtain CBFV-to-BP phase lead as a continuous measure of CA efficacy. They obtained cerebral autoregulation indices similar to values determined before surgery during surgery also. (27)

TCD flow velocities in MCA and various indices such as PI, and RI have been used in patients in peri-agonal periods to predict whether patients died or improved.Mean initial PI and MCBFV in the patients that died were 1.52±0.76 and

28.55±14.92cm/sec respectively, and in the patients that showed neurosurgical recovery was 1.11 ± 0.28 and 36.52 ± 8.56 cm/sec respectively. The specificity and positive predictive value of the TCD waveform in predicting death was 100%, however, it had low sensitivity (47.17%) and negative predictive value (12.5%). Hence TCD has been used as an ancillary in confirming brain death and also to prognosticate neurosurgical patients. (18)

CEREBRAL OXYGENATION

It is measured non-invasively and continuously by employing NIRS(Near-infrared spectroscopy), which is an optical technology based on Beer–Lambert's law allowing the determination of regional cerebral oxygen saturation(rScO2) inreal-time. Based on the differential absorption of infrared light by oxygenated and deoxygenated haemoglobin cerebral oxygenation is determined. (28)Determination of rScO2 by NIRS, most often assumes a fixed ratio of 70:30 or 75:25 for the venous and arterial blood volume, based on anatomical evidence, not taking the capillary blood volume (approximately 5%) into account. There can be contamination from extracranial blood which is a potential source of error, hence multiple probes are used and the spatial resolution principle is followed. cerebral oximeters provide information on the balance between regional oxygen supply and demand but do not provide information regarding oxygen delivery.

Near-infrared light with a wavelength of 650–940 nm penetrates the skull to underlying cerebral tissue and is absorbed by metal complex chromophores: haemoglobin, bilirubin, and the cytochromes. The absorption spectrum for deoxygenated haemoglobin is 650–1000 nm and for oxygenated haemoglobin 700–

1150 nm. The isosbestic point where the absorption spectra for oxygenated and deoxygenated haemoglobin are the same can be used to calculate total tissue haemoglobin concentration.

The main determinants of rScO2 include oxygen content of the blood, CBF, tissue diffusivity of oxygen, and cerebral metabolic rate for oxygen. Factors that affect blood oxygen content and cerebral metabolic rate are relatively stable over short periods; it is proposed that rScO2 might serve as a surrogate for CBF during bedside monitoring. Using rScO2 signals from a standard NIRS monitor, specialized computer software calculates the continuous correlation between low-frequency changes in rScO2 and MAP to render the variable cerebral oximetry index (COx). If autoregulation is intact, the CBF and MAP do not correlate, and COx is zero or negative and vice versa. (28)(29)

Baseline cerebral oximetry values are obtained before induction of anaesthesia. Normal values range from 60% to 80%. Factors affecting CBF and oxygen content affect NIRS values, anatomical variations, for example, an incomplete Circle of Willis or severe carotid artery stenosis can create errors in cerebral oximetry values; therefore, it is recommended that cerebral oximetry is performed bilaterally.

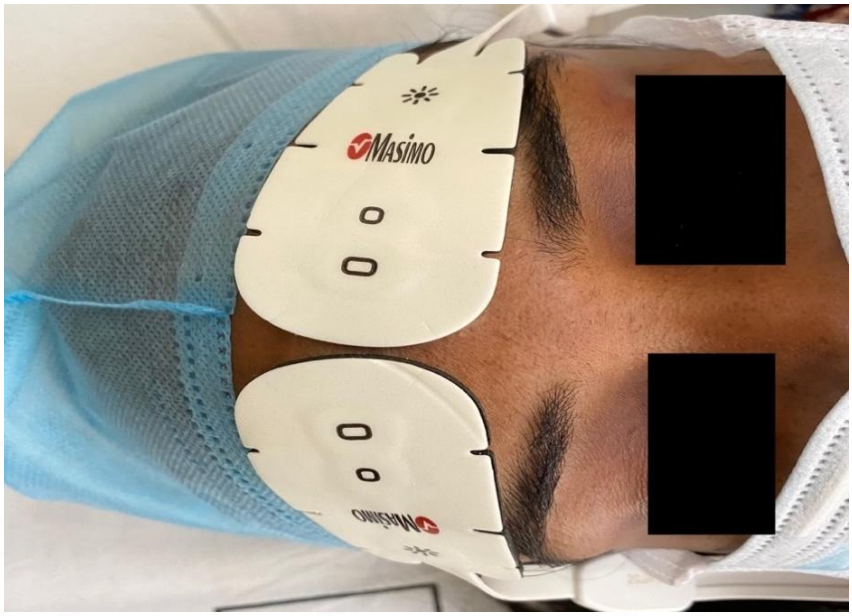


FIGURE 9: DEMONSTRATION OF THE NIRS ELECTRODES POSITION ON THEFOREHEAD.

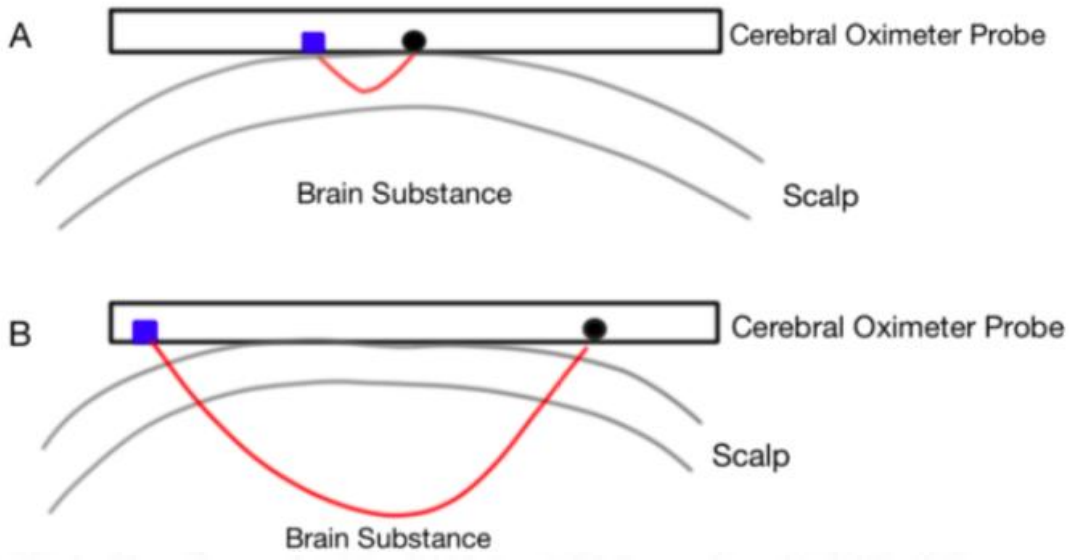


FIGURE 10: DIAGRAMMATIC REPRESENTATION OF SPATIAL RESOLUTION

Limitations of NIRS -

- Blood from an extracranial source can create erroneously low measurements.
- Cerebral oximeters only measure regional cerebral oxygenation.
- Cerebral oximeters do not identify a cause for the desaturation.
- Cerebral oximetry values must not be interpreted in isolation; alterations in cerebral oximetry measurements must take into consideration all available clinical information and the physiological state of the patient. (28)

Functional near-infrared spectroscopy (fNIRS) uses variations in optical absorption to identify changes in haemoglobin species within the brain. Oligochannel fNIRS is a useful tool in the critical care setting for assessing cerebral oxygenation and autoregulation in patients with stroke and traumatic brain injury. It is adequate for assessing global cerebral function.The spatial resolution of fNIRS for brain mapping across several task modalities, such language mapping, has been increased by multichannel NIRS. The existing requirements for averaging and group analysis restrict its clinical applicability for subject monitoring and real-time event detection.(30)

By providing information on oxygen delivery and consumption, NIRS has the advantage of allowing care to be tailored to the patient. Despite an ever-growing body of literature repeatedly describing an association between impaired rScO2 and adverse perioperative outcomes, NIRS awaits further validation in clinical trials that are properly designed and executed.

NIRS FOR MEASURING CEREBRAL AUTOREGULATION

Impaired CA results in secondary brain damage, which is an independent risk factor for fatality. (31)TCD is well established for measuring cerebral autoregulation, using regional cerebral oxygen saturation (rSO_2) as a surrogate for CBF. The NIRS-derived COx is correlated and has been found to have good agreement with the previously validated TCD-based method,COx can be considered an acceptable substitute for Mx monitoring in patients with acute intracranial injury.

Dias et al did a recent prospective trial using multimodal brain monitoring, including ICP, CPP, bilateral transcranial cerebral oximetry with fNIRS, brain tissue oxygenation and CBF, to assess the CPP_{opt} in patients with severe TBI. 18 patients in all with a median Glasgow Coma Scale of 6 were included. Based on the CPPopt curve derived with invasive ABP and ICP data in the previous 4 hours, the CPPopt was displayed at the bedside every minute. In order to determine how much time each patient spent with impaired CA (PRx> 0.25), the CPPopt was tracked virtually in real-time for each patient. The ABP and ICP were managed based on the CPP_{opt} when it was available. Short-term and long-term outcomes were statistically significantly worse for those with high PRx and a prolonged period with PRx> 0.25. An additional post hoc analysis found that the PRx produced by transcranial cerebral oximetry with fNIRS had the highest level of concordance with the ideal CPP determined by invasive PRx. These results suggest that invasive ICP can be reliably supplemented by fNIRS or perhaps completely replaced for calculating CPPopt.

The time-domain fNIRS has been used to investigate cerebral oxygenation in patients with ischemic stroke. The result shows increased total haemoglobin but decreased oxyhemoglobin (namely, decreased oxygen saturation) in the ischemic

hemisphere of large vessel stroke. (32)Furthermore, a new approach combining measurements for haemoglobin species and continuous cerebral oxygenation with time-domain fNIRS can substantially enhance our understanding of dynamic neuronal oxygen metabolism in different cerebral pathologies. (33)

Zweifel et al did a continuous assessment of cerebral autoregulation in Subarachnoid haemorrhage patients using NIRS. They also monitored Arterial blood pressure, intracranial pressure, mean flow velocity, and Tissue Oxygenation Index(TOI). Mx and TOx were calculated as moving correlation coefficients between 10-second averaged values of cerebral perfusion pressure and mean flow velocity and between CPPand TOI, the moving correlation coefficient between arterial blood pressure and Tissue Oxygenation Index TOxA was calculated. Their findings were correlations of Mx and TOx over time varied markedly among individual recordings, time-averaging over the entire recording interval correlations between Mx and TOx and between Mx and TOxA were highly significant. (34)

Multimodality monitoring of cerebral autoregulation in patients with traumatic brain injury using NIRS, ICP monitoring, and TCD MCA flow velocities mainly analysing the slow oscillations of cerebral haemodynamics was done by Highton et al, wanted to identify the relationship between NIRS signal oscillations and multimodal neuromonitoring, examining the utility of near-infrared derived indices of cerebrovascular reactivity. Established indices of autoregulatory reserve such as the PRx, Mx and the NIRS indices such as total haemoglobin reactivity index (THx) and tissue oxygen reactivity index (TOx) were compared.NIRS indices correlated significantly between PRx and THx, PRx and TOx, and Mx and Tox but not between Mx and THx (r_s = 0.26, P = 0.28) and demonstrated wide limits between these

variables: PRx and THx and Mx and Tox. Analysis of slow-wave activity throughout the ICP, TCD and NIRS recordings revealed significant interrelationships, which varied dynamically and were nonsignificant at frequencies <0.008 Hz.Although slow-wave activity in all modalities is significantly similar, it varies dynamically in both time and frequency, and this manifests as an incomplete agreement between reactivity indices. (35)

Rivera-Lara et al studied the use of NIRS for measuring autoregulation in comatose patients. They found a good correlation between Cox and TCD-based methods and Cox can be an acceptable substitute for Mx monitoring in patients with acute intracranial injury. (36)

NIRS has also been studied as a surrogate functional marker of the metabolic activity of rescued brain tissue in stroke patients who underwent recanalization following large vessel occlusion. The ischemic area had significantly higher deoxy-haemoglobin (HbR) and total haemoglobin (HbT) compared with controls in both recanalized and nonrecanalized patients but lower tissue oxygen saturation ($StO_{2)}$ only in recanalized patients. Recanalized patients have significantly lower mean StO_2 in the ipsilateral hemisphere compared with non-recanalized patients. (32)

OPTIC NERVE SHEATH DIAMETER (ONSD)

Optic nerve sheath diameter ultrasound is a safe, valid, and non-invasive method of measuring intracranial pressure (ICP) with high sensitivity and specificity. It has utility in traumatic brain injury as well as no traumatic abnormality. It's useful as a screening tool for raised ICP, initiating anti-oedema measures and also to monitor therapy. It's also cost-effective, short investigation

time, available at the bedside and can be used in conjunction with other imaging modalities and also invasive ICP monitoring.

It has reasonable diagnostic accuracy. The CSF surrounds the optic nerve, which is connected to the ventricular system of the brainThe dura, arachnoid, and pia mater make up the optic nerve's sheath, and they enclose a small amount of CSF in the subarachnoid space. Therefore, it is thought that an increase in ICP will result in a transmission of force through these spaces and distention of the ONSD. The learning curve for experienced sonologists may include as few as 10 examinations, whereas for novice sonologists the number of scans needed may be closer to 25.(37)

MEASUREMENT OF ONSD:

It is done with an ultrasound probe in a high-frequency range (7.5 MHz or higher). Minimum power settings for insonation. The patient is to be positioned supine and a thick layer of gel is applied to the eye. The patient is asked to look forward with eyes closed to delineate anatomy better. The optic nerve can be seen behind the globe in the axial plane.

ONSD is measured 3 mm behind the globe, in each eye perpendicular to the optic nerve axis, using an electronic calliper and an axis perpendicular to the optic nerve the mean of three measured values is computed, to reduce the intra-observer variability. ONSD is measured between the outer hyperechogenic borders of the subarachnoid space. (38)

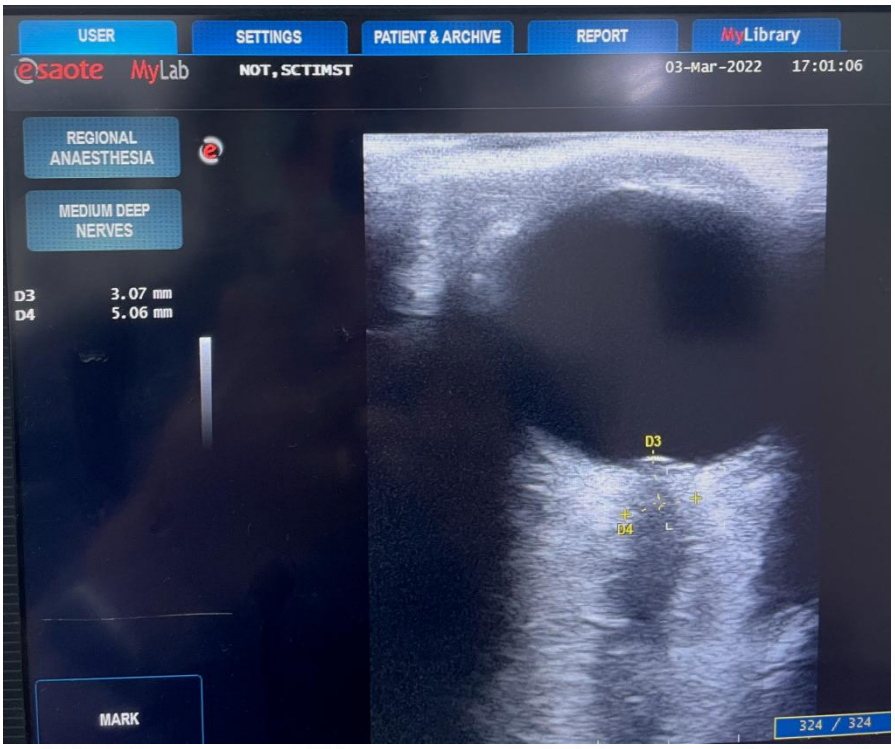


FIGURE 11: DEMONSTRATION OF ONSD MEASUREMENT.

CORRELATION BETWEEN ONSD AND OTHER INVASIVE AND NON-INVASIVE ICP MEASUREMENTS

ONSD has been used in a multitude of conditions to predict intracranial pressure indirectly and also to predict outcomes. In a study by Patel et al in-stroke patients with both ischemic and hemorrhagic,Bilateral ONSD was measured on arrival and within the first 2 days of admission. Outcomes were measured as inpatient survival, Cerebral Performance Category, and modified Rankin Scale at 3 and 6 months. They concluded that elevations in ONSD were associated with increased in-hospital mortality and poor functional outcome at 6 months.For every 0.1 cm increase in optic nerve sheath diameter, the odds ratio for death was 4.2 among ischemic stroke (95% CI, 1.32-13.64; p = 0.015), and the odds ratio was 6.2 among ischemic or haemorrhagic patients (95% CI, 1.160-33.382; p =

0.033).(39)Correlation between TCD measured non-invasive ICP based on two-depth TCD technology from the ophthalmic artery velocities and ONSD was done by ragauskas et al in neurocritical care patients and the correlation with ICP was measured through a lumbar puncture.The diagnostic sensitivity of 37.0%, specificity of 58.5%, and the area under the ROC curve (AUC) of the ONSD method for detecting elevated intracranial pressure (ICP .14.7 mmHg) were 0.57, calculated using a cut-off point of ONSD at 5.0 mm. The diagnostic sensitivity, specificity, and AUC for the non-invasive absolute ICP measurement method were calculated at the same ICP cut-off point of 14.7 mmHg and were determined to be 68.0%, 84.3%, and 0.87, respectively. The TCD technology was observed to have better diagnostic than the ONSD method when expressed by the sensitivity and specificity for detecting elevated ICP > 14.7 mmHg. (40)

ONSD and PI derived from TCD were correlated in traumatic brain injury patients postoperatively by Chang et al to predict intracranial hypertension. They found a correlation between ONSD and ICP and this remained when ONSD > 5mm. Also, there was a strong interrelationship between PI and ICP on post-surgery days 3,4 and 5.The AUC was 0.729, 0.900, and 0.943 for predicting intracranial hypertension with PI 1.2 mm, ONSD 5 mm, or a combination of these, respectively (p .001).(40)

Using the categories of non-trauma patients with ICP monitoring, trauma patients without TBI, trauma patients with mild TBI, and trauma patients with severe TBI with ICP monitoring, Singer et al. conducted a study comparing four non-invasive ICP measurement technologies in traumatic brain injury patients. In comparing ONSD values in patients with mild TBI, non-TBI trauma patients, and patients with

severe TBI, ONSD was found to differ significantly and bilaterally on post-injury days 2 and 3. ONSD as well as the dynamic measurements of pupillometry reliably differentiated severe TBI from more mild brain injuries on post-injury days 2 and 3. Interestingly, however, these same measurements did not correlate to ICP in patients with severe TBI. The TCD measurements did not show consistent or bilateral differences between severe TBI compared with mild and moderate TBI although it correlated well with ICP.(41)

MATERIALS AND METHODS

5. MATERIALS AND METHODS

We designed a prospective observational pilot study to be conducted on patients who underwent craniotomy for supratentorial intracranial lesions in the Neuro-Surgical Operation Theatre (NSOT) of Sree Chitra Tirunal Institute of Medical Sciences and Technology (SCTIMST), Trivandrum, which is a specialized tertiary referral center.

This study was approved by the Institutional Ethics Committee (SCT/IEC/1760/NOVEMBER/2021), dated 28.12.2021 and written informed consent was obtained from all the participants of the study. The study was registered with CTRI on 28.02.2022 (www.ctri.nic.in) and the registration number is CTRI/2022/02/040675. Data for the study was collected for the period starting from December 2021 to June 2022.

Study Design: Prospective observational study. The total number of patients (n) recruited was according to the presentation of patients for surgery fulfilling the inclusion criteria as it was a pilot observational study.

The following were the inclusion and exclusion criteria;

A) Inclusion criteria:

1. Patients posted for supratentorial craniotomy for brain tumour resection with tumour size more than 6 cm along with features of raised ICP, without hydrocephalus.
2. Patients undergoing decompressive craniectomy for malignant stroke.
3. Patients with aneurysmal SAH undergoing clipping.
4. Age more than 18 years.

B) Exclusion criteria

1. Refusal of consent for the study.
2. Age < 18 years, > 65 years
3. Pregnant and lactating mothers
4. patients with technical problems wherein TCD cannot be performed optimally such as a thick skull leading to a poor window for insonation of the vessel.
5. Patients with severe comorbidity like decompensated heart failure, coronary heart disease, Irregularity in the left ventricular ejection volume (due to, for example, fibrillation or atrial flutter, or frequent ventricular extrasystole); and cardiac frequency greater than 140 beats/minute, advanced liver or renal disease, uncontrolled hypertension, diabetes mellitus, severe pulmonary disease.
6. Recurrent surgery.
7. Patients who are on hemodynamic support before surgery.
8. Patients with Aortic Regurgitation.
9. Patients with intracranial tumour compressing the optic nerve or carotid arteries altering the ONSD value and cerebral blood flow velocities due to direct pressure on the nerves or vessels.

Study Protocol:

A) RECRUITMENT OF PATIENTS

Patients with supratentorial pathology and for spine surgery, admitted to the neurosurgery ward for surgery were initially screened by the Principal Investigator and Co-Principal investigator for inclusion and exclusion criteria. If the participant was eligible for inclusion, written informed consent was obtained from the patient or if not close relative. Baseline demographic data that includes age, gender, GCS at the

time of admission, co-morbidities, the neurological condition and CT scan findings of the patient were recorded. Patients were pre-medicated with Tab pantoprazole 40mg and 4mg of Tab ondansetron along with the continuation of antiepileptic drugs and taken up for surgery.

The patients were divided into four groups:

Group A-patients with GCS 13 to 15,

Group B-Patients with GCS 9 to 12 and

Group C- patients with GCS <8 undergoing major neurosurgical procedures.

Group S (Control group)- GCS 15, undergoing elective spine surgery was recruited.

The patients were shifted to the operation theatre. ASA Standard intraoperative monitors attached and a wide-bore intravenous cannula inserted. Intravenous fluid Ringer lactate 2-4 ml/kg was started. Near infra-red spectroscopy (NIRS) sensors were attached to the forehead bilaterally, connected to the NIRS monitor and the baseline NIRS recordings were noted on both sides.

FIGURE 12: DEMONSTRATION OF NIRS MACHINE (MASIMO ROOT WITH O3 REGIONAL OXIMETRY)

TECHNIQUE OF TCD EVALUATION:

TCD was performed preoperatively using [Dolphin IQ, Viasonix] equipment, with a 2MHz probe through the transtemporal window. The insonation depth and signal gain were adjusted to an optimal signal-to-noise ratio to get an optimal waveform. MCA vessel was preferred to be the region of interest in our study as it is very accessible through the temporal window and shows less anatomical variability. TCD probe was placed in front of the tragus above the imaginary line drawn from the outer cantus of the eye to the tragus on the right side. The depth was pre-set to 40-60 mm with a gain setting of 8 and power of 50%. The middle cerebral artery (MCA) flow was identified in the M-mode window showing a red colour. The doppler flow was obtained from the dedicated window for the same and the values were recorded. Doppler parameters like Peak systolic velocity (PSV in cm/s), End-diastolic velocity (EDV in cm/s), Mean flow velocity (MFV in cm/s),Systolic diastolic ratio (S/D) was measured. Pulsatility index (PI), and Resistivity index (RI) were also calculated as they are considered to indicate peripheral vascular resistance. A similar technique was used for the left side.

FIGURE 13: DEMONSTRATING TRANSCRANIAL DOPPLER MACHINE USED IN THE STUDY

TECHNIQUE OF ONSD EVALUATION

The optic nerve sheath diameter was also done. For ONSD, a thick layer of gel was applied over the closed upper eyelid. The probe (10 MHz, GE vivid I echo machine, Milwaukee USA) was placed only on the gel in the temporal area of the eyelid to prevent pressure from being exerted on the eye. The eye was checked for

proper closure to prevent any corneal or conjunctival injury. The position of the probe is adjusted to give a suitable angle for displaying the entry of the optic nerve into the globe. The power of ultrasound is reduced to 75%. ONSD is measured 3 mm behindthe globe using an electronic caliper along an axis perpendicular to the optic nerve.

FIGURE 14: DEMONSTRATING ULTRASOUND MACHINE USED TO MEASURE ONSD

General Anaesthesia was induced using the standard protocol. The patients were pre-oxygenated with oxygen at 6 l/min for three to five minutes after which

they were be induced with injection of Fentanyl 2-3mcg/kg and Propofol 1-2mg/kg intravenously. Intubation facilitated with an intermediate-acting muscle relaxant vecuronium, dosed at 0.1mg/kg IV. Post induction maintenance was achieved with an air: oxygen mixture of the ratio 1:1 and sevoflurane at a MAC of 0.7-1.0 with an infusion of fentanyl (1μg/kg/hr) and atracurium. Mechanical ventilation was instituted in volume-controlled mode (Aestiva /5, DatexOhmeda) with a square wave (constant inspiratory flow) adjusted to obtain a PaCO2 of 35- 40 mm Hg during surgery. The radial artery was cannulated for invasive arterial BP monitoring whereas the central venous line was inserted via the internal jugular vein or Peripherally inserted central line (PICC). The nasopharyngeal temperature probe was attached and the patient's temperature was maintained throughout the procedure between 350-36 0 C.

The intraoperative goals of fluid management were to maintain the urine output of 1ml/kg/hr, pulse pressure variation of less than 12% and systolic pressure variation of less than 10 mmHg. Patients were extubated according to the discretion of the attending anaesthesiologist. and consideration of preoperative neurological status and patients were managed in neurosurgery ICU in the post operative period. TCD of MCA flow velocities NIRS was again performed 24 hrs post-surgery and at discharge or end of care during the hospital stay. Clinical correlation was performed in all patients concerning the aetiology, response to surgery and clinical condition at the time of discharge. The values obtained by TCD were correlated to the patient outcome, as measured by the Glasgow coma scale and Glasgow outcome scale (GOS).

Postoperatively TCD parameters like PSV, EDV, Mean flow velocity, S/D ratio Pulsatility index and Resistivity index were noted post-surgery 24 hours and at the time of discharge. The NIRS values were also noted and the ONSD was measured at postoperative 24 hours.

The detailed analysis of the TCD spectrum was done by identifying the wave which has maximum velocity, the peak of that wave was labelled systolic velocity maximum and the trough as diastolic velocity maximum and in the same reading the wave with minimum velocity was identified and the systolic and diastolic velocity was measured.

