Effect Of Different Surgical Positions On The Changes In Cerebral Venous Drainage And Intracranial Pressure (ICP) In Patients Undergoing Neurosurgery

Dissertation submitted for the partial fulfilment for the Requirement of
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of
DM Neuroanaesthesia

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DECLARATION

I hereby declare that this thesis titled "**Effect of different surgical positions on the changes in cerebral venous drainage and intracranial pressure (ICP) in patients undergoing neurosurgery**" has been prepared by me under the capable supervision and guidance of Dr. Manikandan.S, Professor & Head, Division of Neuroanaesthesia and Neurocritical Care, Department of Anaesthesiology, Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram.

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ABBREVIATIONS

ABG: Arterial blood gas.

ABP: Arterial blood pressure.

AIS: Acute ischemic stroke.

ANOVA: Analysis of variance.

ASA: American Society of Anaesthesiology.

CA: Cerebral autoregulation.

CBF: Cerebral blood flow.

CBV: Cerebral blood flow velocity.

CCA: Common carotid artery.

CFD: Color flow doppler.

CSA: Cross-sectional area.

CO: Cardiac output.

COPD: Chronic obstructive pulmonary disease.

CPP: Cerebral perfusion pressure.

CVP: Central venous pressure.

CVR: Cerebral vascular resistance.

DBP: Diastolic blood pressure.

DM: Diabetes mellitus.

ECG: Electrocardiogram.

EEG: Electroencephalogram.

$ETCO_2$: End tidal carbon dioxide.

EVD: External ventricular drainage.

FiO_2: Fraction of inspired oxygen.

GCS: Glasgow coma scale.

HOB: Head of bed.

HR: Heart Rate.

ICU: Intensive care unit.

IJV: Internal jugular vein.

RIJV: Right Internal jugular vein.

LIJV: Left Internal jugular vein.

MAC: Minimum alveolar concentration.

MAP: Mean Arterial Pressure.

MCA: Middle cerebral artery.

MFV: Mean flow velocity.

MHZ: Megahertz.

NIBP: Non-invasive blood pressure.

NSICU: Neuro surgical intensive care unit.

NICU: Neuro Intensive Care Unit.

NPO: Nil Per Oral.

ONSD: Optic nerve sheath diameter.

$PaCO_2$: Partial pressure of arterial carbon dioxide.

PEEP: Positive end expiratory pressure.

$PETCO_2$: Partial pressure of end tidal carbon dioxide.

PSV: Peak systolic velocity.

PWD: Pulsed wave doppler.

RR: Respiratory Rate.

rScO2: Regional cerebral oxygen saturation.

SAH: Sub arachnoid haemorrhage.

SBP: Systolic blood pressure.

SD: Standard Deviation.

SpO_2 (%): Peripheral oxygen saturation

SSPS: Statistical package for the social sciences.

TBI: Traumatic Brain Injury.

TCD: Transcranial Doppler.

USG: Ultrasound.

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ABSTRACT

Background: Various positions employed to facilitate neurosurgical procedures can compromise the cerebral venous return and can cause increase in intracranial pressure (ICP). There are no direct indices of cerebral venous drainage (CVD). We aimed to use ultrasound (USG) and Doppler indices to assess the changes in CVD during positioning (supine, prone, and lateral) of patients undergoing neurosurgical procedures.

Materials and Methods: After IEC approval, consented ASA I/II and III patients with GCS 14 to 15 undergoing elective primary brain tumour resection surgery were included. Internal jugular vein (IJV) cross-sectional areas and Doppler velocities were recorded on both sides with USG at three different time intervals (before induction of anaesthesia (T0), 10 minutes after induction (T1), and 10 minutes after final positioning (T2)). In addition, optic nerve sheath diameter (ONSD) was measured as an estimate of ICP at T1 and T2. A total of ninety patients were included in the three groups, that is, supine, lateral, and prone (30 each).