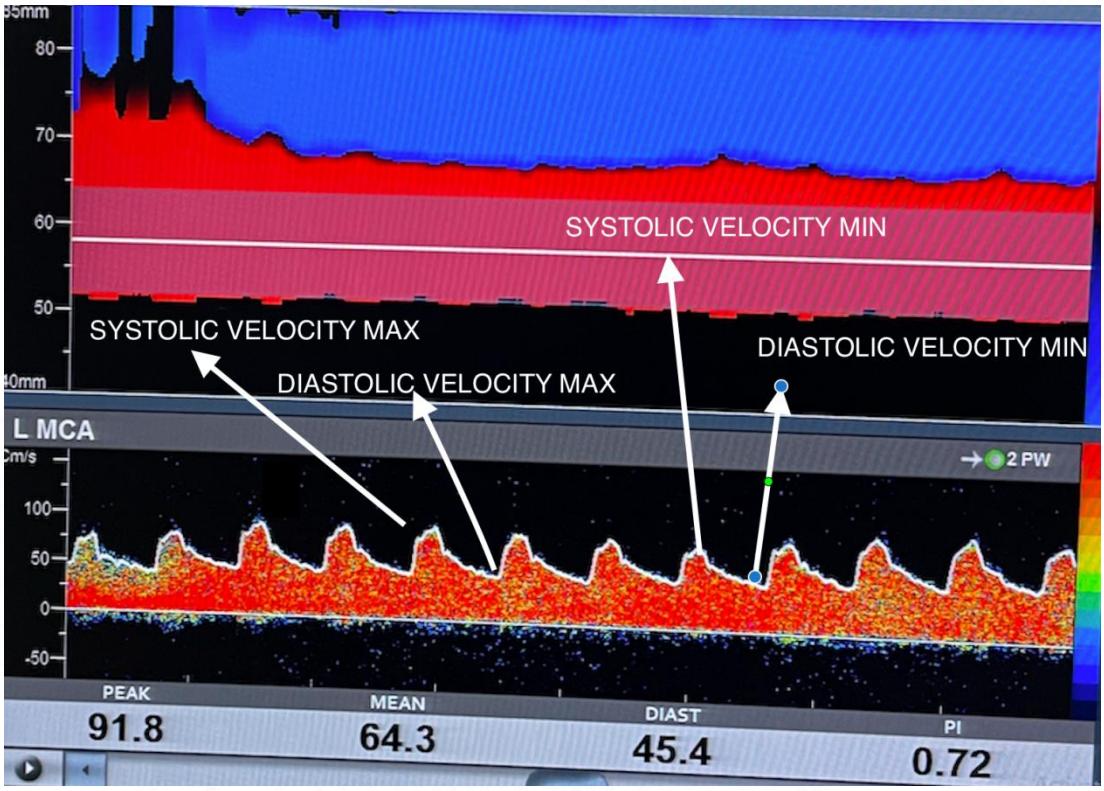


FIGURE 15 :ANALYSIS OF TCD SPECTRUM.

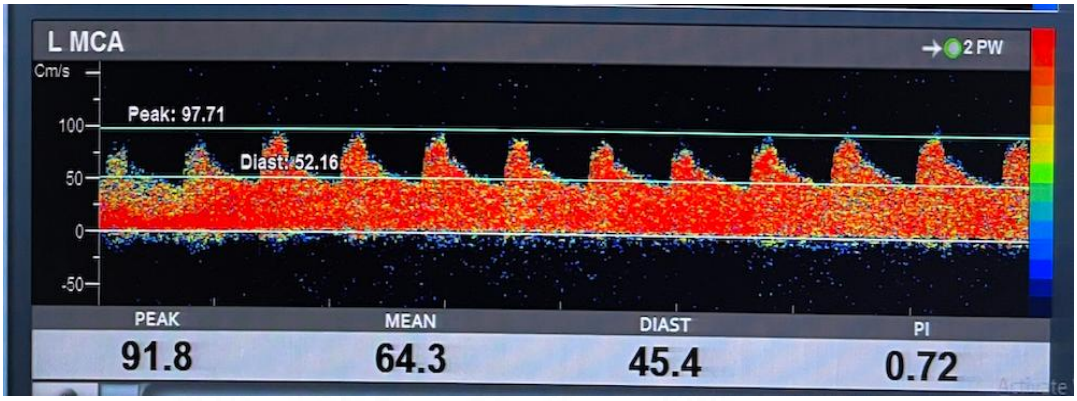


FIGURE 16 :MEASUREMENT OF PULSE VELOCITY MAXIMUM

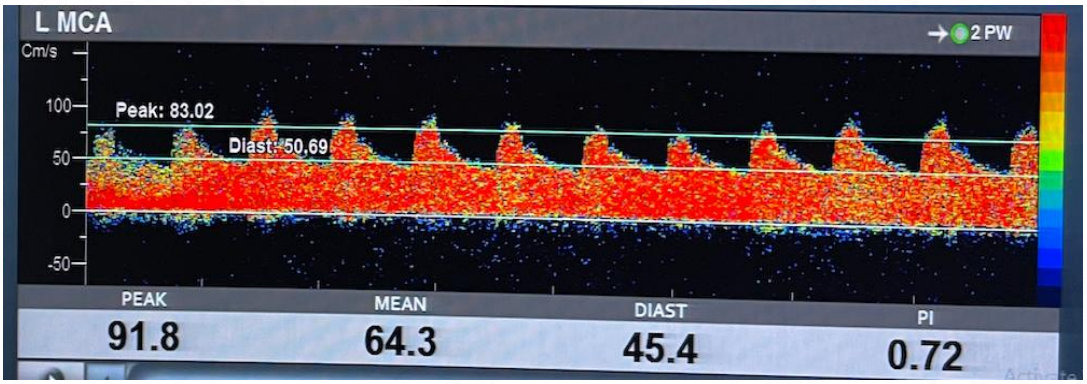


FIGURE 17 : MEASUREMENT OF PULSE VELOCITY MINIMUM.

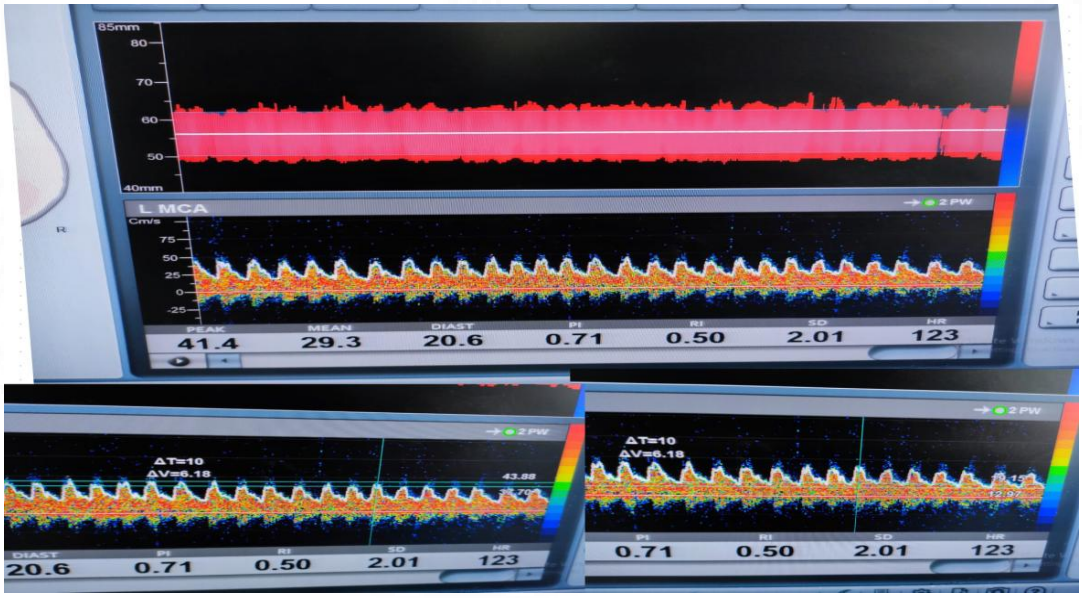


FIGURE 18 : TCD SPECTROGRAM FROM MCA FLOW VELOCITIES AND ANALYSIS OF THE VELOCITY VARIATIONS.

PULSE VELOCITY WAS CALCULATED =

SYSTOLIC VELOCITY (PEAK) - DIASTOLIC VELOCITY(TROUGH)

This was calculated for waveforms with maximum velocity and also for a waveform with minimum velocity.

The Indices derived were:

$$\text{PULSE VELOCITY VARIATION} = \frac{\text{PULSE VELOCITY MAX} - \text{PULSE VELOCITY MIN}}{\text{PULSE VELOCITY MEAN}} \times 100$$

$$\text{SYSTOLIC VELOCITY VARIATION} = \frac{\text{SYSTOLIC VELOCITY MAX} - \text{SYSTOLIC VELOCITY MIN}}{\text{SYSTOLIC VELOCITY MEAN}} \times 100$$

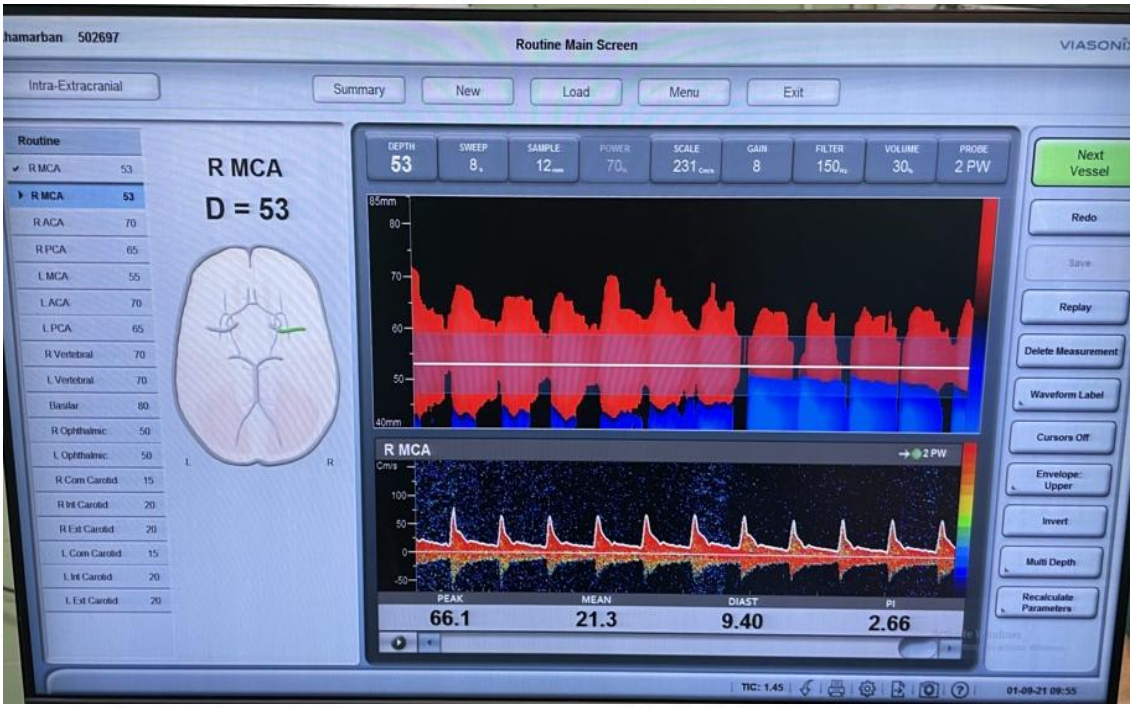


FIGURE 19: DEMONSTRATING PRE OPERATIVE TCD IN A PATIENT BELONGING TO GROUP C

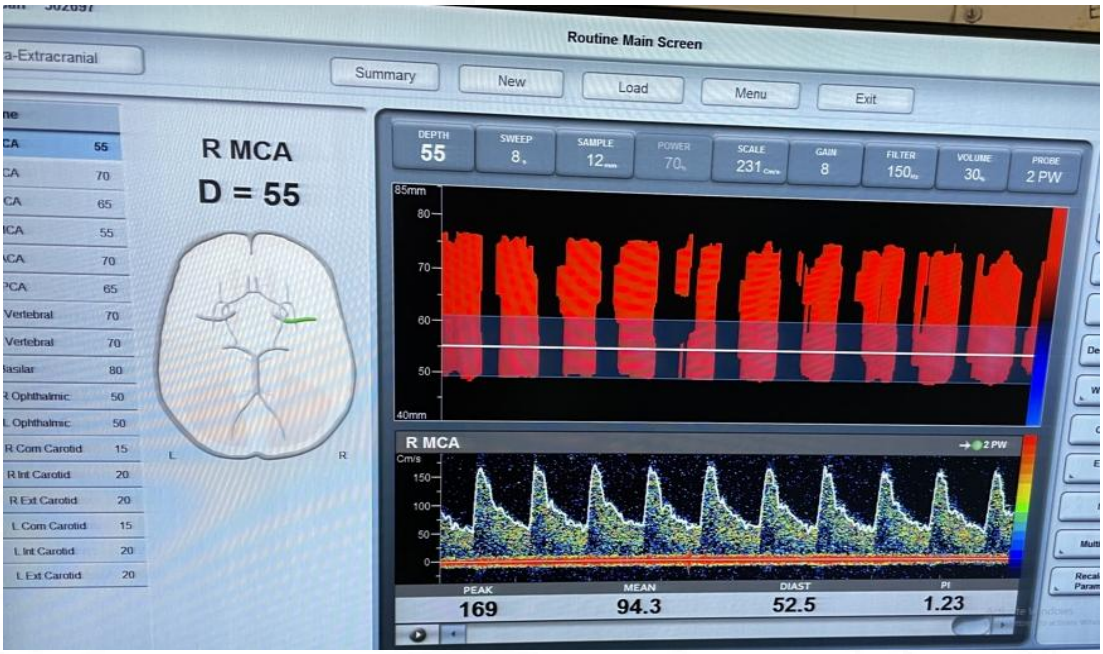


FIGURE 20 : DEMONSTRATING POST OPERATIVE 24 HRS TCD IN A PATIENT BELONGING TO GROUP C

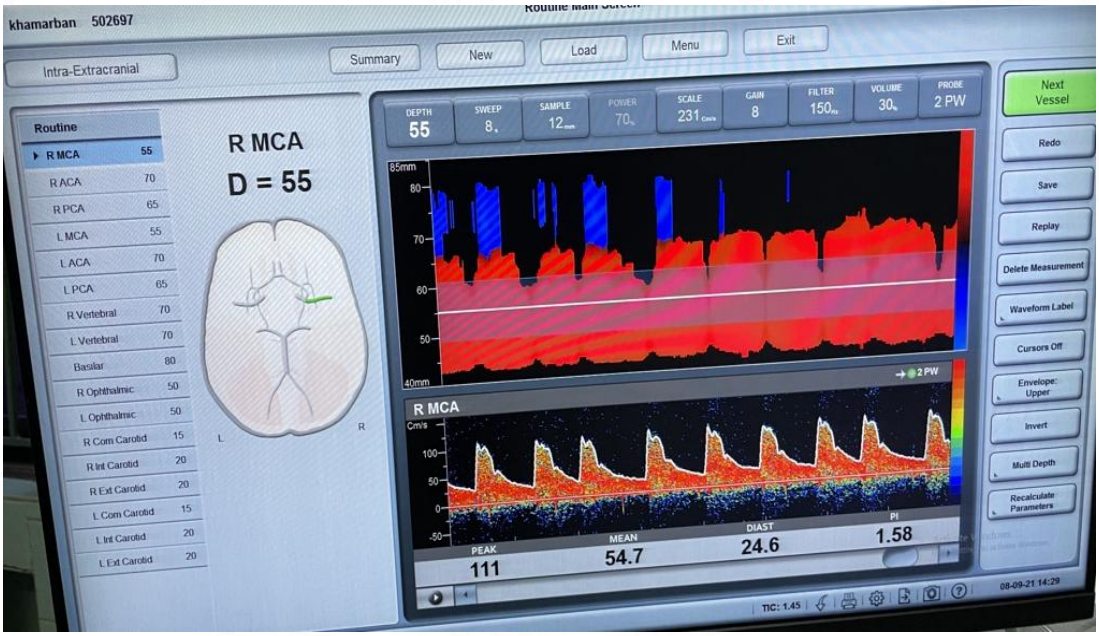


FIGURE 21 : DEMONSTRATING TCD AT THE TIME OF DISCHARGE IN A PATIENT BELONGING TO GROUP C

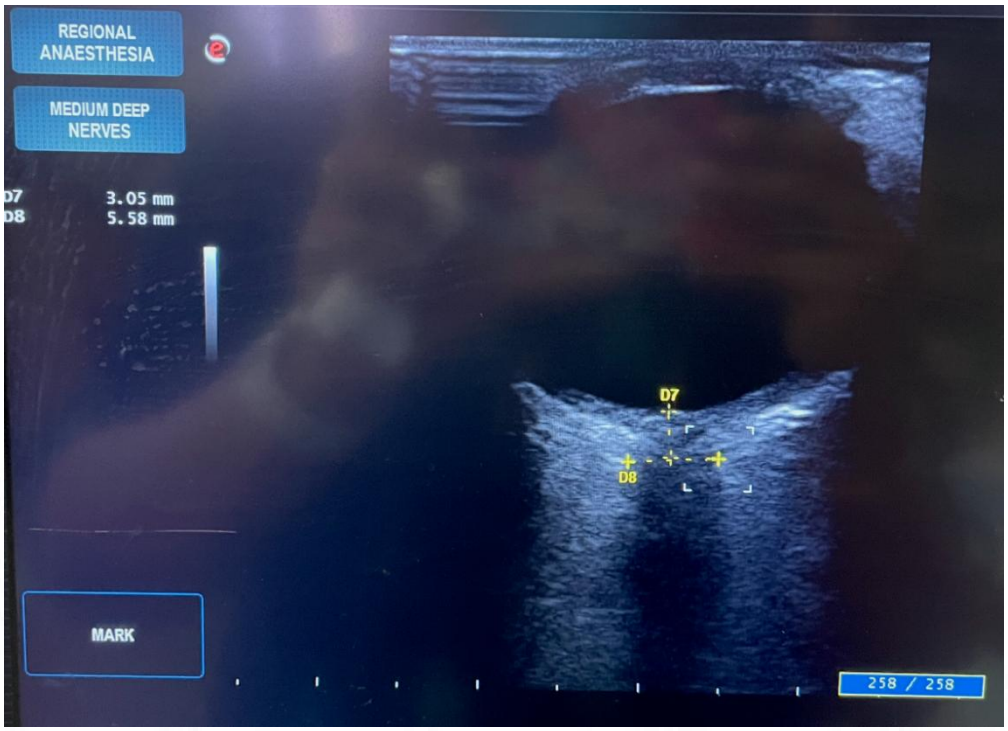


FIGURE 22 : DEMONSTRATING PRE OPERATIVE ONSD IN A GROUP C PATIENT

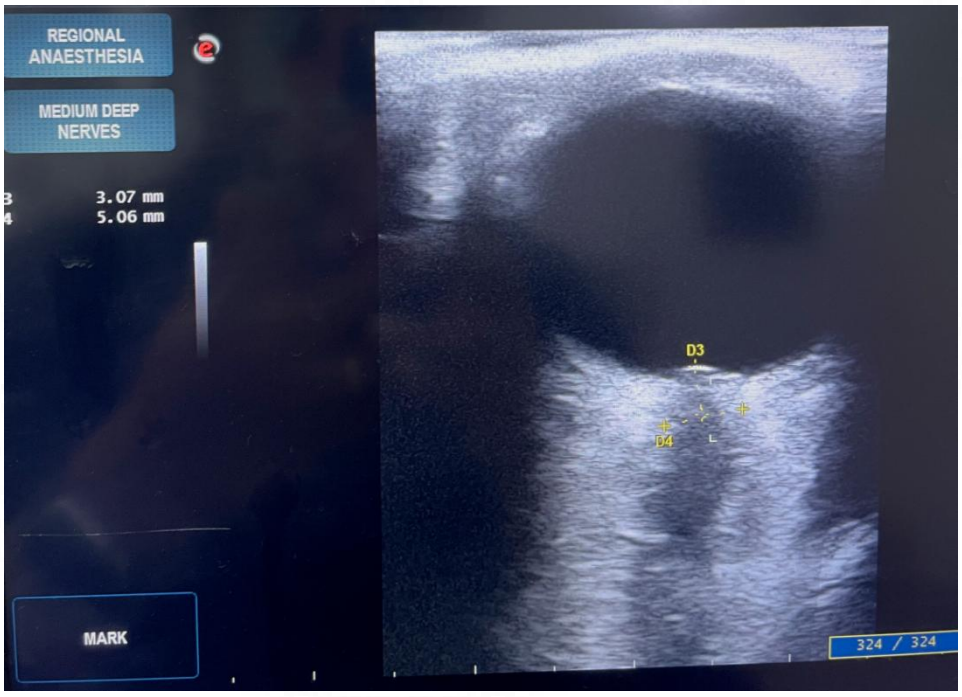


FIGURE 23 : DEMONSTRATING POST OPERATIVE ONSD IN A GROUP C PATIENT

STATISTICAL ANALYSIS

Data was compiled in MS Excel and analysed using SPSS v20.0. Demographic factors were described using univariate analysis. Qualitative variables were described using proportions and compared using the Z test for differences in proportions. Quantitative variables were described using mean (± SD) and compared using ANOVA tests for pre-operative, post-operative 24 hours and discharge variables. A comparison of means was done using the Z test for differences in means. Pearson's Correlation coefficient was used for the correlation of quantitative variables. ROC curve analysis was carried out for identifying cut-off values and diagnostic accuracy of possible predictor variables. A P value of >0.05 was considered for statistical significance.

RESULTS AND OBSERVATIONS

6. RESULTS AND OBSERVATIONS

In this prospective pilot study, seventy-three patients were assessed out of which fifty-six were enrolled as shown in the Consort flow diagram (Figure24). Among the eligible sixty-six patients, ten were excluded. Suitable trans-temporal windows could not be found in six patients and in another four patients had postoperative arrhythmias making them unsuitable for further transcranial doppler analysis.

Fifty-six patients with different Glasgow coma scale scores presenting to our hospital during the study period were included. Twenty-five patients were recruited in group A (GCS 13-15),12 patients in group B (GCS 9-12), 9 patients in group C (GCS < 8) and in Group S (spine pathology, GCS 15 as control group) 10 patients were recruited. All these patients underwent neurosurgical procedures like craniotomy and decompression or excision of tumours or clipping of aneurysms or decompressive craniectomy for stroke and spinal instrumentation. The study was completed successfully in all fifty-six recruited patients.

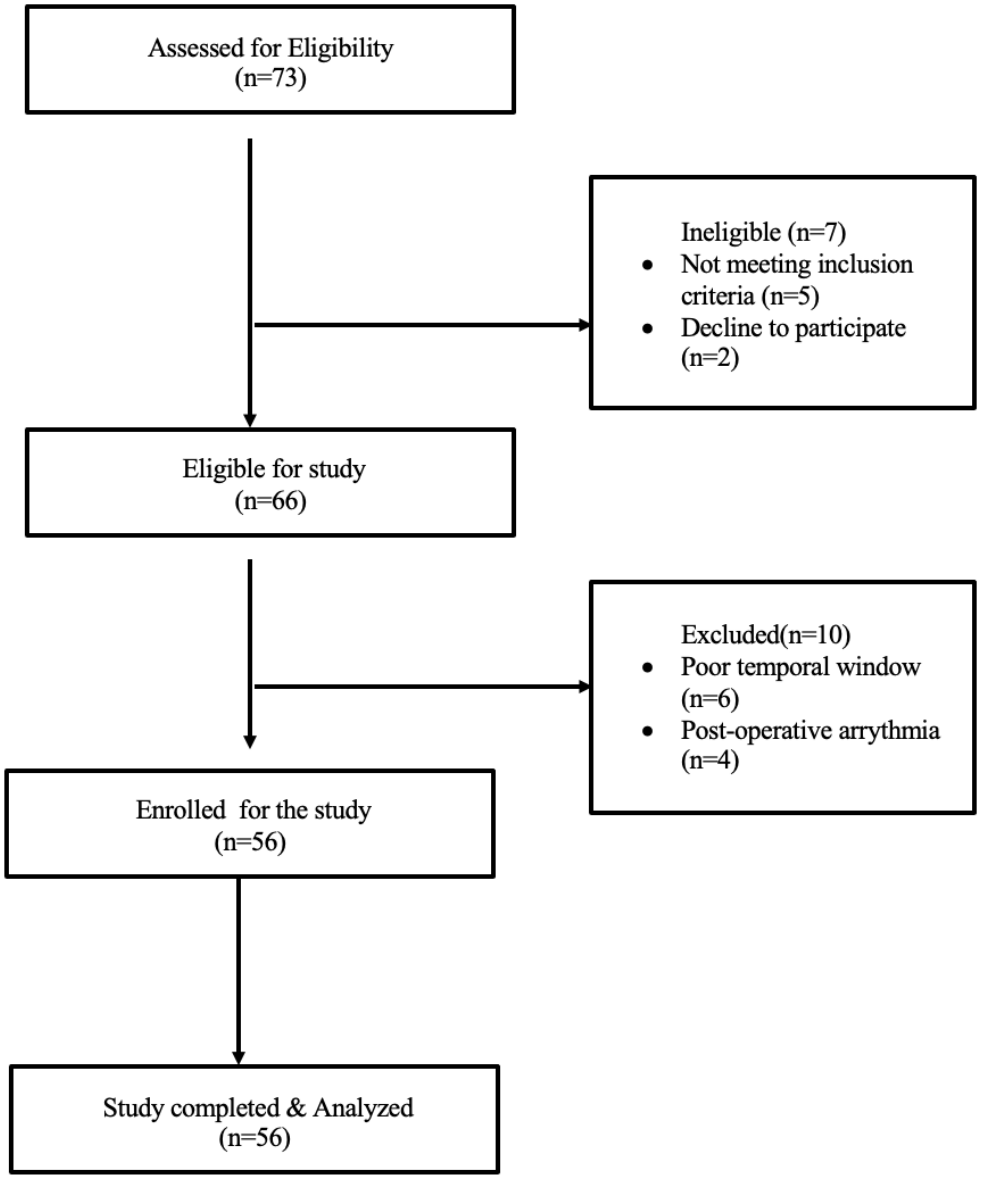


FIGURE 24: CONSORT FLOW CHART PRESENTING THE ENROLMENT, STUDY INCLUSION AND DATA ANALYSIS

The results of our study are described below.

1. DEMOGRAPHIC DATA

TABLE 1: THE COMPARISON OF THE DEMOGRAPHIC BETWEEN THE GROUPS.

Variable	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Age (years) (Mean± SD)	42.76 ±12.18	51.67 ±7.84	53.56 ±16.16	40.00 ±12.10	0.024
Weight (kg) (Mean± SD)	62.84 ±11.48	62.92 ± 10.25	60.78 ±10.21	56.80 ±8.34	0.456
Gender (Male: Females)	17:8 (32.0)	5: 7 (58.3)	5: 4 (44.4)	5: 5 (50.0)	0.458
ASA Grade I (%)	12 (48.0)	0 (0.0)	0 (0.0)	4 (28.6)	<0.001
ASA Grade II (%)	8 (32.0)	4 (33.3)	0 (0.0)	6 (60.0)	
ASA Grade III (%)	5 (20.0)	7 (58.3)	6 (66.7)	0 (0.0)	
ASA Grade IV (%)	0 (0.0)	1 (8.3)	3 (33.3)	0 (0.0)	

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, ASA=American Society of Anesthesiologist, $p<0.05$ considered significant)

The mean age of our patients in group A with GCS 13-15 was 42.76 years, in Group B with GCS 8-12 was 51.6 years and Group C with GCS <8 was 53.56 years and the control group of spine patients had a younger mean age of 40 years, with a mean age in all groups being 45.91years with a standard deviation of 12.95. The difference was statistically significant with a younger population in the spine group and an older population in the low GCS group.

The mean weight of the patients in group A was 62.84 kg, in group B 62.92kg, group C was 60.78kg and in group S, the control group was 56.8 kg and the age was comparable with each other in all the groups.

The gender characteristics of the patients with 11.4 % of patients in group A,10.25% in group B, 44.4% in group C and 50% of patients in group S were females with no statistically significant difference between the groups.

The ASA physical status in Group A with 48% patients being ASA I ,32%being ASA II, 20% being ASA III with no patients being ASA IV, In group B there was no patient who was ASA I, 33.3 % being ASA II,58.3% being ASA III and 8.3% being ASA IV. In group C 66.7% of patients were ASA III and 33.3 % were ASA IV and no patients were in ASA I and II class. in group S 28.6% were ASA I, 60% being ASA II and no patients were in ASA III and IV classes. There was a statistically significant difference between the groups.

2. LESION CHARACTERISTICS

TABLE 2. THE TABLE SHOWS THE PATHOLOGICAL LESIONS INCLUDED AMONG DIFFERENT GROUPS.

Pathology	**Group A (n=25)**	**Gr Group B (n= 12)**	**Gr Group C(n=9)**	**Gro Group S(n=10)**
Meningioma	4	6	1	-
Glioma	19	1	0	-
Aneurysm	2	4	0	-
Decompressive craniectomy for Stroke	0	1	8	-
Spine decompression	0	0	0	10
total	25	12	9	10

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group)

The distribution of intracranial pathology was with 4 patients in group A with a diagnosis of meningioma,19 with glioma,2 with intracranial aneurysm and no patient with stroke. In group B 6 patients had meningioma,1 with glioma,4 with intracranial aneurysm and 1 with a stroke patient. In group C, there was one patient with meningioma, no patients with glioma or aneurysm and 8 patients with stroke for decompression.

TABLE 3: FINDINGS ON PREOPERATIVE CT SCAN OF THE BRAIN AMONG PATIENTS IN DIFFERENT GROUPS. GROUP S-SPINE GROUP CT WERE NORMAL

	Group A (n=25)	Group B (n= 12)	Group C (n=9)	P value
Decreased Ventricle size (%)	13 (52.0)	8 (66.7)	6 (66.7)	0.006
Absent Basal Cisterns (%)	2 (8.0)	4 (33.3)	4 (44.4)	0.018
Effacement of sulci (%)	16 (64.0)	8 (66.7)	1 (11.1)	<0.001
Midline Shift (mm) (Mean ±SD)	6.19 ±4.73	5.65 ±6.78	3.83 ±3.41	0.007
Sub falcineherniation (%)	9 (36.0)	7 (58.3)	5 (55.6)	0.023
Transtentorial Herniation (%)	1 (4.0)	4 (33.3)	4 (44.4)	0.005
Loss of Grey White differentiation (%)	9 (36.0)	4 (33.3%)	0(0.0)	0.033

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

The imaging findings of decreased ventricular size were most seen in 52% of patients in group A, and 66.7% of patients in group B and group C and this difference was statistically significant. the finding of decreased basilar cistern size was found in 8% of Group A patients 33.3% of group B and 44.4% of group C patients and this difference was statistically significant. The effacement of sulci was

seen in 64% of group A,66.7%% of group B and 11.1% of group C patients. The mean midline shift in group A was 6.19mm with a standard deviation of 4.73mm, in group B it was 5.65mm with a standard deviation of 6.78mm and in group C it was 3.83mm with a standard deviation of 3.41mm that difference was statistically significant.

The incidence of trans tentorial herniation was 4% in group A,33.3% in group B and 44.4%in group C and that difference was statistically significant. The imaging finding of loss of grey-white differentiation was 36% in group A,33.3% in group B and there was no loss in group C and these differences were statistically significant.

3. CLINICAL DATA

3.1 HEART RATE

TABLE 4: THE COMPARISON OF THE HEART RATE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND AT DISCHARGE PERIOD.

	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative(beats/min) (Mean ±SD)	71.04 ±14.77	65.50±20.53	71.44 ±24.47	73.80 ±9.16	0.700
Post operative 24 hrs beats/min) (Mean ±SD)	74.52 ±17.65	66.00 ±18.62	75.22 ±17.44	81.70 ±15.33	0.223
At Discharge (beats/min) (Mean ±SD)	72.32 ±13.60	68.33 ±14.32	66.11 ±11.78	82.60 ±8.64	0.029

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

The mean heart rate of group A in the preoperative period was 71 beats/minute with a standard deviation of 14.7 beats/minute. It was 65.50±20.5 in group B and

71.44±24.47 in Group C and a heart rate of 73.8±9.16 beats/min in group S and this difference was not statistically significant.

In the postoperative 24 hours, the mean heart rate of group A was 74 ±17.6beats/min, in group B was 66±18.6 beats/meanwhile in group C was 75.22±17.44 beats/min and in the group, S was 81.7± 15.33 beats/min and this difference was not statistically significant.

At the time of discharge in group A, the mean heart rate was 72.32 ±13.6 beats/minute, in group B was 68.33±14.32 beats/min, meanwhile in group C was 66.11±11.7 beats/min and group S was 82.6±8.64 beats/minute and this difference was statistically significant. ($p<0.05$)

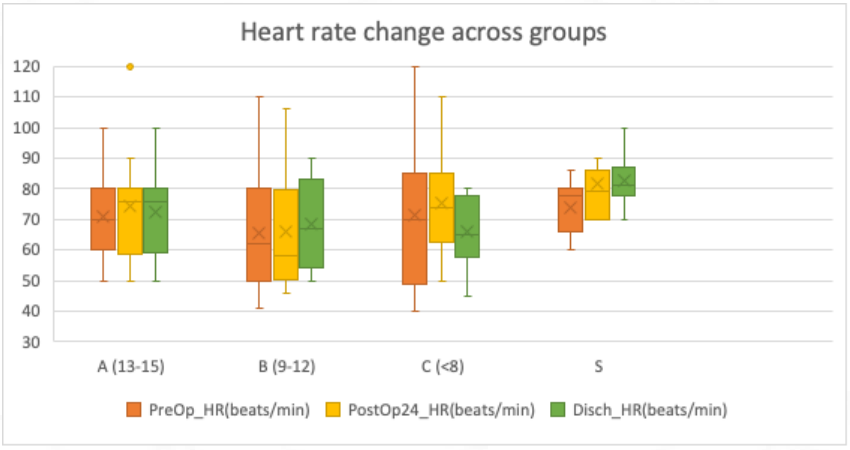


FIGURE 25: VARIATION IN HEART RATE IN DIFFERENT GROUPS FROM PREOPERATIVELY, 24 HOURS POSTOPERATIVELY AND AT THE TIME OF DISCHARGE.

3.2 BLOOD PRESSURE

3.2.1 SYSTOLIC BLOOD PRESSURE

TABLE 5: COMPARISON OF THE SYSTOLIC BLOOD PRESSURE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND DISCHARGE TIME.

Variable	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (mm Hg) (Mean ±SD)	122.40 ±17.61	140.83 ±16.08	144.11 ±17.87	120.70 ±14.81	0.001
24- hours postoperative (mm Hg) (Mean ±SD)	122.00 ±15.57	135.75 ±13.21	137.67 ±15.93	121.90 ±9.88	0.006
At Discharge (mm Hg) (Mean ±SD)	123.28 ±14.01	132.33 ±13.30	130.33 ±16.36	119.40 ±16.57	0.134

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

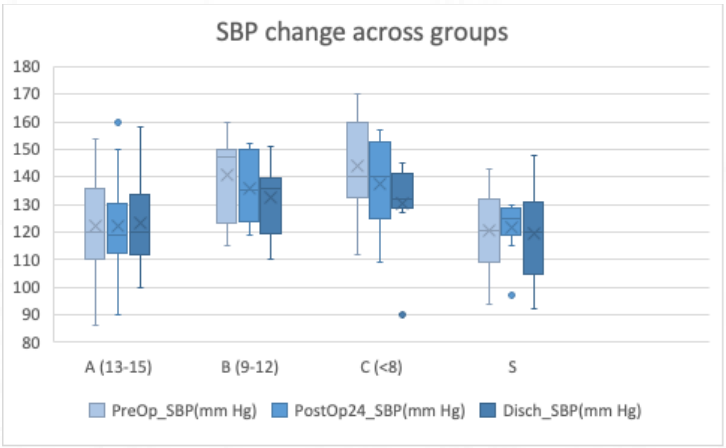


FIGURE 26: THE VARIATION IN SYSTOLIC BLOOD PRESSURE IN DIFFERENT GROUPS FROM PREOPERATIVE, POSTOPERATIVE 24 HOURS AND AT THE TIME OF DISCHARGE

The mean systolic blood pressure in Group A preoperatively was 122.4mm Hg with a standard deviation of 17.61 mm Hg, in Group B the blood pressure was 140.83± 16.08 mmHg and for Group C was 144.11 ± 17.8 mmHg and for the control group of spine patients were 120.70±14.8 mmHg and this difference was statistically significant.

In the postoperative 24 hrs, the systolic blood pressure for group A 122 mmHg with a standard deviation of 15.57mmHg, for group B was 135.75±13.21mmHg, for group C was 137.67±15.9mmHg and for spine group was 121.9±9.88mmHg and this difference was statistically significant.

At the time of discharge the mean systolic blood pressure 123.28mmHg with a standard deviation of 14.01mmHg for group A, for group B it was 132.33±13.3mmHg, for group C was 130.33±16.36mmHg and for the control group it was 119.4±16.5mmHg and the difference between groups was comparable.

3.2.2 DIASTOLIC BLOOD PRESSURE

TABLE 6: THE COMPARISON OF THE MEAN DIASTOLIC BLOOD PRESSURE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND DISCHARGE PERIOD.

Variable	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (mm Hg) (Mean ±SD)	77.76±8.54	83.00 ±12.77	79.56 ±10.57	76.10 ± 14.82	0.47
24- hours postoperative(mm Hg) (Mean ±SD)	76.88±10.98	78.00 ±12.13	70.67 ±15.27	72.20 ±11.56	0.39
At Discharge(mm Hg) (Mean ±SD)	75.36±11.69	77.25 ±10.85	77.56±9.00	71.70±8.89	0.59

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

The mean Diastolic blood pressure in Group A preoperatively was 77.6 mm Hg with a standard deviation of 8.54 mm Hg, in Group B the diastolic blood pressure was 83± 12.77 mmHg and for Group C was 79.56 ± 10.57 mmHg and for the control group of spine patients was 76.1±14.8 mmHg and this difference was comparable between groups.

In the postoperative 24 hrs. the mean diastolic blood pressure for group A 76.88mmHg with a standard deviation of 10.98 mmHg, for group B was 78 ±12.1mmHg, for group C was 70.67 ±15.27 mmHg and for spine group was 72.2±11.56 mmHg and this difference was comparable between groups.

At the time of discharge the mean diastolic blood pressure was 75.36 mmHg with a standard deviation of 11.69 mmHg for group A, for group B it was 77.25 ±10.85mmHg, for group C was 77.56 ±9.0 mmHg and for the control group it was 71.7±8.89 mmHg and the difference between groups were comparable to each other.

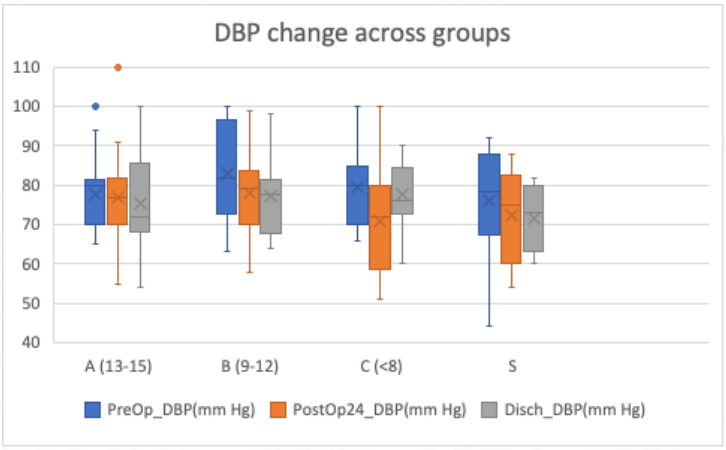


FIGURE 27: THE VARIATION IN DIASTOLIC BLOOD PRESSURE IN DIFFERENT GROUPS FROM PREOPERATIVE, POSTOPERATIVE 24 HOURS AND AT THE TIME OF DISCHARGE

3.2.3 MEAN ARTERIAL PRESSURE (MAP)

TABLE 7: THE COMPARISON OF THE MEAN BLOOD PRESSURE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND DISCHARGE PERIOD.

Variables	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (mm Hg) (Mean ±SD)	92.63 ±10.54	102.27 ±11.91	101.07±12.01	90.96±13.79	0.038
24- hours postoperative (mm Hg) (Mean ±SD)	91.91 ±11.26	97.24 ±11.43	93.00±14.07	88.76 ±10.0	0.382
At Discharge (mm Hg) (Mean ±SD)	91.33±10.98	94.22 ±9.44	95.14 ±10.51	87.60 ±7.98	0.339

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

The mean arterial pressure in Group A preoperatively was 92.63 mm Hg with a standard deviation of 10.54 mm Hg, in Group B the mean arterial pressure was 102.27 ± 11.91 mmHg and for Group C was 101.07 ± 13.79 mmHg and for the control group of the spine, patients was 90.96 ±13,79 mmHg and the difference were statistically significant.

In the postoperative 24 hrs. the mean arterial pressure for group A 91.91 mmHg with a standard deviation of 11.26 mmHg, for group B was 97.24 ±11.43 mmHg, for group C was 93 ±14.07mmHg and for spine group was 88.76 ±10.02 mmHg and this difference was comparable between groups.

At the time of discharge, the mean arterial pressure was 91.33 mmHg with a standard deviation of 10.98 mmHg for group A, for group B it was 94.22 ± 9.44 mmHg, for group C was 95.14± 10.51mmHg and the control group it was 87.6 ±7.98 mmHg and the difference between groups was comparable to each other.

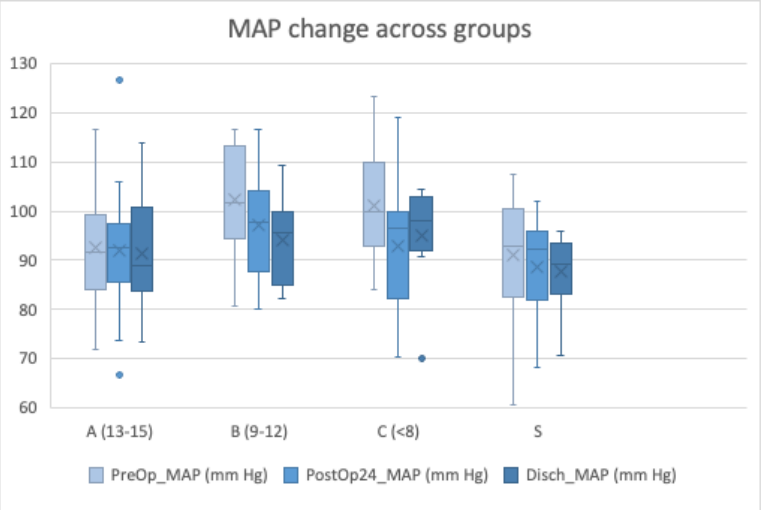


FIGURE28: THE VARIATION IN MEAN ARTERIAL PRESSURE IN DIFFERENT GROUPS FROM PREOPERATIVE, POSTOPERATIVE 24 HOURS AND AT THE TIME OF DISCHARGE.

3.3 RESPIRATORY RATE

TABLE 8: THE COMPARISON OF THE MEAN RESPIRATORY RATE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND AT DISCHARGE TIME

	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (bpm) (Mean ±SD)	16.72±1.54	18.08±1.67	24.11±7.8	17.30±1.94	<0.001
24- hours postoperative(bpm) (Mean ±SD)	16.84±2.52	17.58±1.97	14.78±2.10	17.00±2.00	0.046
At Discharge(bpm) (Mean ±SD)	16.56±1.96	17.75±2.56	16.89±3.21	16.00 ±.94	0.295

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

Comparing the mean respiratory rate, the preoperative respiratory rate in group A was 16.72 breath/min with a standard deviation of 1.54 breaths/min, in group B it was 18.08±1.67 breaths/min, in group C it was 24.11±7.83 breaths/min and in the control group it was 17.3±1.94 breaths/min and the difference was statistically significant.

In the postoperative 24hrs, the mean respiratory rate was 16.84±2.52 breaths/min, in group B was 17.58±1.97 breaths/min, while in group C was 14.78±2.1 breaths/min and in the control group of spine patients it was 17±2 breaths/min and the difference between groups were statistically significant.

At the time of discharge the mean respiratory rate in group A was 16.56±1.96 breaths/min, while in group B was 17.75±2.56 breaths/min, in group C was

16.89±3.21 and in the spine group was 16±0.94 breaths/min and the groups were comparable with each other.

3.4 ARTERIAL OXYGEN SATURATION

TABLE 9: THE COMPARISON OF THE MEAN SPO2 BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND AT DISCHARGE TIME.

Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative SpO2(%) (Mean ±SD)	100 ±.00	98.92±1.379	99.78±.084	100±.00	0.155
PostOperative24 SpO2(%) (Mean ±SD)	100.00±.00	99.67±.65	100.00.00	100.00±.00	0.094
Discharge SpO2 (%) (Mean ±SD)	100.00±.00	99.92±.28	100.00±.00	100.00±.00	0.305

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05considered significant)

Comparing the mean saturation, the preoperative saturation in group A was 100 %with a standard deviation of 0 %, in group B it was 98.91±1.37 %, in group C it was 99.78 ±0.08%and in the control group it was 100±0 % and the groups were comparable with each other.

In the postoperative 24hrs, the mean saturation was 100±0 %, in group B was 99.67±0.65 %, while in group C was 100 ±0. % And in the control group of spine patients it was 100±0 % and the groups were comparable with each other.

At the time of discharge the mean saturation in group A was 100±0 %while in group B was 99.92±0.28 %, in group C was 100 ±0 % and in the spine group was 100±0 %and the groups were comparable with each other.

4. TCD MEASUREMENTS

4.1.1 MEAN FLOW VELOCITY -RIGHT SIDE

TABLE 10: THE COMPARISON OF THE MEAN FLOW VELOCITY ON RIGHT SIDE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND AT DISCHARGE TIME PERIOD.

Time period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative MFV(cm/sec) (Mean ±SD)	37.50±13.74	30.26±12.00	26.31±8.10	42.18±13.24	0.024
Postop24 Hrs MFV (cm/sec) (Mean ±SD)	43.29±16.45	40.11±28.67	50.57±18.82	40.02±11.44	0.602
Discharge MFV (cm/sec) (Mean ±SD)	39.73±15.25	36.12±11.15	37.25±19.29	47.52±16.36	0.340

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean flow velocity, in the preoperative period in group A was 37.50cm/sec with a standard deviation of 13.74cm/sec, in group B it was reduced to 30.26±12cm/sec, in group C further decreased to 26.31 ± 8.10cm/sec and in the control group it was 42.18±13.24 cm/sec and the difference between groups were statistically significant.

In the postoperative 24hrs, the mean flow velocity was 43.29±16.45 cm/sec, in group B was 40.11± 28.67cm/sec, while in group C was 50.57 ±18.82 cm/sec and in the control group of spine patients, it was 40.02 ±11.44cm/sec and the groups were comparable with each other.

At the time of discharge the mean flow velocity in group A was 39.73±15.25cm/sec while in group B was 36.12 ±11.15 cm/sec, in group C was 37.25 ±19.29cm/sec and in the spine group was 47.52 ±16.36cm/sec and the groups were comparable with each other.

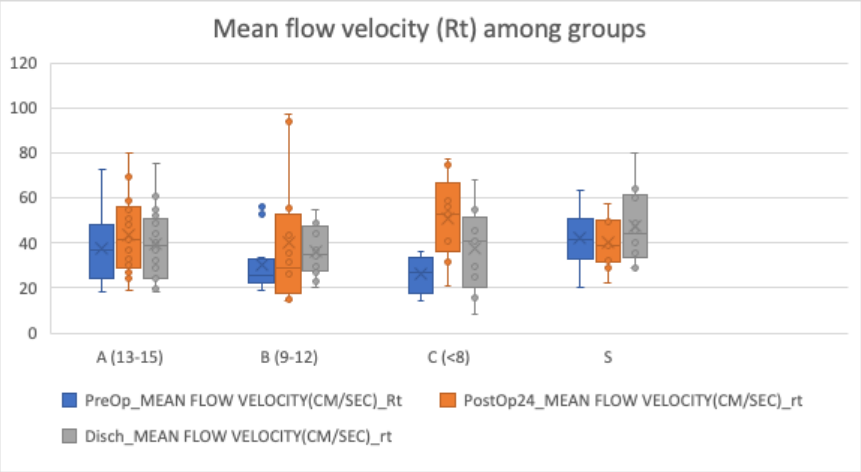


FIGURE 29: SHOWING THE VARIATION IN MEAN FLOW VELOCITY IN DIFFERENT GROUPS FROM PREOPERATIVE, POSTOPERATIVE 24 HOURS AND AT THE TIME OF DISCHARGE.

4.1.2 MEAN FLOW VELOCITY-LEFT SIDE

TABLE11: THE COMPARISON OF THE MEAN FLOW VELOCITY ON LEFT SIDE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, 24 HOURS POSTOPERATIVE AND AT DISCHARGE TIME PERIOD.

Time period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative MFV (cm/sec) (Mean ±SD)	35.97±13.32	33.59±12.99	28.07±7.34	47.21±14.27	0.014
Postop24Hrs MFV(cm/sec) (Mean ±SD)	40.46±19.01	45.60±22.60	47.25±28.17	34.74±14.02	0.533
Discharge MFV (cm/sec) (Mean ±SD)	48.82±28.78	46.64±17.10	47.00±24.82	40.12±15.67	0.818

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant.)

Comparing the mean flow velocity, in the preoperative period in group A was 35.97 cm/sec with a standard deviation of 13.32 cm/sec, in group B it was reduced to 33.59 ±12.99 cm/sec, in group C further decreased to 28.07 ± 7.34cm/sec and in the control group it was 47.21±14.27 cm/sec and the difference between groups were statistically significant.

In the postoperative 24hrs, the mean flow velocity was 40.46±19.01 cm/sec, in group B was 45.60 ± 22.60 cm/sec, while in group C was 47.25±28.17 cm/sec and in the control group of spine patients, it was 34.74 ±14.02 cm/sec and the groups were comparable with each other.

At the time of discharge the mean flow velocity in group A was 48.82 ± 28.78 cm/sec while in group B was 46.64 ±17.10 cm/sec, in group C was 47.00±24.82cm/sec and in the spine, group was 40.12 ±15.67 cm/sec and the groups were comparable with each other.

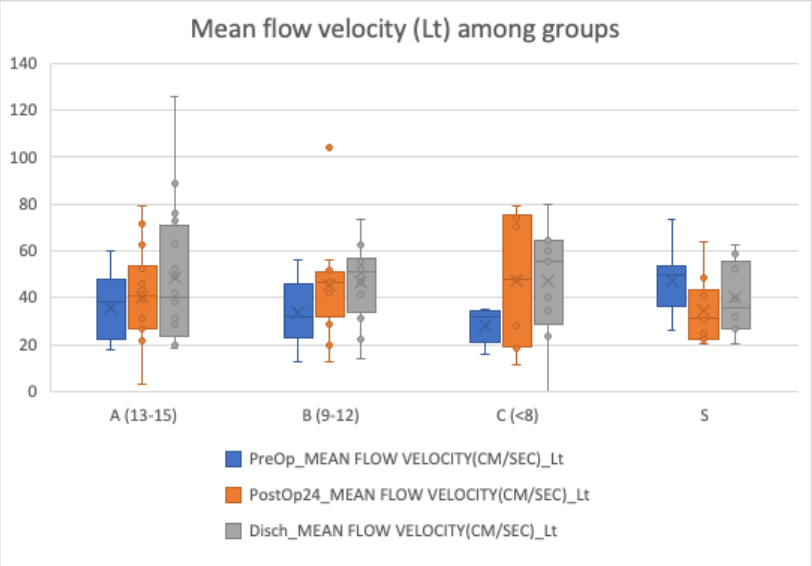


FIGURE30: THE VARIATION IN MEAN FLOW VELOCITY ON THE LEFT SIDE IN DIFFERENT GROUPS FROM PREOPERATIVE, POSTOPERATIVE 24 HOURS AND AT THE TIME OF DISCHARGE.

4.2 .1 PULSATILITY INDEX- RIGHT SIDE

TABLE 12: THE COMPARISON OF PULSATILITY INDEX VALUES IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (Mean ±SD)	.97±.29	1.26±.47	1.31±.47	.91±.19	0.016
Postop24 hrs (Mean ±SD)	1.12±.33	1.17±.27	.69±.17	.64±.06	0.901
Discharge (Mean ±SD)	1.14±.30	1.13±.38	1.44±.80	.99±.19	0.143

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean pulsatility index between different groups, In the preoperative period in Group A the mean PI was 0.97 with a standard deviation of 0.29, while in group B was 1.26 ±0.47, group C was 1.31±.47 and in the control group was 0.911 ± 0.19. The difference was statistically significant.

In the postoperative 24hrs, the mean PI value in group A was 1.124 ± 0.33, in group B was 1.17 ±0.27 while in group C was 0.69±0.17 and in the control group of spine patients it was 0.64 ± 0.06 and the groups were comparable with each other.

At the time of discharge, the mean PI value in group A was 1.14 ± 0.30, in group B was 1.13 ±0.38 while in group C was 1.44 ±0.80 and in the control group of spine patients it was 0.99 ± 0.19 and the groups were comparable with each other.

4.2.2 PULSATILITY INDEX- LEFT SIDE

TABLE 13: THE COMPARISON OF PULSATILITY INDEX VALUES IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (Mean ±SD)	.94±.29	1.23±.47	1.34±.47	.94±.19	0.007
Postop24 hrs (Mean ±SD)	1.10±.36	1.27±.33	1.02±.36	.99±.21	0.227
Discharge (Mean ±SD)	1.02±.18	1.11±.31	1.03±.49	1.06±.34	0.905

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean pulsatility index between different groups, In the preoperative period in Group A the mean PI was 0.94 with a standard deviation of 0.29, while in group B was 1.23 ±0.47, group C was 1.34 ±0.47 and in the control group was 0.945± 0.19. The difference was statistically significant.

In the postoperative 24hrs, the mean PI value in group A was 1.10 ± 0.36, in group B was 1.27 ±0.33 while in group C was 1.02±0.36and in the control group of spine patients it was 0.99 ± 0.21 and the groups were comparable with each other.

At the time of discharge, the mean PI value in group A was 1.02 ± 0.18, in group B was 1.11 ±0.31 while in group C was 1.03 ±0.49 and in the control group of spine patients it was 1.06 ± 0.34 and the groups were comparable with each other.

4.3.1RESISTIVITY INDEX -RIGHT SIDE

TABLE 14 : THE COMPARISON OF RESISTIVITY INDEX VALUES IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP ON RIGHT SIDE FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (Mean ±SD)	.59±.09	.67±.09	.70±.09	.57±.07	0.002
Postop24 hrs (Mean ±SD)	.59±.15	.59±.12	.64±.09	.64±.06	0.666
Discharge (Mean ±SD)	.64±.12	.52±.20	.68±14	.59±.06	0.073

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean resistivity index between different groups, In the preoperative period in Group A the mean PI was 0.59 with a standard deviation of 0.09, while in group B was .67 ±0.09 group C was 0.70±0.09 and in the control group was 0.57 ± 0.07.The difference was statistically significant.

In the postoperative 24hrs, the mean RI value in group A was 0.59± 0.15, in group B was 0.59 ±0.15 while in group C was 0.64 ±0.09 and in the control group of spine patients it was 0.64 ± 0.06 and the groups were comparable with each other.