Results: The IJV flow bilaterally decreased significantly with maximum fall seen in supine (48%) and lateral (40%) positions and less severe in prone (23%). The decrease in flow was associated with concomitant decrease in cross sectional area of IJV which was seen maximum in lateral with park bench position which is usually employed for retro sigmoid suboccipital craniotomy and less with other positions. The non-invasive ICP measurement of optic nerve sheath diameter with the help of ocular ultrasound was most significantly decreased again in lateral position($p<0.05$). Though we did not find significant change in the non-invasive measurement of ICP, and brain relaxation score, the surgical bleeding was more in the lateral group. The right IJV was dominant in 76% patients.

Conclusion: We found that the IJV cross sectional area, velocity and flow, all increased following induction of anaesthesia from awake state, but significantly

reduced following final neurosurgical position especially in the lateral compared to supine and prone position. Hence, ultrasound guided assessment of IJV flow can be a useful and feasible bedside technique to quantify the neurosurgical position related changes in IJV venous drainage.

INTRODUCTION

Neurosurgical procedures involving brain and spinal cord pathologies require different positioning for surgical access depending on the location, site of the lesion and the surgical approach. Six basic body positions and their modifications employed to facilitate neurosurgical procedures are, supine, lateral, prone, concorde, sitting and three-quarter Prone. (1) The choice of the position usually depends on the maximum exposure and shortest approach to the lesion with minimal damage to surrounding structures. Amongst these, the commonly used positions in neurosurgery are supine, prone, lateral and park bench positions. (2)

The supine position is optimum for approach to the surgeries of frontal lobe and anterior spine and lateral position for temporal lobe. The park bench position, where patients lie on the side with head rotated and face towards the floor, is used for surgeries involving cerebello pontine angle tumors and lateral position is used for lesions in parieto-occipital cortex. The spinal cord and posterior fossa surgeries are done in prone position. (1)

The primary objective of perioperative positioning is to balance the optimal surgical exposure, to provide better operating conditions during surgery, with maintenance of cerebral hemodynamics and to maintain normal body alignment without causing injury. Many physical and physiological alterations can occur during patient position during anaesthesia. An important concern during positioning for the neuroanaesthetist is the position of the axes of neck and head with that of body. Inadvertent obstruction to the cerebral venous drainage by affecting flow through the internal jugular vein (IJV) due to

its kinking with excessive neck flexion and rotation is a frequent problem encountered. A rough estimate of two finger breadth gap between the mandible and the clavicle is clinically considered safe for IJV flow, though not supported by relevant studies. As the ICP is determined by intracranial contents (blood, cerebrospinal fluid and cerebral parenchyma) and the skull is a fixed vault, any increase in the volume of one or more components may increase ICP. Hence, in clinical practice it is important to prevent a rise in ICP to avoid intra operative brain bulge. Also, obstruction to cerebral venous outflow can lead to cerebral infarction, airway edema and neck swelling.

Cerebral venous blood flows through the cerebral venous sinus into the sigmoidal sinus and jugular bulb and drains into the internal jugular veins (IJV) and vertebral venous plexus. The total mean (SD) venous blood flow at rest is approximately 766 (226) ml/ min in healthy human volunteers in the supine position, with the majority of flow through the IJV 720 (232) ml/min and remaining flow of 47 (33) ml/min through the vertebral veins. (3) The incidence of different cerebral venous drainage patterns has been analyzed and has been found to be predominantly jugular and hence any flow impairment secondary to partial or total occlusion could potentially result in an increase in cerebral blood volume and ICP. IJV flow can be calculated by the equation Flow (ml.min-1) = Cross-sectional area (cm^2) * Doppler velocity (cm/s) *60. (3) Also, in ventilated patients PEEP can increase ICP and decrease mean arterial pressure, both resulting in decreased cerebral perfusion pressure (CPP),

by increasing central venous pressure (CVP) and by impeding cerebral venous return to the right atrium. (4)

In the mid cervical region of the neck, IJVs are easily accessible by duplex ultrasound and hence its diameter and flow can be calculated. (5) The concurrent changes in ICP associated with positioning due to change in the flow in the IJV can be studied with the help of noninvasive techniques of ICP measurement. 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. (6,7,8) The normal cut off range for ONSD in adults is 4.9 mm. More than 5 mm has been considered as raised intracranial pressure.