At the time of discharge, the mean RI value in group A was 0.64 ± 0.12, in group B was 0.52±0.20 while in group C was 0.68±0.14 and in the control group of spine patients it was 0.59 ± 0.06 and the groups were comparable with each other.

4.3.2 RESISTIVITY INDEX -LEFT SIDE

TABLE 15: THE COMPARISON OF RESISTIVITY INDEX VALUES IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP ON LEFT SIDE FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative (Mean ±SD)	.56±.11	.67±.06	.68±.12	.58±.09	0.007
Postop24 hrs (Mean ±SD)	.55±.33	.65±.16	.56±.11	.56±.10	0.703
Discharge (Mean ±SD)	.61±09	.61±.14	.53±.21	.60±.08	0.549

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean resistivity index between different groups, In the preoperative period in Group A the mean PI was 0.56 with a standard deviation of 0.11, while in group B was .67±0.06 group C was 0.68 ±0.12 and in the control group was 0.588 ± 0.09 .The difference was statistically significant.

In the postoperative 24hrs, the mean RI value in group A was 0.55 ± 0.33, in group B was 0.65 ±0.16 while in group C was 0.56 ±0.11 and in the control group of spine patients it was 0.56 ± 0.10 and the groups were comparable with each other.

At the time of discharge, the mean RI value in group A was 0.61± 0.09, in group B was 0.61 ±0.14 while in group C was 0.53±0.21 and in the control group of spine patients it was 0.60 ± 0.08 and the groups were comparable with each other.

4.4.1 PULSE VELOCITY VARIATION -RIGHT SIDE

TABLE 16: THE COMPARISON OF PULSE VELOCITY VARIATION VALUES ON THE RIGHT SIDE IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative PVV(%) (Mean ±SD)	5.51±2.54	5.35±1.81	6.15±3.87	2.34±1.95	0.007
Postop24 hrs PVV(%) (Mean ±SD)	3.55±2.23	4.92±3.07	3.27±1.85	2.27±1.15	0.062
Discharge PVV(%) (Mean ±SD)	3.10±2.60	3.43±2.33	4.48±3.00	2.26±1.31	0.264

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean pulse velocity variation between different groups, In the preoperative period in Group A the mean PVV was 5.51% with a standard deviation of 2.54%, while in group B was 5.35±1.81%, group C was 6.15 ± 3.87% and in the control group was 2.34 ± 1.95. The difference between groups were statistically significant.

In the postoperative 24hrs, the mean PVV value in group A was 3.55 ± 2.23%, in group B was 4.92 ±3.07 % while in group C was 3.27 % ± 1.85 % and in the control group of spine patients, it was 2.27% ± 1.15 %and the groups were comparable to each other.

At the time of discharge, the mean PVV value in group A was 3.10 ± 2.60%, in group B was 3.43 ± 2.33% while in group C was 4.48 ± 3% and in the control group was 2.26 ± 1.31% and the groups were comparable to each other.

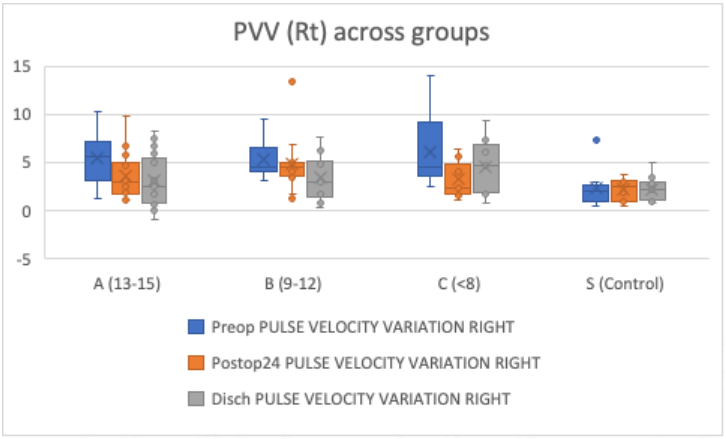


FIGURE31: THE VARIATION OF PVV VALUES ON THE RIGHT SIDE IN DIFFERENT GCS GROUPS AND CONTROL GROUPS FROM PREOPERATIVE TO DISCHARGE.

4.4.2 PULSE VELOCITY VARIATION -LEFT SIDE

TABLE 17: THE COMPARISON OF PULSE VELOCITY VARIATION VALUES ON THE LEFT SIDE IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative PVV(%) (Mean ±SD)	4.78±3.37	5.31±1.99	6.41±4.21	2.16±2.27	0.027
Postop24 hrs PVV(%) (Mean ±SD)	3.63±2.19	3.26±1.86	5.87±4.56	2.00±1.47	0.019
Discharge PVV(%) (Mean ±SD)	4.21±3.10	2.59±2.78	1.84±.94	1.82±1.13	0.035

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean pulse velocity variation on the left side between different groups, In the preoperative period in Group A the mean PVV was 4.78 % with a

standard deviation of 3.37 %, while in group B was 5.31±1.99 %, group C was 6.41 ± 4.21 % and in the control group was 2.16 ± 2.27% and the difference between groups was statistically significant.

In the postoperative 24hrs, the mean PVV value in group A was 3.63 ± 2.19 %, in group B was 3.26 ±1.86 % while in group C was 5.87 % ± 4.56 % and in the control group of spine patients, it was 2 % ± 1.47 % and the difference between groups were statistically significant.

At the time of discharge, the mean PVV value in group A was 4.21 ± 3.10 %, in group B was 2.59 ± 2.78 % while in group C was 1.84 ± 0.94% and in the control group was 1.82 ± 1.13% and the difference between groups was statistically significant.

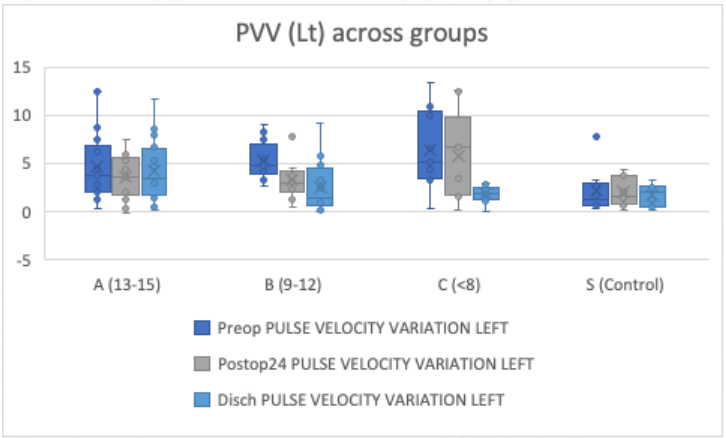


FIGURE 32: THE VARIATION OF PVV VALUES ON THE LEFT SIDE IN DIFFERENT GCS GROUPS AND CONTROL GROUPS FROM PREOPERATIVE TO DISCHARGE.

4.5.1 SYSTOLIC VELOCITY VARIATION-RIGHT

TABLE18: THE COMPARISON OF SYSTOLIC VELOCITY VARIATION VALUES ON THE RIGHT SIDE IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative SVV(%) (Mean ±SD)	9.68±3.85	11.48±6.92	9.67±3.79	8.60±3.91	0.534
Postop24 hrs SVV(%) (Mean ±SD)	9.00±5.70	9.15±5.23	10.97±5.15	5.75±2.12	0.159
Discharge SVV(%) (Mean ±SD)	7.92±4.32	6.60±3.19	11.69±3.47	4.34±1.50	0.001

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean systolic velocity variation on the right side between different groups, In the preoperative period in Group A the mean SVV was 9.68% with a standard deviation of 3.85 %, while in group B was 11.48±6.92%, group C was 9.67 ± 3.79% and in the control, group was 8.60 ±3.91% and the difference between groups was comparable to each other.

In the postoperative 24 hrs, the mean SVV value in group A was 9 ± 5.70%, in group B was 9.15 ±5.23 % while in group C was10.97 % ± 5.15 % and in the control group of spine patients, it was 5.75% ± 2.12 %and the difference between groups were comparable to each other.

At the time of discharge, the mean SVV value in group A was 7.92 ± 4.32%, in group B was 6.60 ± 3.19% while in group C was 11.69 ± 3.47% and in the control group was 4.34 ± 1.50%. The difference between groups was statistically significant.

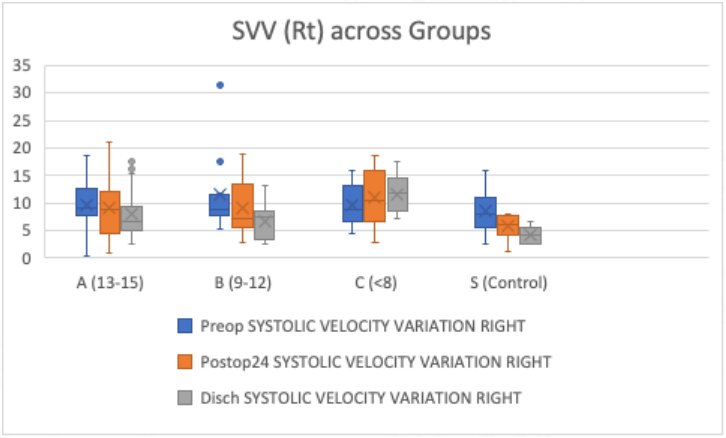


FIGURE 33: THE VARIATION OF SVV VALUES ON THE RIGHT SIDE IN DIFFERENT GCS GROUPS AND CONTROL GROUPS FROM PREOPERATIVE TO DISCHARGE.

4.5.2 SYSTOLIC VELOCITY VARIATION-LEFT

TABLE 19: THE COMPARISON OF SYSTOLIC VELOCITY VARIATION VALUES ON THE LEFT SIDE IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP FROM THE PREOPERATIVE PERIOD TO POSTOPERATIVE 24 HRS AND AT THE TIME OF DISCHARGE.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative SVV(%) (Mean ±SD)	6.86±2.08	10.67±3.68	8.80±5.64	5.74±3.47	0.008
Postop24 hrs SVV(%) (Mean ±SD)	8.37±4.59	9.04±3.30	10.95±6.49	6.23±2.82	0.153
Discharge SVV(%) (Mean ±SD)	8.51±3.94	6.77±3.69	9.10±5.83	5.60±4.02	0.217

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

Comparing the mean systolic velocity variation on the left side between different groups, In the preoperative period in Group A the mean SVV was 6.86% with a standard deviation of 2.08 %, while in group B was 10.67 ±3.68%, group C was 8.80 ± 5.64% and in the control group was 5.74 ±3.47% and the difference between groups was statistically significant.

In the postoperative 24 hrs, the mean SVV value in group A was 8.37 ± 4.59%, in group B was 9.04 ±3.30 % while in group C was 10.95 % ± 6.49 % and in the control group of spine patients, it was 6.23% ± 2.82%and the difference between groups were comparable to each other.

At the time of discharge, the mean SVV value in group A was 8.51 ±3.94 %, in group B was 6.77 ± 3.69% while in group C was 9.10 ± 5.83% and in the control group was 5.60 ± 4.02% and the difference between groups was comparable to each other.

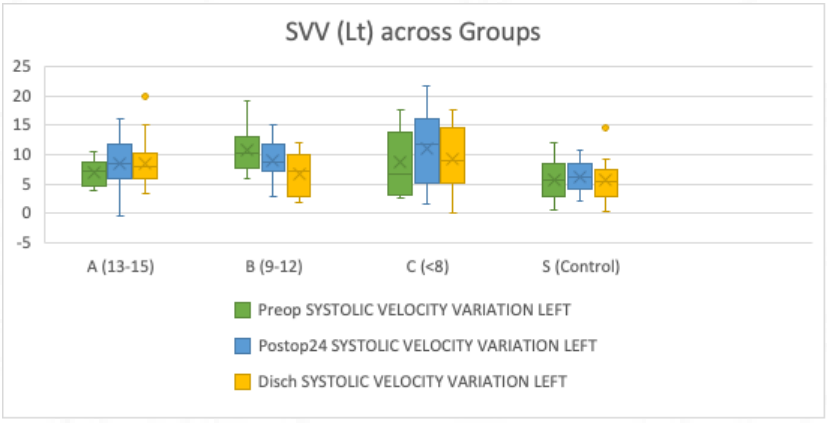


FIGURE 34: THE VARIATION OF SVV VALUES ON THE LEFT SIDE IN DIFFERENT GCS GROUPS AND CONTROL GROUPS FROM PREOPERATIVE TO THE TIME OF DISCHARGE.

5. NIRS MEASUREMENTS

5.1 NIRS -RIGHT SIDE

TABLE 20: THE COMPARISON OF THE NIRS VALUES ON THE RIGHT SIDE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, AND 24 HOURS POSTOPERATIVE AND AT DISCHARGE PERIOD.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preoperative(%) Mean ± SD	66.84±6.40	67.75±4.02	71.89±4.98	72.10±5.68	0.031
Postop24 Hrs(%) Mean ±SD	69.96±8.42	66.58±4.71	70.44±7.03	66.60±4.14	0.340
Discharge (%) Mean ±SD	69.44±5.99	68.17±3.48	71.22±4.41	70.90±5.52	0.504

Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant

Comparing the mean NIRS values, the preoperative NIRS value in group A was 66.84 % with a standard deviation of 6.40 %, in group B it was 67.75 ±4.02 %, in group C it was 71.89 ±4.98 %and in the control group it was 72.1± 5.68 % and there was a statistically significant difference between groups.

In the postoperative 24hrs, the mean NIRS value was 69.96 ± 8.42 %, in group B was 66.58 ±4.71 %, while in group C was 70.44 ±7.03 % and in the control group of spine patients it was 66.6 ±4.12 % and the groups were comparable with each other.

At the time of discharge the mean NIRS value in group A was 69.44 ± 5.99% while in group B was 68.17 ±3.48 %, in group C was 71.22 ±4.41 % and in the spine group was 70.9 ±5.52 % and the groups were comparable with each other.

5.2 NIRS – LEFT SIDE

TABLE 21:THE COMPARISON OF THE NIRS VALUES ON THE LEFT SIDE BETWEEN DIFFERENT GROUPS IN THE PREOPERATIVE, AND 24 HOURS POSTOPERATIVE AND AT DISCHARGE PERIOD.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
Preop NIRS (%) Mean±SD	68.08±6.52	70.75±2.70	68.33 ±4.77	72.60 ±4.94	0.119
Postop24 hrs NIRS (%) Mean±SD	68.88±6.76	70.08±5.07	67.11±3.44	67.70±5.07	0.636
Discharge NIRS (%) Mean±SD	68.96±5.39	72.17±4.80	70.78±4.79	68.90±2.88	0.242

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

Comparing the mean NIRS values, the preoperative NIRS value in group A was 68.08 % with a standard deviation of 6.52 %, in group B it was 70.75 ±2.7 %, in group C it was 68.33 ±4.94 %and in the control group it was 72.6± 4.94 % and the groups were comparable to each other.

In the postoperative 24hrs, the mean NIRS value was 68.88 ± 6.76 %, in group B was 70.08 ±5.07 %, while in group C was 67.11 ±3.44% and in the control group of spine patients it was67.70 ±5.07% and the groups were comparable with each other.

At the time of discharge the mean NIRS value in group A was 68.96 ± 5.39%while in group B was 72.17 ±4.80%, in group C was 70.78 ±4.79 % and in the spine group was 68.9 ±2.88 % and the groups were comparable with each other.

6. ONSD MEASUREMENTS

6.1 .1 ONSD -RIGHT SIDE -PREOPERATIVE

TABLE 22: THE ONSD VALUES ON THE RIGHT SIDE IN THE PREOPERATIVE PERIOD IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP

Time	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
PREOP ONSD_RE(mm) (Mean ±SD)	4.72±.53	5.26±.42	5.33±.50	4.02±51	<0.001

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

On comparing the ONSD values of the right eye in different groups in the preoperative, group A had a mean right ONSD value of 4.72 mm with a standard deviation of 0.53mm. while group B was 5.26±0.42mm, group C was 5.33 ±0.50mm and the control group was 4.02± 0.51mm. The difference was statistically significant.

6.1.2 ONSD -LEFT SIDE PREOPERATIVE

TABLE 23: COMPARING THE ONSD VALUES ON THE LEFT SIDE IN THE PREOPERATIVE PERIOD IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP

Time	GROUPS				
	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
PREOP ONSD_LE(mm) (Mean ±SD)	4.81±.60	5.17±.32	5.08±.46	4.28±.41	0.001

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

On comparing the ONSD values of the left eye in different groups, group A had a mean right ONSD value of 4.81mm with a standard deviation of 0.60 mm.

while group B was 5.17±0.32 mm, group C was 5.08±0.46mm and the control group was 4.28 ± 0.41 mm. The difference was statistically significant.

6.2.1 ONSD -RIGHT SIDE -POST OPERATIVE

TABLE 24: ONSD VALUES ON THE RIGHT SIDE IN THE POST OPERATIVE PERIOD IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP

Variable					
	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
POST OP ONSD RE(mm) (Mean ±SD)	4.59±.52	5.12±.43	4.86±.31	3.98±.49	<0.001

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

On comparing the ONSD values of the right eye in different groups in the postoperative period, group A had a mean right ONSD value of 4.59mm with a standard deviation of 0.52 mm. while group B was 5.12 ±0.43mm, group C was 4.86 ±0.31 mm and the control group was 3.98 ± 0.49 mm. The difference was statistically significant.

6.2.2 ONSD -LEFT SIDE POST OPERATIVE

TABLE 25: COMPARING THE ONSD VALUES ON THE LEFT SIDE IN THE POST-OPERATIVE PERIOD IN DIFFERENT GCS GROUPS AND THE CONTROL GROUP

Variables	GCS Group				
	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
POSTOP ONSD_LE(mm) (Mean ±SD)	4.78±.55	4.97±.44	4.79±.35	4.24±.40	0.007

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

On comparing the ONSD values of the left eye in different groups in the postoperative period, group A had a mean right ONSD value of 4.78 mm with a standard deviation of 0.55 mm. while group B was 4.97 ±0.446 mm, group C was 4.79±0.35 mm and the control group was 4.24± 0.40mm.The difference was statistically significant.

6.3.1ONSD RIGHT EYE PREOPERATIVE VS POSTOPERATIVE

TABLE 26: THE COMPARISON OF PREOPERATIVE VS POSTOPERATIVE ONSD VALUES ON RIGHT SIDE IN DIFFERENT GCS GROUPS.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
PREOP ONSD_RE(mm) (Mean ±SD)	4.72±.53	5.26±.42	5.33±.50	4.02±.51	<0.001
POST OP ONSD RE (mm) (Mean ±SD)	4.59±.52	5.12±.43	4.86±.31	3.98±.49	

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, p<0.05 considered significant)

On comparing the mean ONSD value of the right side, in group A preoperatively the value was 4.72 mm with a standard deviation of 0.53 mm, in the same group in the postoperative period the mean ONSD value was 4.59mm with a standard deviation of 0. 52mm.In group B the mean preoperative ONSD value on right side was 5.26±0.42mm and in the postoperative period the mean ONSD was 5.12±0.43mm.In group C, the mean preoperative ONSD value on the right side was 5.33 ±0.50 mm; in the postoperative period, the mean ONSD was 4.86 ±0.31 mm. In the spine group spine the mean preoperative ONSD value on the right side was 4.028 ±0.51 mm and in the postoperative period, the mean ONSD was 3.98 ±0.49 mm. The difference was statistically significant.

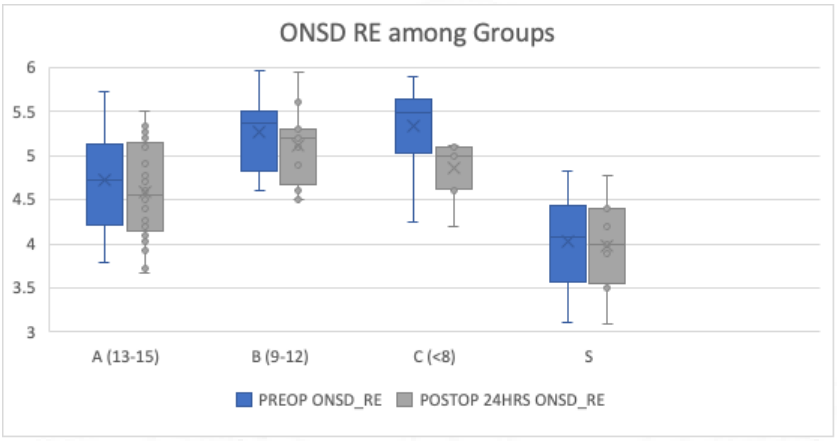


FIGURE 35: THE COMPARISON OF PREOPERATIVE VS POSTOPERATIVE ONSD VALUES ON THE RIGHT SIDE IN DIFFERENT GCS GROUPS.

6.3.2 ONSD LEFT EYE PREOPERATIVE VS POSTOPERATIVE

TABLE 27: THE COMPARISON OF PREOPERATIVE VS POSTOPERATIVE ONSD VALUES ON THE LEFT SIDE EYE IN DIFFERENT GCS GROUPS.

Time Period	Group A (n=25)	Group B (n= 12)	Group C (n=9)	Group S (n=10)	p value
PREOP ONSD_LE (mm) (Mean ±SD)	4.81±.60	5.17±.32	5.08±.46	4.28±.41	<0.001
POST OP ONSD LE (mm) (Mean ±SD)	4.78±.55	4.97±.44	4.79±.35	4.24±.40	

(Group A=GCS 13-15, Group B=GCS 9-12. Group C=GCS <8, Group S=Spine group, repeated measures of ANOVA, $p<0.05$ considered significant)

On comparing the mean ONSD value of the left side, in group A preoperatively the value was 4.81 mm with a standard deviation of 0.60 mm, in the same group in

the postoperative period the mean ONSD value was 4.78 mm with a standard deviation of 0.55mm.In group B, the mean preoperative ONSD value on the left side was 5.17±0.32mm; in the postoperative period, the mean ONSD was 4.97 ±0.44mm.In group C, the mean preoperative ONSD value on the left side was 5.08 ±0.46 mm; in the postoperative period, the mean ONSD was 4.79 ±0.35 mm.

In the spine group spine the mean preoperative ONSD value on the left side was 4.28 ±0.41 mm and in the postoperative period, the mean ONSD was 4.24 ±0.40 mm. The difference was statistically significant.

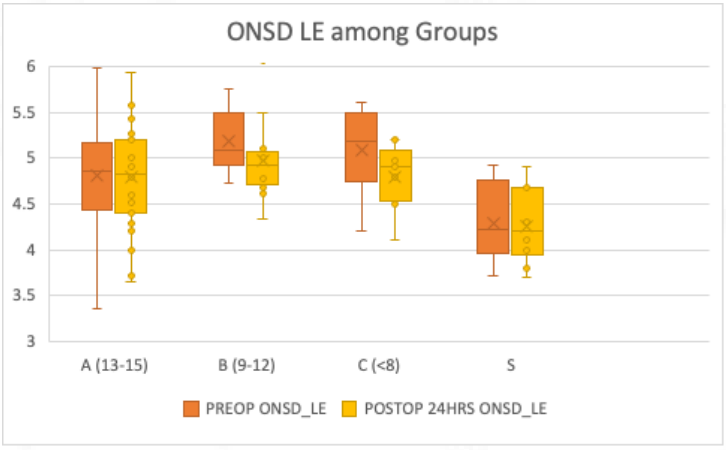
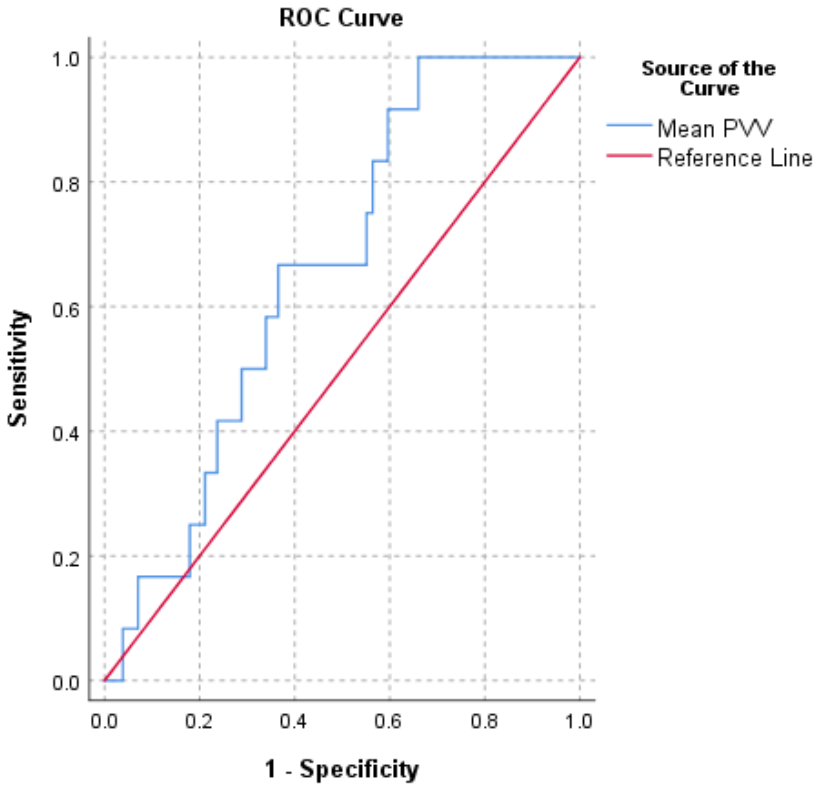


FIGURE 36: THE COMPARISON OF PREOPERATIVE VS POSTOPERATIVE ONSD VALUES ON THE LEFT SIDE IN DIFFERENT GCS GROUPS.

7. CORRELATION OF PVV

7.1 Correlation between Pulse velocity variation (PVV) and Glasgow outcome score (GOS)



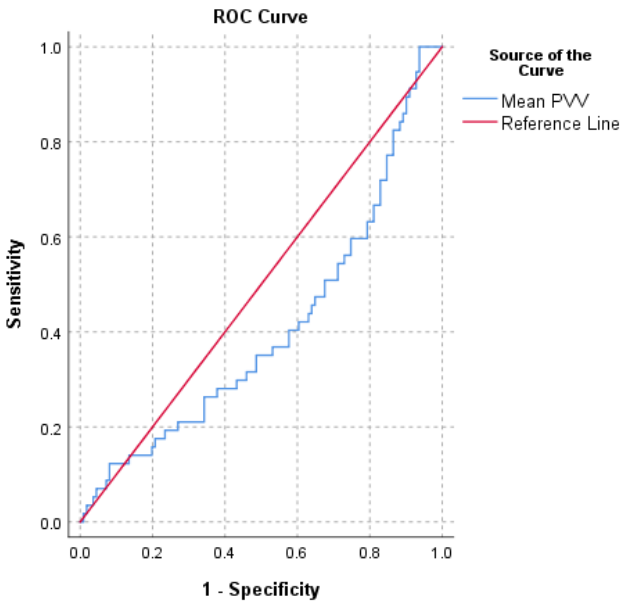
Area Under the ROC Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Mean PVV	.658	.064	.014	.533	.784
a. Under the nonparametric assumption					
b. Null hypothesis: true area = 0.5					

Diagnostic accuracy = 65.8% (p value = 0.014)
Cut off : Mean PVV = 2.5 (Sen 91.7%, Sp 34%)

FIGURE 37 : ROC FOR CORRELATION BETWEEN PVV AND GOS

After doing the ROC analysis, a correlation was found between the PVV value and the GOS score. When the GOS was dichotomized into a good outcome and a poor outcome. mean PVV value of 2.5% gave a predictive value with a sensitivity of 91.7% and specificity of 34%. With a value of less than 2.5% predicting good outcomes and a value of more than 2.5% predicting poor outcomes in different patients. This test had a diagnostic accuracy of 65.8% with a 95% confidence interval from 53.3% to 78.4% with a p-value of 0.014.

7.2 Correlation between Pulse velocity variation(PVV) and Glasgow coma score (GCS)



Area Under the ROC Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Mean PVV	.406	.047	.084	.313	.499
a. Under the nonparametric assumption					
b. Null hypothesis: true area = 0.5					

FIGURE 38: ROC SHOWING CORRELATION BETWEEN PVV AND GCS

After doing the ROC analysis, no correlation was found between the PVV value and the GCS score, with a diagnostic accuracy of 40.6% with a 95% confidence interval of 31.3% to 49.9% and was not statistically significant.

7.3 ONSD VS PVV CORRELATION

TABLE 28: RELATIONSHIP BETWEEN MEAN PVV WITH RESPECT TO ONSD CUT-OFF OF 5MM.

ONSD	<5 mm	>5 mm	p value
Pulse velocity variation Mean PVV(%) (Mean ±SD)	3.62±2.13	4.59±2.12	<0.001

For ONSD cut-off of less than 5 mm the mean PVV Value was 3.62% with a standard deviation of 2.13%, while for ONSD values more than 5mm the mean PVV value was 4.59 ± 2.12%. The difference between groups was statistically significant.

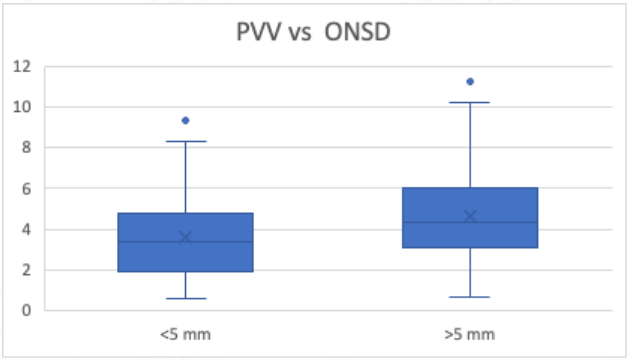
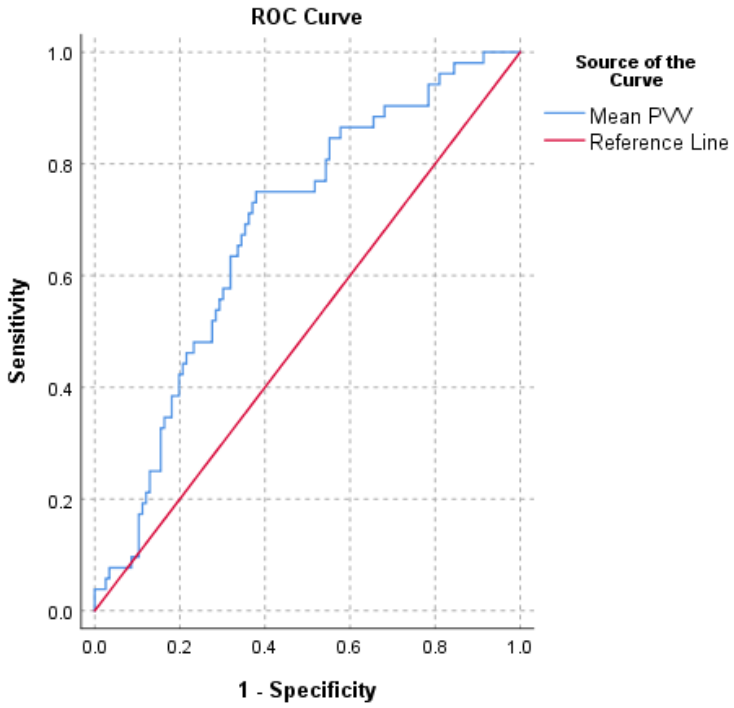


FIGURE 39 : SHOWING THE VARIATION IN PVV WITH RESPECT TO ONSD VALUES OF LESS THAN 5MM AND MORE THAN 5 MM.



Area Under the ROC Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Mean PVV	.682	.043	.000	.598	.766
a. Under the nonparametric assumption					
b. Null hypothesis: true area = 0.5					

FIGURE 40: ROC SHOWING CORRELATION BETWEEN PVV AND ONSD

After doing the ROC analysis, a correlation was found between the PVV value and the ONSD. When the ONSD was dichotomized into a <5mm and >5mm, a mean PVV value of 2.5% gave a predictive value with a sensitivity of 84.6 % and specificity of 42.2 %. This test had a diagnostic accuracy of 68.2 % with a 95% confidence interval from 59.8 % to 76.6 %..

8. PI CORRELATION

8.1 PI and GCS CORRELATION

TABLE 29: RELATIONSHIP BETWEEN PULSATILITY INDEX ON EITHER SIDE WITH GCS DICHOTOMIZED IN TO >8 AND <8.

GCS	>8	<8	p value
PI_Rt(Mean ±SD)	.99±.47	1.11±.34	0.048
PI lt(Mean ±SD)	.92±.42	1.09±.30	0.005

The right side pulsatility index for patients in GCS > 8 was 0.99 with a standard deviation of 0.47 while in patients with GCS <8 the mean PI was 1.11±0.34 and the difference between groups was statistically significant.

The left side pulsatility index for patients in GCS > 8 was 0.92 with a standard deviation of 0.42 while in patients with GCS <8 the mean PI was 1.09±0.30 and the difference between groups were statistically significant.

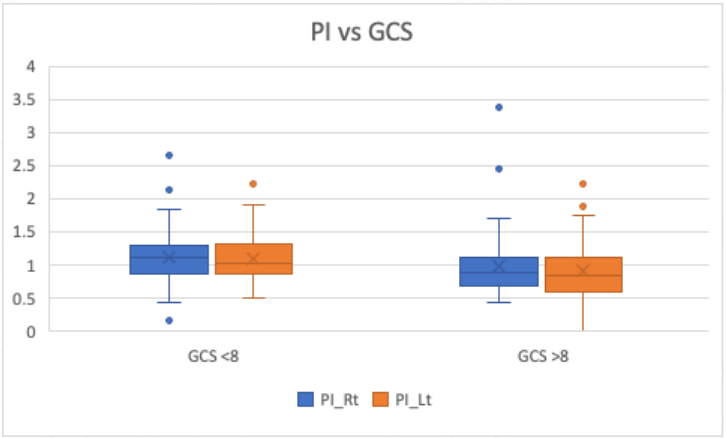


FIGURE 41: THE MEAN PI VALUES IN PATIENTS WITH GCS<8 AND >8.

8.2 PI AND GOS CORRELATION

TABLE 30: SHOWING RELATIONSHIP BETWEEN PULSATILITY INDEX ON EITHER SIDE WITH GOS DICHOTAMISED INTO GOOD AND POOR.

GOS	GOOD	POOR	p value
PIRt(Mean ±SD)	1.05±.33	1.37±.81	0.006
PI Lt(Mean ±SD)	1.02±.33	1.08±.59	0.608

The right side pulsatility index for patients with good GOS was 1.05 with a standard deviation of 0.33 while in patients with poor GOS the mean PI was 1.37 ±0.81 and the difference between groups was statistically significant.

The left side pulsatility index for patients with good GOS was 1.02 with a standard deviation of 0.33 while in patients with poor GOS the mean PI was 1.08 ±0.59 and the difference between groups was comparable to each other.

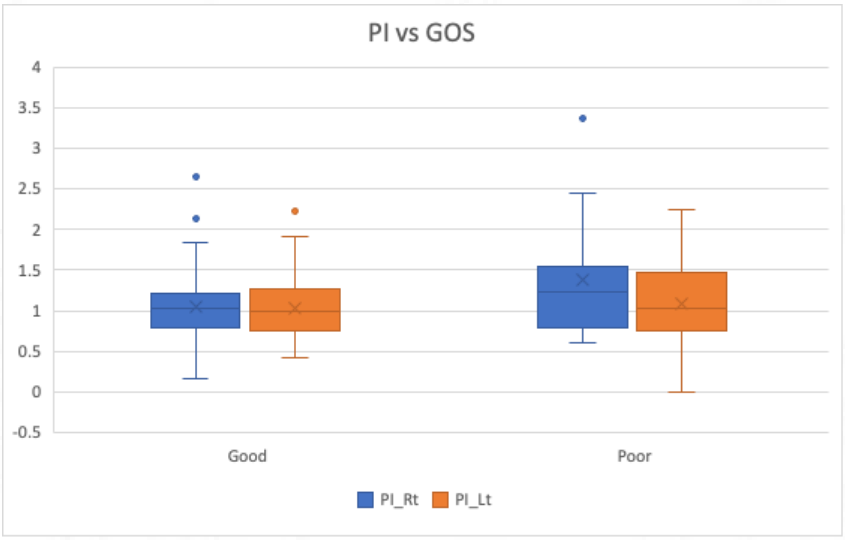


FIGURE 42: THE PULSATILITY INDEX ON RIGHT AND LEFT SIDES IN GOOD AND POOR GOS.

DISCUSSION

7. DISCUSSION

The utility of the Transcranial Doppler has been studied extensively in neurocritical care, especially in conditions like traumatic brain injury (TBI) and subarachnoid haemorrhage (SAH). (42)TCD is now considered to be an important non-invasive neuromonitoring tool to assess cerebral blood flow velocity. Studies have correlated the different measured and derived variables of TCD like Flow velocity (Peak systolic, diastolic and mean), Pulsatility index and resistance index, to assess, and prognosticate the clinical outcome of the patients. (43,44) The TCD waveform resembles the invasive arterial waveform and limited studies have examined the use of waveform analysis for clinical utility. These waveforms are also noted to show variations during respiration similar to the arterial waveform which causes systolic and diastolic flow velocity variations.

Since the cranial contents are placed in the rigid skull and limited capacity for expansion to additional volume, the changes in the flow velocity variation can represent the changes in the compliance of the intracranial system which is proportional to the severity and acute changes in intracranial pressure. The intracranial compliance measurements require the moving correlation between the amplitude of the ICP wave and the mean intracranial pressure which is an invasive technique. We tried to use TCD spectral analysis to derive a measure of intracranial compliance. The literature search did not yield any study done analyzing the TCD spectral waveforms for their velocity variations similar to the pulse pressure waveform of the arterial pressure and also the correlation of these variations in different GCS groups to the clinical outcome of the patients.

We have included patients with different GCS at the time of admission who require neurosurgical procedures to assess the variation in TCD velocity and constructed the systolic and pulse velocity variation along with other TCD indices. A control group was also included consisting of patients undergoing spine surgeries who did not have any intracranial pathology. We used NIRS to monitor cerebral oxygenation and indirect ICP using ONSD measurement. In order to determine the temporal trend in these indices, we also assessed the changes in the aforementioned parameters 24 hours after surgery and at the time of discharge.

The study could be successfully completed in all recruited patients. Based on our data collection, we noted that the systolic flow velocity (SVV) and pulse velocity (PVV) variations were different in different GCS patients. The computed values for the flow velocity variations were different between the control and those with intracranial pathology. We believe that these variations represent the differences in the pressure-volume compliance curve in different groups. Additionally, we also found that the flow velocity variations changed from the presurgical period to post-surgery, till the time of discharge. Moreover, the patient's clinical outcomes could also be correlated to the change in pulse velocity variations. Also, the correlation of the PVV values to the elevated ONSD values is suggestive of raised ICP in the different GCS groups and from the preoperative to the postoperative period. Another significant finding was that NIRS values were stable and did not change with changing ICP values.

In our study, we have analyzed the change in the velocity variations from the preoperative period to postoperative 24 hours and also at the time of discharge. And we have tried to explain these variations in comparison to patients with normal

cerebral vasculature and intracranial compliance with a control group of patients undergoing spine surgery. Our hypothesis was that variation in transcranial Doppler velocity in the spectral pattern and optic nerve sheath diameter can be used to indirectly measure intracranial compliance and predict the outcome of in different GCS patients. Our major result was that, when compared to normal patients, who experienced far fewer fluctuations, the pulse velocity variation in the patients with intracranial pathology was significant, with considerable variation in the GCS< 8 groups and less variation in the GCS 9–12 and GCS 13–15 groups. We tried to correlate this finding to the outcome of the patients and our findings were that a PVV cut-off of 2.5% gave a sensitivity of 91.7% and specificity of 34%.With a value of less than 2.5% predicting good outcomes and a value of more than 2.5% predicting poor outcomes in GOS. This has not been previously described in the literature.

The correlation between the Pulsatility index and the outcome of the patients had been described by Moreno et al in his study the mean PI in cases of good outcome was 1.0 whereas in poor outcomes was 1.56. (43) In the multicentric study by Bouzat et al the addition of the TCD variables along with age and GCS increased the positive predictive value in predicting the secondary neurological deficits in mild to moderate traumatic brain injury. Also, the cut off PI TCD thresholds (PI greater than or equal to 1.25 and FVd less than or equal to 25cm/s) had 80% sensitivity (95% CI, 56 to 94%) and 79% specificity (95% CI, 74 to 83%) to predict early neurologic worsening. (45) In our study we correlated PI with GCS as well as the outcome, with lower PI in the better GCS group and higher PI in GCS< 8 groups. We also found higher PI values was associated with poorer outcomes.

GCS cannot be used as a sole parameter to predict the degree of raised intracranial pressure.ICP that is chronically elevated may have a subtle onset of symptoms. Intracranial volume may increase steadily over months with no change in the level of consciousness and yet present dramatically with an acute deterioration of consciousness when intracranial compliance is finally exhausted. Therefore, the absence of low GCS does not exclude high ICP. Hence the role of multimodal monitoring technologies like TCD and ONSD in diagnosing, managing, and prognosticating in these scenarios is important. (46)

The clinical parameters that indicate raised intracranial pressure consist of the Cushing's triad of bradycardia, hypertension and irregular respiration. In our study, higher mean arterial pressure and respiratory irregularity were found more in the lower GCS groups than in normal GCS and control group, suggesting that clinically also these patients were manifesting features of raised ICP. Bradycardia also develops as ICP rises further and the autoregulatory capacity is compromised.

In our study, the variation in the velocities in the TCD spectrogram was analyzed with various degrees of brain dysfunction marked by GCS as the severity score of raised ICP. We confirmed the raised ICP status with clinical parameters, image findings and ONSD measurements as invasive ICP measurement was not part of our protocol. We explored in our study whether the TCD spectral velocity variations correlated with raised ICP and whether this could be used as a marker for predicting the outcome of the patients. The doppler patterns in TCD reflect the changes in the large vessels like MCA, which occur due to changing intracranial compliance and changes at the microcirculatory level. The spectral variations can be used to objectively assess the changing intracranial compliance, especially from the

preoperative to the postoperative period, and to prognosticate the patient's outcome. This was proven in our study where the PVV had major fluctuations in the preoperative period with higher values in group C followed by groups B and A, while the control group had the least amount of variation. In all groups A, B and C in the postoperative period, the PVV values reduced indicating that the intracranial compliance improved and there was still a statistically significant difference between the groups while examining the side that displayed the largest PVV deviation from baseline.

Comparing the mean flow velocities on either side there were lower MFV in the lower GCS, group C and B compared to the good GCS group of A and the control group. This difference was most significant in the preoperative period with the values improving till the time of discharge and being comparable between groups. Similarly, the pulsatility index also showed elevated values in the lower GCS group in the preoperative period and the values normalized to the time of discharge with no difference between groups. According to a comprehensive study and meta-analysis by Fatima et al, patients with abnormal TCD had a 9-fold higher risk of mortality than those with normal TCD after a traumatic brain injury (OR: 9.96; 95 % CI: 4.41-22.47) Additionally, compared to normal TCD, a finding of hypoperfusion (MCA mean flow velocity < 35 cm/s) was linked to 3-fold increased risk of having a poor functional outcome. The lack of data comparing high PI to normal PI in TBI prevented them from analyzing TCD based on PI. (44). After conducting a study on patients with mild and moderate TBI, Jaffres et al. concluded that PI values and CT findings were the major predictors of neurological deterioration in both groups of TBI patients. Combining PI measurements with CT

findings at admission could assist to identify patients who would be deteriorating neurologically seven days post-TBI.(47)

Mangalore et al in their study elucidated different TCD spectral patterns in patients with good and poor GCS along with the image findings of raised ICP, they could identify patterns of blunted and dampened waves in patients with preserved intracranial compliance, while for patients with low GCS and sluggish pupillary reaction suggestive of raised ICP they demonstrated a varying pattern of TCD spectrum with prominent systolic peaks with and without doppler windows which they concluded as an intracranial vascular system reaching maximum vasodilatory capacity. While patients with refractory increased ICP they demonstrated flow reversal, sharp waves, systolic and diastolic spikes, only systolic spikes, rounding of waveform and no flow. (2).They also commented that patients with prominent systolic peaks had a survival of up to a week, while other patterns had much lower survival. We in our study tried to objectively identify changes in the spectral pattern so that we could diagnose patients who had no apparent clinical signs of raised ICP and even normal GCS, while the imaging findings suggested raised ICP. Also, with these PVV changes, we could assess the status at the bedside, showing improvement in intracranial compliance in the post-operative period and also the utility in prognostication of these patients.

We also used NIRS to assess cerebral oxygenation in addition to TCD to assess the patients with varying degrees of raised intracranial pressure. In our study, we could not find significant relations between GCS and NIRS and also, we could not prove any significant changes in the NIRS values from the preoperative period to the post-operative period and no correlation could be made between NIRS to the

outcome of patients. In their study of NIRS in the context of severe TBI, Kampfl and colleagues found that patients with an ICP of >25 mm Hg had significantly different (lower) NIRS parameters than those with an ICP of <25 mm Hg. Unfortunately, the capacity of NIRS to detect cerebral hypoxia in the presence of elevated ICP was the main emphasis of this investigation rather than the ability of NIRS to assess whether an increase in ICP has occurred and the extent of its temporal relationship.(48)In 41 TBI patients, Budohoski and colleagues investigated the phasing of the responses of cerebral monitoring modalities to changes in arterial blood pressure (AP) and cerebral perfusion pressure (CPP). They found a strong correlation between significant changes in ICP (>5 mm Hg) and NIRS-based parameters in 121 pressure change "events" over the course of about 120 hours of multimodal monitoring. The fact that only occurrences where there was a substantial change in NIRS characteristics that followed changes in ICP were taken into account for analysis limited this study's ability to support the concordance of ICP with NIRS. There were therefore likely many major pressure-related events that occurred during the hours of data collection but did not cause a discernible change in NIRS parameters. Consequently, it is challenging to establish a precise sensitivity. (49)Collectively, these results show that NIRS has the potential to replace invasive ICP measurement in some circumstances, albeit there are still barriers preventing this approach from being adopted. First, although these reported experiments have coupled the relationship between NIRS and ICP in terms of retrospective temporal/waveform analysis, it is still unknown how well NIRS can be relied upon to identify changes in ICP (in the absence of an invasive probe). Furthermore, it is not yet clear enough how this relationship behaves precisely to make predictions about how to translate

changes in NIRS parameters into changes in ICP. Since NIRS parameters have not consistently shown that they can reflect real absolute values, this is also true in any established ICP monitor. (50)

We compared ONSD measurements on both sides in different GCS groups to the control group and found that ONSD values were higher in GCS <8 compared to GCS >8. Aside from that, Group C had higher ONSD values than Group B and Group A, even if this wasn't the same in both eyes. Comparing the postoperative values also among different groups, there was a significant difference between GCS <8 and GCS >8, although we could not differentiate between group B and Group C. In the comparison of the preoperative and postoperative 24 hrs ONSD values, we could identify that the intracranial pressure had decreased post-surgery in all the groups. In their study, Das et al. found that patients with moderate and severe TBI had mean ONSDs of 4.83 mm and higher with an SD of 0.4 mm and, the higher ONSDs associated with admission Rotterdam CT Scores of 4 and above (51). In their study, singer et al. discovered that ONSD and dynamic pupillometry measures reliably distinguished severe TBI from mild TBI on days 2 and 3 following the injury, employing different types of non-invasive methods. Interestingly, in patients with severe TBI, these same parameters did not link to ICP.(41)

We correlated PVV variations with ONSD, when the ONSD was dichotomized into <5mm and >5mm, a mean PVV value of 2.5% gave a predictive value with a sensitivity of 84.6 % and specificity of 42.2 %. This test had a diagnostic accuracy of 68.2 % with a 95% confidence interval from 59.8 % to 76.6 %. This shows that with higher ONSD values indicating raised ICP the PVV values

also increased, suggesting that PVV could also be used to understand the changing intracranial compliance.

We designed this study to assess the difference in spectral changes of TCD and to find the relationship between TCD, NIRS and ONSD. It was not designed to assess static or dynamic autoregulation, we wanted to assess if these velocity variations could indicate changing intracranial compliance and could be used similarly to the use of PI in traumatic brain injury to predict the outcome of patients and if so identify these could result in early intervention, also whether further radiological investigations like CT to be performed as clinically it is not necessarily dependent enough to rely only on GCS of the patient to facilitate further imaging and intervention as GCS alone has a lot of pitfalls.

CLINICAL IMPLICATION

TCD is a reliable, non-invasive tool available at the bedside of the patient. The evidence that is already there in the current literature mainly focuses on the velocity values in the TCD like MFV, PSV and EDV and the derived variables like PI and RI. The spectral waveform analysis has been only given importance during severely raised ICP showing flow reversal or absence of diastolic flow or total absence of flow.

Our study tried to analyze the TCD spectrum in normal patients and patients with varying degrees of GCS with neurosurgical problems needing surgery. We observed that there are velocity variations within the spectrum even in neurologically ill patients with normal GCS and normal TCD and these velocity variations were more pronounced in the patients with poor GCS (<8). But NIRS was not found to indicate any variability in these patients. We could also correlate the PVV variability

with ONSD, an indirect measure of ICP. Hence, we suggest that pulse velocity variation can be used as a marker for predicting changing intracranial compliance and also to predict poor outcomes in non-traumatic neurosurgical patients.

LIMITATIONS

1. Our study was designed as a pilot feasibility study wherein we tried to use TCD spectral waveform as an indirect and noninvasive measure of intracranial compliance. The sample size was low and was of uneven numbers and distribution among the groups due to difficulty in enrollment of patients especially those with GCS < 8 needing surgery. The patients who were included in the study were from a wide range of neurosurgical populations, including brain tumours like meningioma and glioma, aneurysms and stroke patients taken up for decompression. The ongoing COVID-19 pandemic also influenced our patient recruitment.
2. We did not monitor ICP measurement invasively and RAP measurement for comparison with TCD. This will be the plan for future study.
3. Our study was observational, we did not do any active interventions based on TCD velocities, and patients were managed according to standard institutional protocol.
4. Though we tried to maintain factors like fluid status, partial pressure of oxygen and Carbon di oxide, respiratory variables, etc. constant through the study period, these factors could have influenced our results.

SUMMARY AND CONCLUSION

8. SUMMARY AND CONCLUSION

SUMMARY

Our study results showed

1. Statistically significant difference between groups with respect to mean flow velocity and pulsatility index in the preoperative period .
2. Significant change in the pulse velocity variation(PVV) among the groups especially in the preoperative period and also change in these variations prior to surgery to the post operative period with statistically significant changes between the groups.
3. Correlation of PVV with the outcome of patients - Mean PVV value of 2.5% gave a predictive value with a sensitivity of 91.7% and specificity of 34%. With a value of less than 2.5% predicting good outcomes and a value of more than 2.5% predicting poor outcomes in different patients.
4. Correlation with ONSD with a cut-off of 5mm, the PVV value of 2.5% gave a predictive value with a sensitivity of 84.6 % and specificity of 42.2 %.
5. NIRS values did not vary among the groups from the preoperative to the postoperative periods.

CONCLUSION

In our study, we did an analysis of the transcranial doppler waveform spectrum and the derived variables of cerebral flow velocity variations, which is new in the field of neuroscience. It can give useful information on the changing conditions of intracranial compliance in patients with acute neurological disorders like SAH, acute

stroke, etc. It can identify patients at varying points in the intracranial compliance curve non-invasively at the bedside. These variations can be used to prognosticate patients and identify the point of surgical intervention. Also, multimodal monitoring helps us to serially monitor and understand the changing intracranial physiology so that focused and early interventions can be done to facilitate better outcomes

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ANNEXURES

10.APPENDICES

1. TECHNICAL ADVISORY COMMITTEE FORM.
2. INSTITUTIONAL ETHICS COMMITTEE FORM.
3. PATIENT INFORMATION SHEET-ENGLISH.
4. PATIENT INFORMATION SHEET-MALAYALAM.
5. CONSENT FORM-ENGLISH.
6. CONSENT FORM-MALAYALAM.
7. PROFORMA.
8. MASTER CHART.
9. PLAGIARISM REPORT.

Technical Advisory Committee (Clinical Studies)

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES & TECHNOLOGY
THIRUVANANTHAPURAM – 695011, INDIA

TAC Registration No: SCT-/S/2020/1210 **Date: 23.12.2020**

Project title: EVALUATION OF TRANSCRANIAL DOPPLER SPECTRAL(TCD) SIGNATURES AND ASSESSMENT OF CEREBRAL OXYGENATION USING NEAR INFRARED SPECTROSCOPY (NIRS) IN PATIENTS UNDERGOING NEUROSURGICAL PROCEDURES AS A NOVEL MARKER FOR CLINICAL OUTCOME AND PROGNOSTICATION -AN OBSERVATIONAL STUDY

Principal Investigator:
Dr Jeeva George, Division of Neuroanaesthesia and Neurocritical Care Department of Anaesthesiology, SCTIMST Degree: DM (Neuroanesthesia) Ist Year Resident
Co-Principal Investigator(s):
Dr Manikandan S, Professor and Incharge, Division of NeuroAnaesthesia and Neurocritical care Department of Anaesthesiology, SCTIMST Degree: M.D., P.D.C.C.(Neuroanesthesia)
Dr. Ranganatha Praveen C.S, Assistant Professor, Division of NeuroAnaesthesia and Neurocritical care Department of Anaesthesiology, SCTIMST Degree: MD, DM Neuroanaesthesia
Dr Jayanand Sudhir, Associate Professor, Department of Neurosurgery, SCTIMST Degree: Mch (Neurosurgery)

Members who participated in the TAC meeting on 21/11/2020
Dr Harikrishnan S (Chairman)
Dr Manikandan S
Dr Sylaja P N
Dr Narayanan Namboodiri
Dr Sanjay G
Dr Ramshekhar N Menon
Dr Jayanand Sudhir B
Dr Sabarinath Menon
Dr Madhusoodanan U K
Dr Srinivas G (Member Secretary)

Dr Ramshekhar N Menon, Dr Madhusoodanan U K, Dr Jayanand Sudhir B, Dr Manikandan S, Dr Sabarinath Menon and Dr Narayanan Namboodiri (#1189,1201, 1204, 1207, 1208, 1209, 1210, 1213, 1214).

Risk Classification of the project (Minimum/ Moderate/ High): Minimum

Requirement of DSMB: No

Recommended members of DSMB: Not applicable

Recommendations of TAC:
Recommended for consideration of IEC in the light of the responses received from the investigator

The PI may note that there can be no additions / alterations in the documents approved by TAC when they are submitted to the IEC.

MEMBER SECRETARY
Dr Srinivas G TAC (Clinical Studies)
SCTIMST

Note for IEC
Copy of the investigator's responses to questions/suggestions from TAC is attached (Appendix-1).

श्री चित्रा तिरुनाल आयुर्विज्ञान और प्रौद्योगिकी संस्थान, त्रिवेन्द्रम
तिरुवनन्तपुरम - ६९५०११, केरल, इंडिया
SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM
Thiruvananthapuram - 695 011, Kerala, India
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Institutional Ethics Committee

(IEC Regn No. ECR/189/Inst/KL/2013/RR-21)

SCT/IEC/1760/NOVEMBER/2021 28.12.2021

Dr. Jeeva George
Senior Resident
Department of Anaesthesiology
SCTIMST, Thiruvananthapuram

Dear Dr. Jeeva George,

The Institutional Ethics Committee held on 26th November, 2021, reviewed and discussed your application to conduct the study titled "**EVALUATION OF TRANSCRANIAL DOPPLER SPECTRAL(TCD) SIGNATURES AND ASSESSMENT OF CEREBRAL OXYGENATION USING NEAR INFRARED SPECTROSCOPY (NIRS) IN PATIENTS UNDERGOING NEUROSURGICAL PROCEDURES AS A NOVEL MARKER FOR CLINICAL OUTCOME AND PROGNOSTICATION - AN OBSERVATIONAL STUDY** " (IEC/1760).

The following members of the Ethics Committee were present at the meeting held on 26th November, 2021 at Residences and Offices of IEC Members via Video Conference

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Prof. C.C. Kartha	MBBS,MD	Male	Basic Medical Scientist (Chairman)	No
2.	Dr. Kala Kesavan P	MBBS,MD	Female	Basic Medical Scientist	No
3.	Smt. Sathi Nair	MA (English Literature)	Female	Lay Person	No
4.	Dr. Pradeep S	MBBS, MD	Male	Basic Medical Scientist	No
5.	Adv. N Anand	BAL, L.LB	Male	Legal Expert	No
6.	Adv. Priya Kaimal	LLM, MBL	Female	Legal Expert	No
7.	Dr. Achuth Sankar S. Nair	Ph.D (i.Engineering ii.Music)	Male	Social Scientist	No
8.	Dr. Harikrishna Varma P. R	Ph.D (Materials Sciences)	Male	Medical Technology	Yes
9.	Dr. Narayanan Namboodiri. K K	MBBS,MD,DM	Male	Clinician	Yes
10.	Dr. Manikandan.S	MBBS,MD,PDCC	Male	Clinician	Yes
11.	Dr. Ashalatha R	MBBS, MD,DM	Female	Clinician	Yes
12.	Dr. Biju Soman	MBBS,MD, DPH, MSc, DLSHTM	Male	Basic Medical Scientist	Yes
13.	Dr. Srinivas G	PhD	Male	Basic Medical Scientist (Member Secretary)	Yes

SCT/IEC/1760/NOVEMBER-2021

The following documents were reviewed:

Original submission

1. Checklist Form
2. Covering letter addressed to the Chairperson, IEC, SCTIMST dated 19.07.2021
3. TAC Approval Letter
4. IEC Application Form
5. Project Proposal
6. Proforma
7. Consent Form in English and Malayalam
8. Patient Information Form in English and Malayalam
9. CV of PI and Co-PIs
10. Declaration Form

Revised submission

1. Checklist Form
2. Covering letter addressed to the Chairperson, IEC, SCTIMST dated 21.12.2021
3. IEC Recommendations and reply
4. TAC Approval Letter
5. IEC Application Form
6. Project Proposal
7. Proforma
8. Consent Form in English and Malayalam
9. Patient Information Form in English and Malayalam
10. CV of PI and Co-PIs
11. Declaration Form

IEC Decision

The IEC approved the conduct of the study in the present form.

Remarks:
The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,

G. Srinivas
Member Secretary, IEC

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES & TECHNOLOGY • INSTITUTIONAL ETHICS COMMITTEE (IEC) SCTIMST THIRUVANANTHAPURAM

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE (IEC)
SCTIMST, THIRUVANANTHAPURAM

Page 2 of 2

PATIENT INFORMATION FORM

Title: Evaluation of Transcranial Doppler Spectral (TCD) signatures and assessment of cerebral oxygenation using Near infrared spectroscopy (NIRS) in patients undergoing neurosurgical procedures as a novel marker for clinical outcome and prognostication -An observational study

Name of the Investigators:

Dr. Jeeva George (PI), Dr.Manikandan S (Guide and CO-PI), Dr.Ranganatha Praveen C S. (Co guide and CO-PI) ,Dr Jayanand Sudhir (Co-investigator).

You are being requested to participate in the above titled study which is being conducted to evaluate the role of transcranial doppler spectral changes and assessment of cerebral oxygenation using NIRS as a marker for the outcome and prognosis in patients undergoing neurosurgical procedures.

We have planned to recruit 90 patients who come for neurosurgical interventions such as large brain tumour resection, aneurysm clipping and patients undergoing decompression for malignant stroke at SCTIMST, Trivandrum.

What is TCD?

TCD is ultrasound that detects blood flow in the brain's major arteries when applied to the sides of head. Ultrasound is safe, noninvasive, and does not use ionizing radiation. This procedure requires little to no special preparation

Does TCD use & measurement have any side effects?

As a non-invasive procedure, it doesn't carry any risk to patient. Adverse events related to TCD is nil.

Safety of ultrasound ?

Ultrasound is considered a routine procedure with almost no complications.

What is NIRS?

Near-infrared spectroscopy (**NIRS**) is a non invasive technology that continuously monitors regional tissue oxygenation. It uses infrared light to detect changes in the concentration of oxygenated and de-oxygenated haemoglobin in the blood, through obstacles such as skin and bone.

What will happen if you develop any study related injury?

We do not expect any injury to happen to you. In addition, adverse events related to TCD is minimal. But if you do develop any side effects or problems due to the study, the side effects will be treated at no cost to you. We are unable to provide any monetary compensation, however.

Will you have to pay for the cost of using the devices?

TCD are used as a part of ICU management in detection of vasospasm and as surrogate marker for cerebral blood flow in patients with intracranial hypertension. So, no extra money will be charged for it, to the patients.

Can you withdraw from this study after it starts?

Your participation in this study is entirely voluntary and you are also free to decide to withdraw permission to participate in this study. If you do so, this will not affect your usual treatment at this hospital in any way.

Will you have to pay additional cost?

No additional cost will be borne because no new test will be done for the purpose of study. Study will not influence the treatment, ICU stay and the duration of hospital stay.

Will your personal details be kept confidential?

The results of this study will be used for thesis submission as a part of academic research and will be submitted to a medical journal for publication, but you will not be identified by name in any publication or presentation of results. However, your medical notes may be reviewed by people associated with the study, without your additional permission, should you decide to participate in this study.

If you have any further questions, please ask DR. JEEVA GEORGE (Principal investigator) mobile number: 9779886524. Email: jeevaupasana@gmail.com

For technical advisory committee contact, please ask Dr. Mala Ramanathan, telephone number: 0471-2524234. Email: iec.mem.sec@sctimst.ac.in

രോഗിക്കുള്ളകാര്യവിവരണപത്രം

പഠനശീർഷകം: ന്യൂറോ ശസ്ത്രക്രിയയ്ക്ക് വിധേയരാകുന്ന രോഗികളിൽ ക്ലിനിക്കൽ നേട്ടത്തിന്റെയും ചികിത്സുടെയും നൂതനമായ സൂചകങ്ങളായി എൻഐആർഎസ് ഉപയോഗിച്ച് ട്രാൻസ്ക്രേനിയൽ സ്പെക്ടറൽ സൂചകങ്ങളുടെയും തലച്ചോറിലെ ഓക്സിജനേഷന്റെയും വിലയിരുത്തൽ- ഒരു നിരീക്ഷണ പഠനം

ഗവേഷകരുടെ പേര്

ഡോ. ജീവ ജോർജ് (പ്രധാന ഗവേഷക), ഡോ. മണികണ്ഠൻ എസ് (ഗൈഡ്, സഹ പ്രധാന ഗവേഷകൻ), ഡോ. രംഗനാഥപ്രവീൺ സി. എസ് (സഹ ഗൈഡും സഹ പ്രധാന ഗവേഷകനും), ഡോ. ജയാനന്ദ് സുധീർ (സഹ- ഗവേഷകൻ)

ന്യൂറോസർജിക്കൽ നടപടികൾക്ക് വിധേയരാകുന്ന രോഗികളുടെ ചികിത്സയിലും നേട്ടങ്ങളിലും എൻഐആർഎസ് ഒരു സൂചകമായി തലച്ചോറിലെ ഓക്സിജനേഷൻ വിലയിരുത്തുന്നതിനും ട്രാൻസ്ക്കോനിയൽ സ്പെക്ടറൽ മാറ്റങ്ങളുടെ പങ്ക് വിലയിരുത്തുന്നതിനമായി നടത്തുന്ന ഒരു പഠനത്തിൽ പങ്കെടുക്കാൻ താങ്കളെ ഞങ്ങൾ ക്ഷണിക്കുന്നു.

തിരുവനന്തപുരം SCTIMST യിൽ തലച്ചോറിലെ വലിയ മുഴകൾ നീക്കം ചെയ്യുന്നതിനായുള്ള ന്യൂറോ ശസ്ത്രക്രിയാ ഇടപെടലുകൾ, അന്യൂറിസം ക്ലിപ്പിംഗ്, മാരകമായ സ്ട്രോക്ക് സമ്മർദ്ദം കുറയ്ക്കൽ എന്നിവക്കായി വരുന്ന 90 രോഗികളെ പങ്കെടുപ്പിക്കുവാൻ ഞങ്ങൾ ആസൂത്രണം ചെയ്യുന്നു.

എന്താണ് റ്റിസിഡി?

തലയുടെ വശങ്ങളിൽ പ്രയോഗിക്കുമ്പോൾ തലച്ചോറിലെ പ്രധാന ആർട്ടറികളിലെ രക്തപ്രവാഹം കണ്ടെത്താൻ കഴിയുന്ന അൾട്രാസൗണ്ടാണ് റ്റിസിഡി. അൾട്രാസൗണ്ട് സുരക്ഷിതവും, ശരീരത്തിൽ കടന്നുള്ള പരിശോധന വേണ്ടാത്തതും അയണൈസിംഗ് റേഡിയേഷൻ ഉപയോഗിക്കാത്തതുമാണ്. ഈ നടപടിക്ക് വളരെകുറച്ച് അല്ലെങ്കിൽ പ്രത്യേക തയാറെടുപ്പ് ഒട്ടും ആവശ്യമില്ലാത്തതുമാണ്.

റ്റിസിഡിയുടെ ഉപയോഗത്തിലും അളവെടുപ്പിലും എന്തെങ്കിലും പാർശ്വഫലങ്ങളുണ്ടാകുമോ?

ശരീരത്തിൽ പ്രവേശിക്കാതെയുള്ള നടപടിയാകയാൽ രോഗിക്ക് ഒരു അപായവും അതുണ്ടാക്കുന്നില്ല. റ്റിസിഡിയുമായി ബന്ധപ്പെട്ട ദോഷകരമായ സംഭവങ്ങളൊന്നുമില്ല.

അൾട്രാസൗണ്ടിന്റെ സുരക്ഷിതത്വം?

മിക്കവാറും സങ്കീർണ്ണതകളില്ലാത്ത ഒരു പതിവ് നടപടിയായിട്ടാണ് അൾട്രാസൗണ്ട് പരിഗണിക്കപ്പെടുന്നത്.

എൻ ഐ ആർ എസ് എന്നാലെന്ത്?

ശരീരത്തിൽ പ്രവേശിക്കാതെ, തുടർച്ചയായി പ്രാദേശിക കലകളുടെ ഓക്സിജനേഷൻ നിരീക്ഷിക്കുന്ന ഒരു സങ്കേതമാണ് നീയർ ഇൻഫ്രാറെഡ് സ്പെക്ട്രോസ്കോപ്പി (എൻഐആർഎസ്). തൊലിയും എല്ലും പോലുള്ള തടസ്സങ്ങൾ കടന്ന് രക്തത്തിലെ പ്രാണവായു സമ്പുഷ്ഠവും പ്രാണവായു ഇല്ലാത്തതുമായ ഹീമോഗ്ലോബിൻന്റെ പൂരിതാവസ്ഥയിലെ മാറ്റങ്ങൾ കണ്ടെത്തുന്നതിനായി അത് ഇൻഫ്രാറെഡ് പ്രകാശം ഉപയോഗിക്കുന്നു.

പഠനസംബന്ധിയായി എന്തങ്കിലും പരുക്കുണ്ടായാൽ എന്തുചെയ്യും?

താങ്കൾക്ക്ഒരു പരിക്കും ഉണ്ടാവുമെന്ന് ഞങ്ങൾ പ്രതീക്ഷിക്കുന്നില്ല, റ്റിസിഡിയുമായി ബന്ധപ്പെട്ട സംഭവങ്ങൾ വളരെ കുറവാണ്. പക്ഷേ താങ്കൾക്ക് പഠന സംബന്ധമായി പ്രശ്നങ്ങളോ പാർശ്വഫലങ്ങളോ ഉണ്ടാവുകയാണെങ്കിൽ അവ താങ്കൾക്ക് അധികച്ചിലവുണ്ടാകാതെ ഞങ്ങൾ ചികിത്സിക്കും. എന്തായാലും, നഷ്ടപരിഹാരം നൽകാൻ ഞങ്ങൾക്കാവില്ല.

ഉപകരണങ്ങൾ ഉപയോഗിക്കുന്നതിന് താങ്കൾ പണം നൽകണോ?

തലയോട്ടിക്കുള്ളിൽ രക്തസമ്മർദ്ദമുള്ള രോഗികളിൽ തലച്ചോറിലെ വാസോസ്പാസവും രക്തപ്രവാഹവും നിരീക്ഷിക്കുന്നതിന് പകരമുള്ള സൂചകമായും ഐസിയുവിലെ നടപടികളുടെ ഭാഗമായും റ്റിഡിഎസ് ഉപയോഗിക്കുന്നു എന്നതിനാൽ രോഗികളിൽനിന്നും അധികമായി പണം ഈടാക്കില്ല.

പഠനമാരംഭിച്ചശേഷംതാങ്കൾക്ക് പിൻമാറാനാകുമോ?
താങ്കളുടെ പഠനത്തിലുള്ള പങ്കാളിത്തം പൂർണമായും സ്വമേധയാ ഉള്ളതും പഠനത്തിൽ നിന്ന് പിൻമാറാൻ സ്വാതന്ത്ര്യം ഉള്ളതും ആണ്. അങ്ങനെ ചെയ്യുന്നതുകൊണ്ട് ഈ ആശുപത്രിയിലെ താങ്കളുടെ സാധാരണ ചികിത്സയെ ഒരു വിധത്തിലും ബാധിക്കുകയില്ല.

താങ്കൾ അധികമായി പണം നൽകണോ?

ഈ പഠനത്തിനായി പുതിയ പരിശോധനകൾ ഒന്നും ചെയ്യുന്നില്ല എന്നതിനാൽ അധികച്ചിലവുണ്ടാകില്ല. പഠനം ചികിത്സയെയോ തീവ്രപരിചരണ വിഭാഗത്തിലെ താമസത്തെയോ ആശുപത്രിവാസത്തിന്റെ കാലയളവിനെയോ ബാധിക്കില്ല.

താങ്കളുടെ വ്യക്തിപരമായ വിവരങ്ങൾ രഹസ്യമായിവയ്ക്കുമോ ?

പഠനഫലങ്ങൾ അക്കാദമിക ഗവേഷണത്തിന്റെ ഭാഗമായുള്ല പ്രബന്ധത്തിലും ഒരു വൈദ്യശാസ്ത്ര ജേർണലിൽ പ്രസിദ്ധീകരിക്കുമെങ്കിലും താങ്കളുടെ പേരുവിവരങ്ങൾ പ്രസിദ്ധീകരണത്തിലോ പഠനഫലങ്ങളുടെ പ്രദർശനത്തിലോ ഉണ്ടാവില്ല. എന്നലും, താങ്കൾ പഠനത്തിൽ പങ്കെടുക്കുകയാണെങ്കിൽ താങ്കളുടെ ചികിത്സാ രേഖകൾ താങ്കളുടെ വീണ്ടുമുള്ള സമ്മതമില്ലാതെ പഠനവുമായി ബന്ധപ്പെട്ടവർ അവലോകനം ചെയ്തേക്കാം.

പ്രധാന ഗവേഷകൻ ഡോ. ജീവ ജോർജ്, (പ്രധാന ഗവേഷക), ഡിപ്പാർട്ട്മെന്റ് ഓഫ് അനസ്തീഷ്യോളജി (ഫോൺ- 9779886524. ഇമെയിൽ. jeevaupasana@gmail.com

പഠനത്തിന്റെ നൈതീക അനുവാദ സംബന്ധമായ വിശദീകരണങ്ങൾക്ക് **SCTIMST** നൈതീക കമ്മിറ്റിമെംബർ സെക്രട്ടറിയെ ബന്ധപ്പെടാൻ

പ്രൊഫ.മാല രാമനാഥൻ

ഫോൺ-0471-2524234

ഇമെയിൽ -iec.mem.sec@sctimst.ac.in

പ്രധാന ഗവേഷകന്റെ പേരുംഒപ്പും

ഡോ. ജീവ ജോർജ്,

ഫോൺ -9779886524

CONSENT FORM

Title: Evaluation of Transcranial Doppler Spectral(TCD) signatures and assessment of cerebral oxygenation using Near infrared spectroscopy (NIRS) in patients undergoing neurosurgical procedures as a novel marker for clinical outcome and prognostication -An observational study.

Participant's name: Age (in years):

I_____, son/daughter of _____

Declare that (Please tick boxes)

- I have read the above information provided to me regarding the evaluation of Transcranial Doppler Spectral signatures and assessment of cerebral oxygenation using NIRS in patients undergoing neurosurgical procedures as a novel marker for clinical outcome and prognostication.( )
- I have clarified any doubts that I had. [ ]
- I also understand that my participation in this study is entirely voluntary and that I am free to withdraw permission to continue to participate at any time without affecting my usual treatment or my legal rights [ ]
- I understand that the study staff and institutional ethics committee members will not need my permission to look at my health records even if I withdraw from the trial. I agree to this access [ ]
- I understand that my identity will not be revealed in any information released to third parties or published [ ]
- I voluntarily agree to take part in this study [ ]
- I have been provided with the contact numbers of the principle investigator, in case I want to know more about the study and participants rights [ ].
- I received a copy of this signed consent form [ ]

Name:

Signature:

Date:

Name of witness:

Relation to participant:

Signature:

Person Obtaining Consent

I attest that the requirements for informed consent for the medical research project described in this form have been satisfied. I have discussed the research project with the participant and explained to him or her in nontechnical terms all of the information contained in this informed consent form, including any risks and adverse reactions that may reasonably be expected to occur. I further certify that I encouraged the participant to ask questions and that all questions asked were answered.

Name:

Signature: Date:

സമ്മതപത്രം

പഠനശീർഷകം: ന്യൂറോ ശസ്ത്രക്രിയയ്ക്ക് വിധേയരാകുന്ന രോഗികളിൽ ക്ലിനിക്കൽ നേട്ടത്തിന്റെയും ചികിത്സുടെയും നൂതനമായ സൂചകങ്ങളായി എൻഐആർഎസ് ഉപയോഗിച്ച്

ട്രാൻസ്ക്രേനിയൽ സ്പെക്ടറൽ സൂചകങ്ങളുടെയും തലച്ചോറിലെ ഓക്സിജനേഷന്റെയും വിലയിരുത്തൽ- ഒരു നിരീക്ഷണ പഠനം

പങ്കെടുക്കുന്നയാളുടെ പേര് വയസ്സ് (വർഷത്തിൽ):

ഞാൻ..... ..... .(മകൻ/മകൾ).....

(കോളങ്ങൾ അടയാളപ്പെടുത്തുക).

ഞാൻ പ്രഖ്യപിക്കുന്നതെന്തെന്നാൽ

- പഠനസംബന്ധിയായി എനിക്കു നൽകിയ ന്യൂറോ ശസ്ത്രക്രിയയ്ക്ക് വിധേയരാകുന്ന രോഗികളിൽ ക്ലിനിക്കൽ നേട്ടത്തിന്റെയും ചികിത്സുടെയും നൂതനമായ സൂചകങ്ങളായി എൻഐആർഎസ് ഉപയോഗിച്ച് ട്രാൻസ്ക്രേനിയൽ സ്പെക്ടറൽ സൂചകങ്ങളുടെയും തലച്ചോറിലെ ഓക്സിജനേഷന്റെയും വിലയിരുത്തൽ- ഒരു നിരീക്ഷണ പഠനസംബന്ധമായ വിവരങ്ങൾ വായിച്ചു [ ]
- എനിക്കുായ സംശയങ്ങൾ പരിഹരിക്കാൻ അവസരം ലഭിച്ചു.
- എന്റെ ഈ പഠനത്തിലുള്ള പങ്കാളിത്തം പൂർണ്ണമായും സ്വമേധയാ ആണെന്നും അനുവാദം എനിക്ക് ഏതുസമയത്തും എന്റെ ചികിത്സയെ ബാധിക്കാതെ പിൻവലിക്കാൻ അവകാശമുന്നെും ഞാൻ മനസ്സിലാക്കുന്നു. [ ]
- ഞാൻ ഈ പഠനത്തിൽ നിന്നും പിൻമാറിയാലും പഠനം നടത്തുന്നവർക്കും സ്ഥാപനത്തിലെ നൈതിക കമ്മിറ്റി അംഗങ്ങൾക്കും നിയന്ത്രണാധികാരികൾക്കും എന്റെ ആരോഗ്യരേഖകൾ പരിശോധിക്കുന്നതിന് എന്റെ അനുവാദം ആവശ്യമില്ലെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു. അതിനോട് ഞാൻ യോജിക്കുന്നു.[ ]
- എന്നെ തിരിച്ചറിയാനുതകുന്ന വിവരങ്ങൾ ഒന്നും മറ്റുള്ളവർക്കു നൽകുകയോ പ്രസിദ്ധീകരിക്കുകയോ ചെയ്യില്ലെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു. [ ]
- എനിക്ക് പഠനത്തെപ്പറ്റിയോ പങ്കാളിയുടെ അവകാശങ്ങളെപ്പറ്റിയോ കൂടുതൽ അറിയണമെങ്കിൽ പ്രധാനഗവേഷകയെ ബന്ധപ്പെടാനുള്ള നമ്പർ നൽകിയിട്ടു് [ ]
- ഞാൻ സ്വമേധയാ പഠനത്തിൽ പങ്കെടുക്കാൻ സമ്മതിക്കുന്നു [ ]
- സമ്മതപത്രത്തിന്റെ ഒപ്പിട്ട ഒരു കോപ്പി എനിക്കു കിട്ടി [ ]

പേര്

ഒപ്പ്

തീയതി

സാക്ഷിയുടെ പേര്

പങ്കെടുക്കുന്ന ആളുമായുള്ള ബന്ധം

തീയതി

(സമ്മതം വാങ്ങുന്നയാൾ)

മെഡിക്കൽ റിസർച്ച് പ്രോജക്ടിനാവശ്യമായ സമ്മതപത്രത്തിനു വേുന്ന എല്ലാ ഘടകങ്ങളും തൃപ്തികരമായി നിർവഹിച്ചിരിക്കുന്നുവെന്ന് ഞാൻ ബോധ്യപ്പെടുത്തുന്നു. പഠനപങ്കാളിയുമായി ഗവേഷണപദ്ധതിയെപ്പറ്റി സാങ്കേതികേതര പദങ്ങളുപയോഗിച്ച് എല്ലാ വിവരങ്ങളെപ്പറ്റിയും ചർച്ച നടത്തുകയും പ്രതീക്ഷിക്കാവുന്ന അപകടസാധ്യതകളും പാർശ്വഫലങ്ങളും വിശദീകരിക്കുകയും ചെയ്തു. പങ്കാളിയെ ചോദ്യങ്ങൾ ചോദിക്കാൻ പ്രേരിപ്പിക്കുകയും എല്ലാ ചോദ്യങ്ങൾക്കും ഉത്തരം നൽകുകയും ചെയ്തു എന്നും ഞാൻ സാക്ഷ്യപ്പെടുത്തുന്നു.

സമ്മതപത്രം വാങ്ങുന്ന ആളുടെ പേരും ഒപ്പും

ഡോ. ജീവ ജോർജ്,

ഫോൺ -9779886524

സാക്ഷി

PROFORMA

Title - Evaluation of Transcranial Doppler Spectral(TCD) signatures and assessment of cerebral oxygenation using Near infrared spectroscopy (NIRS) in patients undergoing neurosurgical procedures as a novel marker for clinical outcome and prognostication -An observational study.

Sl No
Group

Age/sex:

Weight:

ASA Grade:

Date of Surgery:

Diagnosis:

Clinical Findings:

Imaging Findings (Eg; decreased ventricle size, decreased basilar cistern size, effacement of sulci, transfalcine herniation (MLS), transtentorial herniation, and loss of gray-white matter differentiation.)

Surgery:

Intraoperative adverse events

1	Hypotension	Yes	NO
2	Hypertension	Yes	NO
3	Arrythmia	Yes	NO
4	Bradycardia	Yes	NO
5	Cerebral oedema	Yes	NO
6	Brain bulge	Yes	NO
7	Seizure	Yes	NO
8	Bleeding /Haemorrhage	Yes	NO
9	Hypoxia	Yes	NO
10	Hypercarbia	Yes	NO
11	Allergic reaction	Yes	NO
12	Na/K/Hco3 levels		

	PREOPERATIVE	POST SURGERY-24 hrs	POST SURGERY-48hrs	AT DISCHARGE
GCS				
PUPPILARY REACTION Size				
HR(beats/min)				
SBP(mm Hg)				
DBP(mm Hg)				
MAP (mm Hg)				
RR (/min)				
SpO2 (%)				
HAEMOGLOBIN (g/dl)				
Pa O2 (mm Hg)				
PaCO2(mm Hg)				
GLUCOSE LEVELS (mg/dl)				
Sodium(Meq/L)				
Pottasium(Meq/L)				
Hco3(Meq/L)				

TCD and NIRS FINDINGS

	PREOPERATIVE	POST SURGERY-24 hours	POST SURGERY -48 HOURS	AT DISCHARGE
NIRS				
PEAK SYSTOLIC VELOCITY(CM/SEC)				
END DIASTOLIC VELOCITY(CM/SEC)				
MEAN FLOW VELOCITY(CM/SEC)				
SYSTOLIC /DIASTOLIC RATIO				
PULSATILITY INDEX(PI)				
RESISTANCE INDEX(RI)				
TYPE OF SPECTRAL WAVE FORM OBSERVED IN MCA				
SYSTOLIC MAXIMUM				
DIASTOLIC MAXIMUM				
SYSTOLIC MINIMUM				
DIASTOLIC MINIMUM				

ONSD	Right Eye	Left Eye
Prior to Surgery		

GCS	TIME	PVV RIGHT	PVV LEFT	SVV RIGHT	SVV LEFT
A (13-15)	Preop	7.043019102		8.81	
A (13-15)	Preop	10.28205128		14.95	
A (13-15)	Preop	8.347513708		3.61	
A (13-15)	Preop	1.648351648		13.23	
A (13-15)	Preop	8.4634221	3.783783784	8	
A (13-15)	Preop	4.963452016	7.529899927	12.53	7.6
A (13-15)	Preop	6.190248566	12.53746254	12.82	9.88
A (13-15)	Preop	7.451122375	4.942058623	5.88	10.41
A (13-15)	Preop	1.351848446	3.842125933	14.69	7.27
A (13-15)	Preop	6.414732065	3.848167539	7.35	7.34
A (13-15)	Preop	10.00544514	12.48936773	14.69	8.82
A (13-15)	Preop	7.137300661	8.830596716	7.35	8.81
A (13-15)	Preop	5.654480015	3.3408962	10.28	4.41
A (13-15)	Preop	3.748370274	1.698330455	10.38	8.82
A (13-15)	Preop	4.491141327	4.002178056	8.33	3.93
A (13-15)	Preop	3.032178218	1.220322099	7.29	7.35
A (13-15)	Preop	6.468531469	6.207482993	8.82	4.41
A (13-15)	Preop	2.378669862	1.765022905	10.3	6.81
A (13-15)	Preop	7.305730573	7.587628866	7.95	6.62
A (13-15)	Preop	5.348122117	2.063709539	0.46	4.4
A (13-15)	Preop	2.745520902	4.622395833	7.97	5.55
A (13-15)	Preop	3.148911124	2.217997465	9.27	9.52
A (13-15)	Preop	1.921101294	2.89930919	9.14	4.75
A (13-15)	Preop	7.047688683	0.363636364	9.37	6.67
A (13-15)	Preop	5.303558119	4.789618638	18.67	3.97
Post Operative 24 hrs					

GLASGOW OUTCOME SCALE (GOSE) AT HOSPITAL DISCHARGE:

1. Death	Severe injury or death without recovery of consciousness
2. Persistent vegetative state	Severe damage with prolonged state of unresponsiveness and a lack of higher mental functions
3. Severe disability	Severe injury with permanent need for help with daily living
4. Moderate disability	No need for assistance in everyday life, employment is possible but may require special equipment.
5. Low disability	Light damage with minor neurological and psychological deficits.

A (13-15)	Postop24	6.768100735		8.82	
A (13-15)	Postop24	2.5		6	
A (13-15)	Postop24	1.3548021		3.88	
A (13-15)	Postop24	4.713588492		7.34	
A (13-15)	Postop24	5.817634953	2.50338295	14.7	9.5
A (13-15)	Postop24	3.524229075	5.266929416	20.07	7.35
A (13-15)	Postop24	1.780722013	1.787016776	7.34	5.88
A (13-15)	Postop24	1.074780503	5.382198953	11.75	16.16
A (13-15)	Postop24	5.057898187	4.344448428	12.2	11.68
A (13-15)	Postop24	1.191679908	5.266929416	6.05	7.35
A (13-15)	Postop24	1.397849462	1.787016776	0.97	5.88
A (13-15)	Postop24	1.719281774	5.967583497	8.81	13.22
A (13-15)	Postop24	2.769899792	6.412493457	3.5	0.57
A (13-15)	Postop24	1.923076923	0.345508391	9	3
A (13-15)	Postop24	7.33440064	2.338385801	13.18	10.18
A (13-15)	Postop24	1.87005187	2.230122818	5.88	4.72
A (13-15)	Postop24	3.638958259	0.066250237	11.7	6.81
A (13-15)	Postop24	3.202173805	4.635558284	19	14.57
A (13-15)	Postop24	2.992413397	7.500314347	1.47	11.93
A (13-15)	Postop24	4.945054945	5.930902111	21	9.27
A (13-15)	Postop24	9.856262834	1.278568476	9.6	14
A (13-15)	Postop24	1.397849462	1.787016776	0.97	5.88
A (13-15)	Postop24	2.769899792	5.905239495	3.5	0.12
A (13-15)	Postop24	5.735676278	2.084972463	9.27	10.6
A (13-15)	Postop24	3.55567855	3.63441692	8.82	4.5

A (13-15)	Disch	0.861287398		5.8	
A (13-15)	Disch	1.685393258		3	
A (13-15)	Disch	0.23255814		5.01	
A (13-15)	Disch	0.704225352		5	
A (13-15)	Disch	2.762923351	2.083333333	7.7	15
A (13-15)	Disch	7.483461963	1.783652385	15.26	10.28
A (13-15)	Disch	5.884707766	7.941914665	4.41	5.87
A (13-15)	Disch	2.001089028	3.062925406	5.88	4.41
A (13-15)	Disch	2.079722704	3.537298041	17.03	11.76
A (13-15)	Disch	5.089285714	1.783652385	8.71	10.28
A (13-15)	Disch	8.338060125	7.941914665	7.35	5.87
A (13-15)	Disch	3.218106996	11.77412895	5.38	10.29
A (13-15)	Disch	6.486966825	1.972789116	17.54	5.86
A (13-15)	Disch	3.120567376	1.639439231	2.46	10.18
A (13-15)	Disch	6.751287712	5.321996926	7.34	20
A (13-15)	Disch	2.035911853	3.669877117	7.43	5.88
A (13-15)	Disch	6.050695012	8.624735977	16.23	7.35
A (13-15)	Disch	0.470219436	0.524109015	4.4	3.4
A (13-15)	Disch	3.696763203	0.24990004	10.28	9.13
A (13-15)	Disch	-0.857215967	4.683412981	10.59	8.49
A (13-15)	Disch	0.86526576	5.930902111	5.3	9.27
A (13-15)	Disch	2.490566038	3.437213566	6.62	5.05
A (13-15)	Disch	5.089285714	6.777186051	8.71	6.55
A (13-15)	Disch	1.039697543	1.488833747	6.7	5.3

SLNO	AGE	SEX	WEIGHT	ASA STATUS	DIAGNOSIS
GROUP A					
1	40	MALE	70	II	PARASAGGITAL MENINGIOMA ,RECURRENT
2	44	MALE	85	II	RIGHT FRONTAL GLIOMA
3	29	MALE	60	I	LEFT FRONTAL GLIOMA
4	41	MALE	50	II	RIGHT PERISYLVIAN GLIOMA
5	30	FEMALE	65	I	RIGHT FRONTAL GLIOMA
6	52	MALE	52	II	LEFT TEMPORAL HGG
7	36	FEMALE	50	I	LEFT FRONTAL GLIOMA
8	60	MALE	75	I	RIGHT FRONTAL GLIOMA
9	58	MALE	72	III	LEFT POSTERIOR PARASAGITTAL MENINGIOMA
10	35	MALE	66	I	RIGHT FRONTAL GLIOMA
11	40	MALE	40	I	RIGHT INSULO FRONTAL GLIOMA
12	29	FEMALE	60	I	RIGHT FRONTAL GLIOMA WITH CORPUS CALLOSAL EXTENSION
13	28	FEMALE	50	I	RECURRENT ANTERIOR PARASAGITTAL MENINGIOMA
14	33	MALE	64	I	LEFT FRONTAL GLIOMA
15	62	MALE	65	II	RIGHT FRONTAL GLIOMA
16	45	MALE	60	I	LEFT TEMPORAL HGG
17	67	FEMALE	65	II	LEFT TRIGONAL GLIOMA
18	35	FEMALE	70	III	RIGHT MCA ANEURYSM
19	46	FEMALE	53	III	ACOM ANEURYSM BLED,SAH
20	46	MALE	62	II	RIGHT TEMPORAL GLIOMA
21	40	MALE	67	I	RIGHT INSULAR GLIOMA
22	46	MALE	70	II	RIGHT PARIETO OCCIPITAL GLIOMA
23	18	MALE	63	I	LEFT CEREBELLAR GLIOMA
24	52	MALE	90	III	LEFT FRONTAL GLIOMA
25	57	FEMALE	47	III	RIGHT FRONTAL MENINGIOMA

GROUP B					
1	54	FEMALE	54	II	LEFT FRONTAL GLIOMA
2	55	MALE	60	III	LEFT TEMPORAL HIGH GRADE GLIOMA
3	55	FEMALE	70	IV	ACOM ANEURYSM WITH SAH
4	57	FEMALE	70	III	LEFT LATERAL WING SPENOID MENINGIOMA
5	32	FEMALE	70	II	LEFT OPTHALMIC ARTERY AND PARA PCOM ANEURYSM BLED
6	52	FEMALE	60	III	SAH WITH LEFT MCA ANEURYSM
7	48	FEMALE	50	III	SAH WITH ACOM ANEURYSM
8	48	MALE	75	II	RIGHT FRONTAL CONVEXITY MENINGIOMA
9	51	MALE	46	III	RIGHT FRONTO TEMPORAL MULTIFOCAL GLIOMA
10	61	FEMALE	60	III	RIGHT MCS STROKE
11	46	MALE	60	II	RIGHT FRONTAL MENINGIOMA
12	61	MALE	80	III	LEFT FRONTAL MENINGIOMA
GROUP C					
1	20	FEMALE	50	IV	CVT-RIGHT SIGMOID SINUS AND TRANSVERSE SINUS THROMBOSIS WITH ICH
2	58	FEMALE	65	III	ANTERIOR SKULL BASE FUNGAL GRANULOMA
3	76	FEMALE	65	III	OBSTRUCTIVE HYDROCEPHALUS
4	52	MALE	52	IV	LEFT MCA MALIGNANT STROKE
5	73	MALE	70	III	B/L FRONTO PARIETAL SDH
6	52	MALE	50	III	R MCA BIFURCATION ANEURYSM WITH IC BLEED
7	47	MALE	75	III	LEFT CAPSULOGANGLIONIC BLEED
8	50	FEMALE	50	IV	LEFT TEMPEROPARIETAL HAEMATOMA
9	54	MALE	70	III	LEFT MCA INFARCT S/P MECHANICAL THROMBECTOMY

GROUP S					
1	18	FEMALE	50	I	COMPLEX CVJ ANOMALY WITH MYELOPATHY
2	57	MALE	67	II	DEGENERATIVE CERVICAL COMPRESSIVE MYELOPATHY
3	31	MALE	68	I	L5-S1 IVDP WITH RADICULOPATHY
4	47	FEMALE	61	II	CERVICAL COMPRESSIVE MYELOPATHY AT C5-C6 LEVELS
5	25	MALE	45	I	DORSAL CHONDROSARCOMA
6	46	FEMALE	60	I	C3-C4IDEM
7	47	MALE	60	II	L5-L5IVDP WITH CAUDA EQUINA
8	42	FEMALE	45	II	IDEM FORAMEN MAGNUM
9	52	MALE	52	II	L4-L5 EXTRUDED DISC
10	35	FEMALE	60	II	L4-L5 EXTRUDED DISC

	IMAGE FINDINGS						
	DECRESED VENTRICLE SIZE	DECREASED BASILAR CISTERN SIZE	EFFACEMENT OF SULCI	MIDLINE SHIFT(MLS)	SUBFALCINE HERNIATION	TRANSTENTORIAL HERNIATION	LOSS OF GREY WHITE DIFFERENTIATION
	GROUP A						
1.	YES	YES	YES	6MM	NO	NO	NO
2.	NO	NO	YES	5MM	NO		YES
3.	NO	NO	YES	8.8MM	YES	NO	NO
4.	NO	NO	YES	10MM	YES	NO	YES
5.	NO	NO	YES	4.5MM	NO	NO	NO
6.	YES	NO	YES	5.0MM	NO	YES	NO
7.	NO	NO	YES	5.OMM	NO	NO	YES
8.	YES	NO	YES	6.5MM	NO	NO	YES
9.	YES	NO	YES	8.6MM	NO	NO	NO
10	NO	NO	YES	5MM	NO	NO	YES
11	NO	NO	YES	3.4MM	YES	NO	YES
12	YES	NO	YES	6.2MM	YES	NO	YES
13	YES	NO	YES	5.0MM	NO	NO	NO
14	YES	NO	NO	8MM	YES	NO	NO
15	YES	NO	NO	9MM	YES	NO	NO
16	YES	NO	NO	6.2MM	YES	NO	YES
17	NO	NO	NO	14MM	NO	NO	NO
18	NO	YES	NO	N	NO	NO	NO
19	NO	NO	NO	N	NO	NO	NO
20	YES	NO	NO	N	NO	NO	NO
21	YES	NO	YES	8.6MM	NO	NO	NO
22	YES	NO	YES	5	YES	NO	NO
23	NO	NO	NO	N	NO	NO	NO
24	NO	NO	NO	3MM	NO	NO	YES
25	YES	NO	YES	22MM	YES	NO	NO

GROUP B							
1.	YES	NO	YES	5.2MM	NO	NO	YES
2.	YES	YES	YES	6.6MM	YES	YES	YES
3.	NO	NO	YES	4MM	NO	NO	YES
4.	NO	NO	NO	10MM	YES	YES	NO
5.	YES	YES	YES	2MM	NO	NO	NO
6.	YES	YES	YES	NO	NO	NO	NO
7.	YES	YES	NO	NO	NO	NO	NO
8.	NO	NO	NO	5MM	YES	YES	NO
9.	YES	NO	YES	NO	YES	NO	NO
10	NO	NO	NO	NO	YES	NO	NO
11	YES	NO	YES	23MM	YES	YES	NO
12	YES	NO	YES	12MM	YES	NO	YES
GROUP C							
1.	NO	YES	NO	3MM	YES	NO	NO
2.	YES	NO	NO	5MM	YES	NO	NO
3.	YES	NO	NO	NO	NO	NO	NO
4.	YES	YES	NO	5.5MM	YES	YES	NO
5.	YES	NO	NO	NO	NO	NO	NO
6.	NO	NO	YES	NO	NO	NO	NO
7.	YES	YES	NO	5MM	NO	YES	NO
8.	YES	YES	NO	10MM	YES	YES	NO
9.	NO	NO	NO	6MM	YES	YES	NO

CLINICAL DATA

PREOPERATIVE

	HR(beats/min)	SBP(mm Hg)	DBP(mm Hg)	MAP (mm Hg)	RR (/min)	SpO2 (%)SATURATION
SLNO	GROUP A					
1.	70	125	80	95	16	100
2.	80	109	83	91.6666667	15	100
3.	70	120	70	86.6666667	16	100
4.	50	110	80	90	14	100
5.	60	110	72	84.6666667	14	100
6.	90	134	81	98.6666667	16	100
7.	68	114	72	86	15	100
8.	100	150	100	116.666667	16	100
9.	94	154	94	114	16	100
10.	60	140	80	100	18	100
11.	72	110	80	90	18	100
12.	70	110	70	83.3333333	17	100
13.	80	102	74	83.3333333	18	100
14.	80	114	72	86	16	100
15.	80	130	80	96.6666667	17	100
16.	90	131	87	101.666667	15	100
17.	60	150	80	103.333333	18	100
18.	60	110	70	83.3333333	18	100
19.	70	110	70	83.3333333	16	100
20.	50	138	72	94	20	100
21.	50	133	90	104.333333	18	100
22.	70	140	70	93.3333333	18	100
23.	50	86	65	72	16	100
24.	60	98	70	79.3333333	18	100
25.	92	132	82	98.6666667	19	100

	GROUP B					
1.	50	150	90	110	15	98
2.	80	160	90	113.333333	18	100
3.	110	150	100	116.666667	20	96
4.	82	146	72	96.6666667	19	100
5.	70	149	99	115.666667	19	100
6.	54	134	74	94	16	100
7.	45	160	80	106.666667	18	99
8.	80	115	74	87.6666667	18	99
9.	41	140	100	113.333333	20	98
10.	50	150	70	96.6666667	18	100
11.	74	120	84	96	20	100
12.	50	116	63	80.6666667	16	97
	GROUP C					
1.	40	160	90	113.333333	12	100
2.	75	135	66	89	14	100
3.	70	140	80	100	30	100
4.	80	130	80	96.6666667	28	100
5.	120	160	80	106.666667	35	100
6.	50	150	70	96.6666667	19	100
7.	48	170	100	123.333333	30	98
8.	70	112	70	84	27	100
9.	90	140	80	100	22	1000
	GROUP S					
1.	60	94	44	60.6666667	19	100
2.	68	143	88	106.333333	16	100
3.	60	128	60	82.6666667	15	100
4.	76	116	76	89.3333333	18	100
5.	80	107	70	82.3333333	20	100
6.	68	110	77	88	18	100
7.	80	138	92	107.333333	14	100
8.	80	121	86	97.6666667	18	100
9.	80	120	88	98.6666667	16	100
10.	86	130	80	96.6666667	19	100

POSTOPERATIVE 24 HRS

SLNO	HR(beats/ min)	SBP(mm Hg)	DBP(m m Hg)	MAP (mm Hg)	RR (/min)	SpO2 (%)SATURATION
GROUP A						
1.	76	120	70	86.6666667	14	100
2.	80	119	78	91.6666667	12	100
3.	80	130	80	96.6666667	15	100
4.	68	130	80	96.6666667	12	100
5.	57	109	56	73.6666667	20	100
6.	60	118	72	87.3333333	16	100
7.	120	110	70	83.3333333	18	100
8.	80	115	77	89.6666667	16	100
9.	80	117	75	89	14	100
10.	55	160	110	126.666667	20	100
11.	76	122	84	96.6666667	16	100
12.	80	100	74	82.6666667	19	100
13.	120	120	80	93.3333333	16	100
14.	70	110	70	83.3333333	18	100
15.	80	114	85	94.6666667	18	100
16.	82	120	70	86.6666667	16	100
17.	70	140	70	93.3333333	18	100
18.	70	150	74	99.3333333	16	100
19.	50	142	78	99.3333333	18	100
20.	55	118	80	92.6666667	18	100
21.	56	131	84	99.6666667	20	100
22.	76	113	70	84.3333333	19	100
23.	52	90	55	66.6666667	14	100
24.	80	112	91	98	16	100
25.	90	140	89	106	22	100

GROUP B						
1.	106	145	84	104.333333	20	99
2.	74	130	70	90	16	100
3.	78	140	80	100	18	98
4.	56	124	58	80	19	100
5.	80	152	99	116.666667	20	100
6.	52	150	80	103.333333	18	100
7.	50	150	73	98.6666667	16	100
8.	60	124	83	96.6666667	16	100
9.	46	150	97	114.666667	18	99
10.	56	124	64	84	20	100
11.	86	119	78	91.6666667	16	100
12.	48	121	70	87	14	100
GROUP C						
1.	60	109	51	70.3333333	12	100
2.	65	120	57	78	14	100
3.	72	138	76	96.6666667	14	100
4.	80	130	80	96.6666667	14	100
5.	90	140	80	100	18	100
6.	110	155	72	99.6666667	17	100
7.	50	157	100	119	16	100
8.	76	140	60	86.6666667	16	100
9.	74	150	60	90	12	100
GROUP S						
1.	70	97	54	68.3333333	20	100
2.	70	130	88	102	16	100
3.	70	130	60	83.3333333	14	100
4.	80	123	66	85	16	100
5.	120	115	60	78.3333333	18	100
6.	70	126	74	91.3333333	18	100
7.	85	124	82	96	15	100
8.	90	120	84	96	20	100
9.	78	126	78	94	16	100
10.	84	128	76	93.3333333	17	100

DISCHARGE

SLNO	HR(beats/min)	SBP(mm Hg)	DBP(mm Hg)	MAP (mm Hg)	RR (/min)	SpO2 (%)SATURATION
GROUP A						
1.	80	112	70	84	16	100
2.	80	117	75	89	12	100
3.	68	110	70	83.3333333	15	100
4.	76	120	70	86.6666667	14	100
5.	58	110	60	76.6666667	18	100
6.	70	120	84	96	14	100
7.	78	120	80	93.3333333	16	100
8.	75	146	89	108	15	100
9.	76	142	100	114	18	100
10.	55	137	92	107	20	100
11.	100	114	70	84.6666667	18	100
12.	50	100	60	73.3333333	17	100
13.	80	124	90	101.333333	20	100
14.	84	120	72	88	18	100
15.	84	120	68	85.3333333	16	100
16.	72	130	70	90	18	100
17.	50	123	54	77	18	100
18.	90	108	68	81.3333333	15	100
19.	68	135	82	99.6666667	16	100
20.	60	112	75	87.3333333	18	100
21.	52	138	81	100	16	100
22.	80	158	64	95.3333333	18	100
23.	54	104	63	76.6666667	14	100
24.	90	132	87	102	16	100
25.	78	130	90	103.333333	18	100

GROUP B						
1.	74	136	82	100	16	100
2.	70	140	80	100	20	100
3.	72	150	70	96.6666667	22	100
4.	90	110	70	83.3333333	22	100
5.	64	132	98	109.333333	18	100
6.	61	151	66	94.3333333	18	100
7.	52	113	67	82.3333333	16	100
8.	50	136	95	108.666667	16	100
9.	50	138	77	97.3333333	18	99
10.	63	138	64	88.6666667	18	100
11.	86	127	78	85	15	100
12.	88	117	80	85	14	100
GROUP C						
1.	80	143	85	104.333333	12	100
2.	65	145	75	98.3333333	15	100
3.	64	127	76	93	16	100
4.	80	140	84	102.666667	16	100
5.	76	136	76	96	24	100
6.	55	130	90	103.333333	17	100
7.	60	130	82	98	18	100
8.	70	132	70	90.6666667	16	100
9.	45	90	60	70	18	100
GROUP S						
1.	70	92	60	70.6666667	16	100
2.	80	130	76	94	16	100
3.	80	120	80	93.3333333	15	100
4.	86	148	64	92	15	100
5.	100	100	80	86.6666667	16	100
6.	72	134	60	84.6666667	16	100
7.	90	106	65	78.6666667	15	100
8.	86	120	80	93.3333333	18	100
9.	82	124	82	96	16	100
10.	80	120	70	86.6666667	17	100

NIRS VALUES

	NIRS-PREOP		NIRS -POSTOP 24HRS		DISCHARGE	
SLNO	RIGHT SIDE	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE	LEFT SIDE
GROUP A						
1.	68	69	68	75	73	77
2.	65	68	73	79	70	78
3.	65	54	76	71	74	72
4.	64	69	91	64	84	74
5.	46	69	84	74	80	70
6.	65	75	68	70	66	70
7.	78	76	76	70	74	72
8.	61	59	61	60	62	60
9.	60	56	56	58	57	60
10.	69	71	74	77	72	75
11.	71	69	64	62	65	63
12.	69	64	71	63	70	64
13.	63	71	60	68	64	66
14.	70	68	72	70	70	66
15.	72	66	70	72	64	68
16.	68	75	68	76	72	76
17.	74	76	76	72	72	67
18.	68	69	61	60	65	63
19.	65	68	56	58	70	64
20.	65	54	74	77	64	66
21.	64	69	64	62	70	78
22.	66	67	71	63	74	72
23.	69	70	68	76	67	70
24.	80	79	82	78	75	68
25.	66	71	65	67	62	65

GROUP B						
1.	72	66	73	70	72	71
2.	65	70	63	70	65	68
3.	72	68	75	82	70	80
4.	67	70	62	68	63	74
5.	68	75	70	76	72	70
6.	65	70	68	72	67	69
7.	66	72	64	66	65	64
8.	74	72	70	69	68	70
9.	72	75	67	71	70	80
10.	66	68	65	62	63	74
11.	60	72	60	68	72	70
12.	66	71	62	67	71	76
GROUP C						
1.	72	68	68	66	65	63
2.	79	75	80	74	78	76
3.	68	70	72	66	68	64
4.	80	64	82	69	76	74
5.	67	66	67	69	69	74
6.	71	74	70	66	71	68
7.	70	61	59	62	69	70
8.	66	65	66	64	76	74
9.	74	72	70	68	69	74
GROUP S						
1.	80	77	68	66	63	65
2.	78	81	70	72	78	69
3.	76	70	67	59	78	70
4.	68	74	64	76	64	64
5.	72	69	60	66	76	71
6.	76	66	66	69	75	66
7.	65	72	62	61	69	70
8.	65	74	70	67	68	72
9.	66	66	74	70	70	72
10.	75	77	65	71	68	70

ONSD

	PREOP		POSTOP 24HRS	
SLNO	RIGHT EYE	LEFT EYE	RIGHT EYE	LEFT EYE
	GROUP A			
1.	3.79	4.49	3.67	4.41
2.	4.25	3.35	4.08	3.72
3.	4.98	4.5	5.34	5.05
4.	4.09	4.42	4.3	4.6
5.	4.2	4.78	3.93	4.95
6.	3.9	4.72	3.73	4.51
7.	4.21	3.82	4.03	3.65
8.	4.8	4.4	4.76	4.28
9.	5.34	4.85	5.22	5.27
10.	4.23	5.13	4.2	5
11.	5.49	4.45	5.2	4.21
12.	4.53	5.62	4.27	5.42
13.	4.73	4.05	4.5	4
14.	4.68	5.67	4.55	5.2
15.	4.89	5.2	4.6	4.8
16.	5.72	5.99	5.5	5.94
17.	4.69	5.06	4.4	4.83
18.	4.9	5	4.91	4.83
19.	4.85	4.9	4.78	4.8
20.	5.35	5.69	5.27	5.58
21.	5.5	4.85	5.22	5.27
22.	5.3	4.5	5.1	4.8
23.	4.2	4.42	4.1	4.4
24.	4.6	5	4.5	4.9
25.	4.9	5.4	4.7	5.21

GROUP B				
1.	5.3	5	5.21	4.61
2.	4.61	5.64	4.9	4.34
3.	4.8	4.72	4.51	4.68
4.	5.7	5.56	5.6	5.49
5.	4.9	5.2	4.6	4.8
6.	5.35	4.84	5.94	6.07
7.	4.69	5.06	4.5	4.83
8.	5.97	5.75	5.3	5.1
9.	5.49	5.28	5.3	5
10.	5.5	5.1	5.2	5
11.	5.4	4.9	5.3	4.78
12.	5.45	5.06	5.1	5
GROUP C				
1.	5.9	5.6	5	4.9
2.	5.2	4.2	5.12	4.11
3.	4.25	4.6	4.2	4.5
4.	5.49	5.18	4.63	4.97
5.	4.87	4.9	4.6	4.56
6.	5.6	5.4	5.1	5.2
7.	5.4	5.6	5	5.2
8.	5.6	5.1	5	4.9
9.	5.7	5.2	5.1	4.8
GROUP S				
1.	4.5	4	4.4	4
2.	3.58	4.92	3.56	4.9
3.	3.11	4.79	3.1	4.68
4.	4.08	4.34	4	4.3
5.	4.42	3.86	4.4	3.8
6.	4.83	4.04	4.78	4
7.	3.56	3.71	3.5	3.7
8.	4.23	4.75	4.2	4.69
9.	4.08	4.34	4	4.3
10.	3.89	4.1	3.9	4.1

TCD VELOCITIES

SLNO	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
GROUP A -PREOP																		
1.	73.7		91.83	55.1	83.02	46.29					21.6		43.2		1.21		0.70691995	
2.	68.7		83.02	46.29	68.07	40.41					37		52		0.61		0.46142649	
3.	33.5		40.41	16.9	36.8	21.31					14.7		21.5		0.87		0.56119403	
4.	54.5		65.39	34.53	52.16	30.13					28.1		38.9		0.68		0.48440367	
5.	86		88	41	80	36					39		56		0.7		0.54651163	
6.	60.7	74	66.53	28.33	54	26.86	81	41.2	73.4	39.2	20.7	34	32.7	51.3	1.22	0.9	0.65897858	0.55
7.	59.5	25.7	97.31	50.69	84.49	46.29	43.88	20.31	34	16.6	28.5	15	42.4	21	0.73	0.8	0.5210084	0.41634241
8.	41.4	31.1	41.21	17.7	35.33	17	42.41	17.37	32	17	14.2	20	23.8	20	1.14	0.85	0.65700483	0.35691318
9.	57.5	45.7	75.67	36	60.98	31.6	60.9	28.66	53.63	27.19	22.9	15.2	37.1	27.4	0.93	1.11	0.60173913	0.66739606
10	40.8	68.5	49.23	21.31	41.88	15.43	87.42	46.29	80.08	44.82	16.1	32.9	24.9	48.1	0.99	0.74	0.60539216	0.51970803
11	77.8	24.7	87.42	55.1	72.73	47.76	41.88	21.31	33.06	15.43	39.6	13.5	56	18.8	0.68	0.6	0.49100257	0.4534413
12	29.9	30.1	40.41	18.37	33.06	18.37	40.41	18.37	31.6	18.37	9.83	13.3	18	19.8	1.11	0.85	0.67123746	0.55813953
13	65.4	35.5	75.67	46.29	65.39	43.35	40.41	25.72	36	25.72	34.5	19	47	25.6	0.6	0.68	0.47247706	0.46478873
14	55.1	71.4	60.98	31.6	50.6	27.19	80.08	33.06	71.26	30.13	15.9	23.4	31.3	38.6	1.25	1.24	0.71143376	0.67226891
15	86.5	85.7	89.88	40.41	81.55	38.98	89.88	44.98	85.95	44	30.7	28	49.1	45.6	1.14	1.27	0.64508671	0.67327888
16	40.9	75.2	50.69	24.24	43.4	21.31	80.08	40.41	72.73	38.94	14.1	33.4	23.7	50.7	1.13	0.82	0.65525672	0.55585106
17	39.8	61.2	99.18	47.76	90.36	44.82	58.04	27.19	53.63	24.25	12.7	25.5	23.1	38.5	1.18	0.93	0.68090452	0.58333333
18	53.9	34.9	60.9	28.6	50.6	25.7	40.41	13.97	33.6	13	24.9	9.35	37	17.6	0.78	1.46	0.5380334	0.73209169
19	79.6	65.4	86.69	42.98	78.74	39	77.42	39	70.8	35	31.9	26	50.4	43.2	0.95	0.91	0.59924623	0.60244648
20	38	45.7	40.41	21.31	39.95	25.72	50.69	22.76	46.29	25.72	18.1	19.4	26.4	29.2	0.75	0.9	0.52368421	0.57549234
21	35.5	69.8	48.3	23.1	40.33	20	74.7	44.3	69.15	41.16	13.6	34.7	22.2	47.7	0.99	0.74	0.61690141	0.50286533
22	87.1	89.9	97.29	33.7	88.02	31.05	76.52	26.18	67	25.18	25.3	44.9	45.2	59.9	1.37	0.75	0.70952928	0.50055617
23	114	42.6	121	66.82	111.86	64.1	46.5	21.78	41.75	19.13	53.8	17.8	72.8	26	0.82	0.98	0.52807018	0.58215962
24	49.2	54.9	64.27	39	54.9	31.5	68.17	42.9	61.5	39	25.5	31.2	34.1	41.1	0.7	0.57	0.48170732	0.43169399
25	66	111	90.67	20.45	72	19.13	113.19	21.78	109.22	19.13	12.9	19.7	28.9	49.4	1.84	1.84	0.80454545	0.82252252

GROUP B-PREOP

SLNO	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
1.	47	65	47	65	54.1	42.2	22.8	14.7	70	25	60	19.6	29	34.1	1.05	1.45	0.64042553	0.72615385
2.	43.5	34.7	43.5	34.7	53.05	17.79	45.7	17.79	38.94	12.5	32.06	12.5	23.2	19.2	1.41	1.27	0.75172414	0.70317003
3.	66.1	64.6	66.1	64.6	68.32	15.37	58	13.97	63.92	28.66	55	25.2	21.3	37.3	2.66	1.11	0.85779123	0.64086687
4.	47.4	23.7	47.4	23.7	55.1	18.37	46.29	18.37	28.66	13.97	21.31	9.56	24.8	13	1.41	1.35	0.73628692	0.73544304
5.	39.5	50.5	39.5	50.5	50.69	22.79	41.88	18.37	58.04	27.19	47.76	25.72	21.8	31.4	1.15	0.93	0.63544304	0.57821782
6.	87.4	53.7	87.4	53.7	103.57	53.63	91.83	49.23	59.51	25.72	53.63	25.72	52.6	29.7	1.06	1.3	0.64073227	0.71880819
7.	61.2	57.6	61.2	57.6	63.92	28.66	55	25.72	62.45	24.25	52.16	25.76	33.3	29.4	1.19	1.37	0.64869281	0.69791667
8.	82.2	108	82.2	108	113.87	62.45	96.42	53.63	127.09	60.98	107.99	53.66	56.1	56.3	0.76	1.29	0.52068127	0.67037037
9.	38.3	15.6	38.3	15.6	46.9	25.75	41.6	24.43	102.5	58.87	89	50.9	26.5	48.9	0.92	0.73	0.5926893	0.51
10	50.5	65.3	50.5	65.3	52.5	23	45	20	70.8	28.4	58.87	24.43	25	21.1	1.1	1.18	0.58019802	0.68
11	99.9	91.3	99.9	91.3	101.27	46.95	90	42	95.97	45.63	81.39	39	30.9	50	1.13	1.34	0.75675676	0.73
12	35.6	66.2	35.6	66.2	39	15.15	30	12.5	69.4	23.1	60	20.45	18.7	32.7	1.37	1.45	0.7	0.7

GROUP C-PREOP

	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
1.	72	68.2	84.63	33.2	71.4	27.33	76.24	20.84	63.23	26.42	19	19.8	36	33.2	1.45	1.65	0.73611111	0.70967742
2.	61.2	50.8	65.39	25.72	58.64	22.78	40.1	23.78	33.39	20.15	17.1	23.1	31.8	35.1	1.39	0.98	0.72058824	0.54527559
3.	52.2	55.7	69.79	34.53	60.98	30.13	68.32	30.13	50.69	28.6	22.1	21.4	34.3	34.2	0.81	1	0.57662835	0.61579892
4.	43.3	39.2	44.82	21.31	38	18.37	43.35	11.03	40	12	15.3	9.95	26.8	18.8	1.05	1.56	0.64665127	0.74617347
5.	29.1	69.2	41.31	14.86	33.96	11.93	77.14	19.84	62.45	25.72	8.98	16.8	15.6	32.2	1.29	1.63	0.69140893	0.75722543
6.	29.6	52.8	41.65	20.45	31.05	19.13	39	21.78	32.38	19.13	12.15	22.4	19.2	34.5	0.89	0.88	0.58952703	0.57575758
7.	24.9	23.3	29.43	16.19	25	15.52	24.8	14.2	22.15	12.87	6	11	14.6	16.1	1.29	0.76	0.75903614	0.527897
8.	65.4	47.8	68.15	21.78	52.25	21.75	48.27	21.78	45.63	19.48	17.5	12.4	32.2	23.2	1.18	1.38	0.7324159	0.74058577
9.	72.1	61.5	90.67	9.7	77.47	8.53	77.4	12.5	65.5	11.18	7.68	4.64	26.3	25.4	2.45	2.24	0.89348128	0.92455285

GROUP S-PREOP

	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
1.	109.2	37.6	98.6	32.3	44.95	17.8	44.3	17.8	33.6	14	109.2	37.6	56.5	26	1.17	1.12	0.6626506	0.67592593
2.	89.88	28.4	84.04	27.73	62.85	15.15	61.5	15	28.2	13.5	89.88	28.4	45.7	27.6	1.12	1.65	0.64528302	0.7715736
3.	94.64	45.63	89.34	44.9	97.2	44.9	89	40.3	45	42.3	94.64	45.63	63.3	59.6	0.75	0.84	0.51	0.54
4.	69.5	33.76	58.93	24	76.5	35.3	73	33	22.1	33.8	69.5	33.76	35.2	51.5	0.92	0.83	0.59	0.56
5.	73.4	38.4	64.1	31	94.6	41.6	85.3	39	22.8	33	73.4	38.4	37.9	51	1.11	1.06	0.65	0.67
6.	70.8	25.7	54.9	14.13	113	54.9	107.2	50.9	23.3	51.3	70.8	25.7	38	73.7	0.91	0.7	0.51	0.5
7.	57.55	25.75	54.9	24.43	77.42	37.6	70.8	35	17.8	29	57.55	25.75	26.6	42.9	0.86	0.98	0.56	0.59
8.	89.86	39	77.42	32.3	86.69	39	74.77	32.3	31.3	30.7	89.86	39	49.1	48.9	1	0.95	0.61	0.61
9.	36	16.3	29.5	14.9	57.55	28.4	52.25	31	13.3	25.5	36	16.3	20.1	39	0.72	0.75	0.54	0.54
10	72	38	65.1	32.3	74.4	32.4	69.6	28.1	36	38.2	72	38	49.4	51.9	0.55	0.57	0.43	0.43

POSTOP 24 HRS

SLNO	PSV		RIGHT				LEFT				EDV		MFV		PI		RI	
	RIGHT	LEFT	SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
								GROUP A -POSTOP 24 HRS										
1.	57										14		26		1.81		0.75438596	
2.	65		54.36	27.31	45.54	24.94					33		39		0.82		0.49230769	
3.	61		64	22	58	20					18		27		1.59		0.70491803	
4.	67.8		73.67	37.47	69.79	35.5					24.9		41.8		1.03		0.63274336	
5.	67.5		87.42	44.82	80.08	44.82					32.6		48.6		0.7		0.51703704	
6.	52.2	120	65.39	30.13	50.69	22.78	135	57.4	125.5	55.3	19.9	32.5	31.2	62.4	1.04	1.23	0.61877395	0.72916667
7.	103	41.9	113.87	50.69	93.8	38.94	60.98	30.13	53.63	28.66	39.6	19.9	36.8	31.1	1.2	1.12	0.61553398	0.52505967
8.	84.2	38.7	87.42	44.82	80.08	40.41	91.83	49.23	85.95	46.29	30.4	16.6	47.9	26.9	1.12	1	0.63895487	0.57105943
9.	105	81.7	124.15	56.67	112.4	47.76	99.18	46.29	83.02	40.41	43.8	34.7	69.6	53.7	0.88	0.88	0.58285714	0.5752754
10	93.4	90.1	105.5	55.1	93.3	52.16	94.7	49.23	83.02	44.82	41.7	37.5	58.8	54	0.88	0.97	0.55353319	0.58379578
11	57.7	41.9	69.97	34.53	63.92	30.13	60.98	30.13	53.63	28.66	13.8	19.9	32.8	31.1	1.34	0.71	0.76083189	0.52505967
12	87.7	38.7	88.39	47.76	87.42	49	91.83	49.23	85.95	46.29	37.8	16.6	56.9	26.9	0.88	0.83	0.56898518	0.57105943
13	86	67.3	90.36	46.29	81.55	40.41	80.08	34.5	66.86	31	29.9	24.4	50.6	39.8	1.11	1.08	0.65232558	0.63744428
14	41.9	43.2	50.69	22.78	47.19	22.21	46.62	14.29	47.19	22.21	15.3	13	24.2	21.6	1.1	1.39	0.63484487	0.69907407
15	89.3	84.3	94	40	85	35	88	37	85	34.7	35	34	54.9	52.3	0.99	0.96	0.60806271	0.59667853
16	91.3	135	100.65	43.35	87.47	44.83	147.66	66.86	137.48	63.9	26.6	35.2	48.5	71.6	1.33	1.39	0.70865279	0.73925926
17	59.5	41.8	66.86	28.86	60.98	25.72	54.36	22.04	49.64	20.08	16.6	9.95	30.1	21.4	1.42	1.5	0.7210084	0.76196172
18	116	63.5	127	66.86	115.3	63.32	66.32	39.94	59.51	33.06	56.4	28.5	80.4	42.2	0.75	0.83	0.5137931	0.5511811
19	115	85.5	129	61	110	53.57	97.29	35	82.72	31	44.2	24.6	70.2	46.1	1.02	1.32	0.61565217	0.7122807
20	43.3	73.7	47.76	27.16	46.29	24.25	90.67	44.94	78.74	44.94	26.7	37.3	30.4	53.8	0.84	0.68	0.56	0.49389417
21	54	82	74	44	53	28.4	84.04	40.33	74.77	40.33	16.8	30.2	49.1	3.32	1	0.7	0.62	0.65
22	47.9	137	54.9	25.75	45.3	25.75	151	64.17	137	54.5	16.5	48.2	27.2	79.4	1.15	1.13	0.66	0.65
23	87.7	38.7	88.39	47.76	87.42	49	91.83	49.23	85.95	46.29	64	70	56.9	26.9	0.88	0.83	0.27023945	-0.8087855
24	41.9	43.2	50.69	22.78	47.19	22.21	46.62	14.29	46.5	21	37.8	16.6	24.2	21.6	1.1	1.39	0.09785203	0.61574074
25	47.4	110	54.9	9.86	45.63	9.86	117.1	17.8	106.5	15.15	6.32	14.2	19.2	43.2	2.14	2.22	0.87	0.81

GROUP B-POSTOP 24 HRS

SLNO	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
1.	47	65	47	65	54.1	42.2	22.8	14.7	70	25	60	19.6	35.3	46.5	1.27	1.34	0.5888	0.72053872
2.	43.5	34.7	43.5	34.7	53.05	17.79	45.7	17.79	38.94	12.5	32.06	12.5	14.9	46.8	1.32	1.32	0.74356061	0.73571429
3.	66.1	64.6	66.1	64.6	68.32	15.37	58	13.97	63.92	28.66	55	25.2	94.3	28.7	1.23	1.44	0.68934911	0.72631579
4.	47.4	23.7	47.4	23.7	55.1	18.37	46.29	18.37	28.66	13.97	21.31	9.56	26.2	12.8	1.75	1.77	0.81349911	0.81805054
5.	39.5	50.5	39.5	50.5	50.69	22.79	41.88	18.37	58.04	27.19	47.76	25.72	26.9	42	0.76	0.71	0.50995025	0.47833066
6.	87.4	53.7	87.4	53.7	103.57	53.63	91.83	49.23	59.51	25.72	53.63	25.72	14.8	20	1.42	1.92	0.49659864	0.55947137
7.	61.2	57.6	61.2	57.6	63.92	28.66	55	25.72	62.45	24.25	52.16	25.76	97.3	104	1.19	1.1	0.43430233	0.39181287
8.	82.2	108	82.2	108	113.87	62.45	96.42	53.63	127.09	60.98	107.99	53.66	14.6	51.7	0.98	1.04	0.38135593	0.41581921
9.	38.3	15.6	38.3	15.6	46.9	25.75	41.6	24.43	102.5	58.87	89	50.9	26.5	48.9	0.96	0.92	0.6	0.92
10	50.5	65.3	50.5	65.3	52.5	23	45	20	70.8	28.4	58.87	24.43	31.3	42.1	0.78	1.15	0.53	0.68
11	99.9	91.3	99.9	91.3	101.27	46.95	90	42	95.97	45.63	81.39	39	55.8	56.4	1.19	1.18	0.68	0.69
12	35.6	66.2	35.6	66.2	39	15.15	30	12.5	69.4	23.1	60	20.45	43.5	47.4	1.2	1.36	0.67	0.71

GROUP C-POSTOP 24 HRS

	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
1.	124	40.9	153.54	65.39	135	50.89	47.3	17.1	35.1	17.1	42	21.2	75	20.1	1.09	1.14	0.66129032	0.48166259
2.	34.8	111	44.82	13.97	41.88	12.9	117.4	61.2	101.4	59.3	12.1	50.1	21.2	70	1.07	0.81	0.65229885	0.54864865
3.	98.1	102	127.09	38.94	115.34	40.41	159.41	65.39	137.78	50.69	29	45.7	56	79.3	1.23	0.71	0.70438328	0.55196078
4.	74.8	35.7	88.39	38.94	78.61	33.06	37.47	18.37	36	17	19.7	20.9	41.2	11.4	1.34	1.16	0.73663102	0.41456583
5.	63.7	38.9	69.79	21.31	63	18.37	46.29	16.9	34.5	16.9	14.8	9.06	31.4	18.2	1.55	1.74	0.76766091	0.76709512
6.	79	109	97.29	45.63	82.72	41.65	116.32	60.68	100.42	58.03	34	48.8	52.9	74.3	0.85	0.81	0.56962025	0.55229358
7.	104	42.6	110.5	68.15	103.92	65.5	45.63	23.1	42.9	25.7	58.4	19.1	77.6	28	0.59	0.84	0.43846154	0.55164319
8.	72.5	90.1	74.77	33.7	64.17	32.38	91.99	40.33	82.72	37.68	24	23.9	41.2	47.8	1.18	1.38	0.66896552	0.73473918
9.	90.1	104	97.29	35.03	80.07	27.08	126.44	65.5	118.8	61.6	37.9	58.1	58.7	76.2	1.01	0.6	0.61	0.44134615

GROUP S-POSTOP 24 HRS																				
	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI			
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT		
1.	123	49.8	133	39	125.1	32.8	60.5	19.13	54.9	15.15	33.2	14.1	57.8	25	1.55	1..43	0.7300813	0.71686747		
2.	90.7	65.1	99.94	32.3	94.64	32	70.8	23.1	68.15	23.1	26	37.3	49.6	20.3	1.29	1.2	0.71334068	0.42703533		
3.	92	66	100	35	95.7	33.4	72	25	70	24.7	27	38	50.4	22	1.14	1.1	0.70652174	0.42424242		
4.	58.8	38.9	60.2	23.1	58.87	23.2	46.9	19.1	39	15.14	19.9	14.9	32.4	22.8	1.2	1.06	0.66	0.62		
5.	59.8	83	90.67	33.7	84	35.05	99.97	44.3	89.34	37.6	22.5	34.1	38.6	48.8	0.97	1	0.62	0.59		
6.	51.6	53.4	52.25	24	48.2	23.1	61.5	37	53.5	31	20.4	29.9	32	41.5	0.97	0.57	0.6	0.44		
7.	87.1	85.2	90.67	39	82.7	37.6	90.67	39	84	33.7	34.4	30.6	29.1	31.7	1.1	1.24	0.64	0.68		
8.	82	101	91.99	37.6	86.69	36.5	114.5	46	110	42	28.8	38.1	49.7	63.9	1.07	0.98	0.65	0.61		
9.	30	55	37	20	30	15	58	30	53.1	29	14	26	22	41	0.75	0.75	0.54	0.54		
10	54.4	50	62.3	28.1	54.6	24.3	53.1	22.5	43.6	17.9	25.8	19.3	38.6	30.4	0.74	1.01	0.55	0.61		

LNO	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
GROUP A -DISCHARGE																		
1.	56		57	16	53	12					14		29		1.45		0.75	
2.	89		93.2	37.1	87.4	33.2					35		50		1.08		0.606741573	
3.	25		28	23.4	25	20.7					22		18		0.17		0.12	
4.	69.4		85.81	42.61	80.8	38					25.9		44.4		0.98		0.626801153	
5.	61		63	27	58	23					25		40		0.9		0.590163934	
6.	76	140	78.2	48.6	70.5	44	160	85	145	76	35	63	47	88.66	0.87	0.86842105	0.539473684	0.55
7.	66.4	121	77.07	35.36	61.81	30.96	144.72	59.51	134.44	55.1	22.4	49.1	36.8	73.06	1.2	0.98403285	0.662650602	0.594214877
8.	98.5	31.3	47.76	19.84	43.35	21.31	37.47	21.31	31.6	19.87	33	12.3	55.6	18.63	1.18	1.019678	0.664974619	0.607028753
9.	54.7	57.5	64.87	26.67	58.99	23.73	66.86	28.66	62.45	28.66	17.5	18.4	32.1	33.4	1.16	1.17	0.680073126	0.68
10	44	124	144.72	78.61	127.69	66.86	151.12	73.25	139.36	71.78	8.67	55.8	20.5	77.7	1.74	0.87	0.802954545	0.55
11	44.7	121	52.16	21.31	43.45	18.3	144.72	59.51	134.44	55.1	11.9	49.1	24	76.1	1.37	0.94	0.733780761	0.594214877
12	36.7	31.3	43.35	22.78	36	21.31	37.47	21.31	31.6	19.87	12.3	12.3	21.3	19.7	1.14	0.96	0.664850136	0.607028753
13	88.3	51.7	90.37	58.04	84.99	56.57	60.98	30.13	50.69	31.6	43.1	33.7	61	22.2	0.74	0.88	0.51189128	0.348162477
14	91.3	36.9	107.9	50.69	90.36	46.29	43.35	24.25	37.49	19.84	31.6	14.9	48.8	21.7	1.22	1.01	0.65388828	0.596205956
15	89.3	84.3	89.88	44.94	87.42	47.76	93.8	49.23	83.62	41.88	35	34	54.9	52.3	0.99	0.96	0.60806271	0.596678523
16	46.6	196	53.63	22.78	46.29	22.78	202	90.41	182	91.88	13.2	69.1	24.3	126	1.38	1	0.716738197	0.647448983
17	93.9	52.6	102.2	44.82	94.77	41.88	58.04	25.72	52.16	24.26	25.1	13.2	48.7	28.8	1.41	1.36	0.732694356	0.749049433
18	61.4	32.4	72.73	31.6	56.5	24.25	43.35	18.37	36	18.37	22.3	11.8	38.7	20.2	1.01	1.03	0.636807818	0.635802468
19	71.7	48.7	130.4	66	126	62.8	52.5	28.4	49.1	25.5	47.4	19.9	75.7	31.5	0.92	0.91	0.6	0.59
20	101	99.9	107.99	44.95	97.71	43.35	103.9	53.63	94.77	45	35.7	42.7	57.2	65.6	1.14	0.87	0.65	0.57
21	62.3	78	78.74	40.33	68.15	28.4	89.88	40.333	81.39	40.33	19.2	25.8	37.2	42.2	1.16	1.24	0.68	0.67
22	56	79.5	73.45	32.3	68.15	28.4	84.04	40.33	74.77	40.33	16.8	30.2	32.5	49.1	1.2	1	0.7	0.62
23	40.1	54.9	44.3	16.48	37.68	12.5	57.55	28.4	52.5	27.1	9.15	12.7	19.7	28.5	1.57	1.48	0.7	0.77
24	44.7	56.3	52.16	21.31	43.45	18.3	69.4	36.35	62.85	37.69	11.9	27.67	24	38	1.37	0.76	0.733780761	0.51
25	93.9	109	97.2	29.7	90.5	25.75	115.8	32.8	110.5	32.3	26.1	29.5	51.9	63.2	1.31	1.26	0.72	0.73

ROUP B-DISCHARGE

LNO	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
13	40	81.2	42	7	39	4.5	56.55	35.03	54	33	38.8	40.6	20	55.7	1.68	0.8	0.03	0.5
14	54.3	26.3	65.39	19.84	56.57	19	36	12.5	25.72	9.56	13.5	6.34	29.5	13.7	1.38	1.46	0.751381215	0.7589353
15	55.7	54.7	115.34	30.13	102.12	27.19	68.32	25.72	59.51	25.72	21.4	16.1	34.2	31.1	1.58	1.24	0.615798923	0.7056672
16	40.8	60	50.69	18.37	47.76	21.31	64	8	59	5.5	11.5	7.8	23.2	22	1.26	1.4	0.718137255	0.87
17	60.8	59	65.39	43.35	58.04	41.88	65.39	41.88	62.45	40.41	40.1	35.6	48.6	46.5	0.43	0.5	0.340460526	0.3966101
18	73.2	89.8	80.08	36	75.67	33.05	102.12	52.16	94.77	44.82	21.6	33.9	37	52.2	1.39	1.07	0.704918033	0.6224944
19	68.8	144	75.76	36	68.32	36	164.89	81.15	158	75	35.5	73.2	35.5	73.2	1.39	1.49	0.484011628	0.4916666
20	74	113	80.08	40.41	75.67	38.74	124.15	66.86	112.4	65.39	44.3	62.7	44.3	62.7	1	1.11	0.401351351	0.4451327
21	43.1	88.9	49.6	25.75	41.6	23.1	90.61	42.98	88.7	42.98	16.5	34	26.6	54.1	1	1.02	0.617169374	0.6175478
22	80.1	87.3	84.1	45.63	74.7	39	94.64	39	82.72	32.38	36	24.8	55.1	49.4	0.8	1.26	0.550561798	0.7159221
23	48.5	72.5	55.9	23.1	48.27	19.13	80	31.5	70.8	28.4	14.5	19.4	29.9	41.5	1.14	1.28	0.7	0.73
24	69	82.9	69.47	42.98	66.82	41.65	57.55	37.03	54.9	35	38.8	42.6	49.6	57.6	0.6	0.7	0.44	0.49

ROUP C-DISCHARGE

	PSV		SYS MAX	DYS MAX	SYS MIN	DYS MIN	SYS MAX	DYS MAX	SYS MIN	DYS MIN	EDV		MFV		PI		RI	
	RIGHT	LEFT	RIGHT				LEFT				RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
10	39.8	88.3	42.76	26.6	35	20	90.188	54.4	73.1	40	21.4	45	29.5	65.1	0.62	0.94	0.462311558	0.4903737
11	99.8	97	108.7	36	96.95	29.37	99.2	38	94.2	38.1	21.6	43	45.5	55.3	1.72	1.1	0.783567134	0.5567010
12	101	47.7	99.18	40.41	81.55	33.06	66.84	25.72	56.57	20	41	20	48	23.7	1.4	1.75	0.594059406	0.5807127
13	106	124	112.4	53.6	100.65	46.29	132.9	63.9	127.09	60.98	41.4	50.7	68.1	80.1	0.95	0.91	0.609433962	0.5911290
14	47.2	64.9	52.16	18.37	44.82	18.37	71.26	19.84	62.4	16.9	11.6	15.8	24.9	34.2	1.43	1.43	0.754237288	0.7565485
15	64.7	91.8	74.77	33.7	58.87	28.4	99.97	57.5	88	48.27	26	45.4	41	64.3	0.99	0.72	0.598145286	0.5054466
16	92.7	72	99.94	57.55	86.69	45.63	89.88	53.57	72.2	38	37.1	23.1	54.6	40.1	1.02	1.34	0.59978425	0.6791666
17	29.1	96.6	39	13.83	28.4	11.18	98.62	37.6	93.32	37.6	6.37	31.1	15.4	60.2	1.48	1.09	0.781099656	0.6780538
18	29.5	0	39	3.23	29.73	1.91	0	0	0	0	1.53	0	8.28	0	3.38	0	0.948135593	0
19																		

GCS	GOSE AT DISCHARGE				
	1. Death	2. Persistent vegetative state	3. Severe disability	4. Moderate disability	5. Low disability
GROUP A					
1.					YES
2.					YES
3.				YES	
4.					YES
5.					YES
6.					YES
7.					YES
8.					YES
9.					YES
10.					YES
11.					YES
12.					YES
13.					YES
14.					YES
15.					YES
16.				YES	
17.					YES
18.					YES
19.				YES	
20.					yes
21.				YES	
22.				YES	
23.					
24.				YES	
25.				YES	
GROUP B					
1.			YES		
2.			YES		
3.			YES		
4.				YES	
5.					YES
6.			YES		
7.					YES
8.					YES
9.			YES		
10.			YES		
11.			YES		

12.				YES	
GROUP C					
1.				YES	
2.			YES		
3.			YES		
4.			YES		
5.		YES			
6.			YES		
7.			YES		
8.		YES			
GROUP S					
1.				YES	
2.					YES
3.					YES
4.					YES
5.				YES	
6.					YES
7.					YES
8.				YES	
9.					YES
10.					YES
11.					

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