Patients with many intracranial pathologies coming for craniotomy undergo neurosurgical procedures in lateral, park bench or prone position for adequate surgical exposure. As previously mentioned, IJV being the dominant cerebral venous outflow in majority of population, any flow impairment during positioning can cause undesirable effects during the surgical procedure like brain bulge, excessive venous ooze and in the postoperative period in the form of brain edema, facial edema, IJV thrombosis etc. Maintaining adequate cerebral perfusion, minimizing ICP elevation and preventing position related complications is of paramount importance to the neuro anaesthesiologist during intraoperative patient care.

Currently, there is lack of adequate evidence on the effects of patient positioning on cerebral venous blood flow through the IJV and ICP changes under anaesthesia. We intend to study the cerebral venous drainage by studying the flow in IJV in different surgical positions under anaesthesia with the help of ultrasound and correlating the effect of changes in flow to the non-invasive estimation of ICP using the optic nerve sheath diameter (ONSD).

REVIEW OF LITERATURE

Neurosurgical procedures involve different patient positioning depending on the location of the pathological lesion as well as surgical approach. Positioning of the patient during neurosurgery requires utmost care and attention to the physical as well as physiological changes that can occur during the procedure. Patients positioning is a team effort by the surgeon and anesthesiologist. The most appropriate positioning of the patient should take care of both the surgical comfort will balancing the risks related to patient positioning. (9) The ideal patient positioning should facilitate the surgical procedure, but it the responsibility of the team to prevent any iatrogenic injuries and harm that may occur due to improper positioning. (10,11) Optimum positioning requires cooperation between the anesthesiologist and the neurosurgeon to achieve quality outcomes and also to recognize any adverse events that might occur to institute adequate therapy if necessary. Position related injuries are one of the important causes of malpractice claims in neurosurgery. (9)

There are six basic body positions utilized in neurological surgery namely; supine, lateral, prone, concorde, sitting and three-quarter prone. (2) Positioning of the neurosurgical patient becomes challenging as it mandates adequate anaesthetic depth, hemodynamic stability, appropriate monitoring and oxygenation. Many positions may require the disconnection of intravenous and arterial line and endotracheal tubes during movement or rotation of the patient. This situation may lead to a time period where the patient is neither monitored nor ventilated under anaesthesia which can be very dangerous in a

hemodynamically unstable patient. Various standard positioning for a range of procedures have been devised by the surgeons and the anaesthesiologists which can provide optimum surgical field while minimizing non anatomic patient positioning. Usually minor compromises in positioning might be tolerated for small procedures but neurosurgeries are typically long duration position which can cause potential harm due to ill positioning. (10,11) Any overlooking of even a small detail can result in long term or even permanent injury or disability after a long neurosurgical procedure. Positioning of the patient is usually based on the guidelines by the practice advisory of American society of anesthesiologists (ASA). (9)

Head positioning

Positioning for craniotomies for brain tumors begin with positioning of the head. Most surgical procedures are performed in the supine position with positioning of the head which can provide optimum surgical approach. (1) The neuro-anaesthesiologist should have adequate knowledge of the neurosurgical approach because evaluation of whether the patient can tolerate the desired intraoperative positioning especially long procedures is important. Excessive neck flexion and rotation can be hazardous to the patient which may impair cerebral venous drainage and result in increase in intracranial pressure, brain bulge and excessive venous oozing. (12)

The positioning of the head in neurosurgery (10) is based on two important principles:

(1) an imaginary trajectory from the highest point at the skull surface to the area of interest in the brain should be the shortest distance between the two points, and

(2) whenever possible, the exposed surface of the skull and an imaginary perimeter of craniotomy should be parallel to the floor

Types of craniotomies

There are five classic surgical approaches for craniotomies which are currently used: frontal, parietal, temporal, occipital, and posterior fossa.

To facilitate extensive exposure of entire lobe the modern neurosurgery uses six standard types of craniotomies as shown in Figure 1:

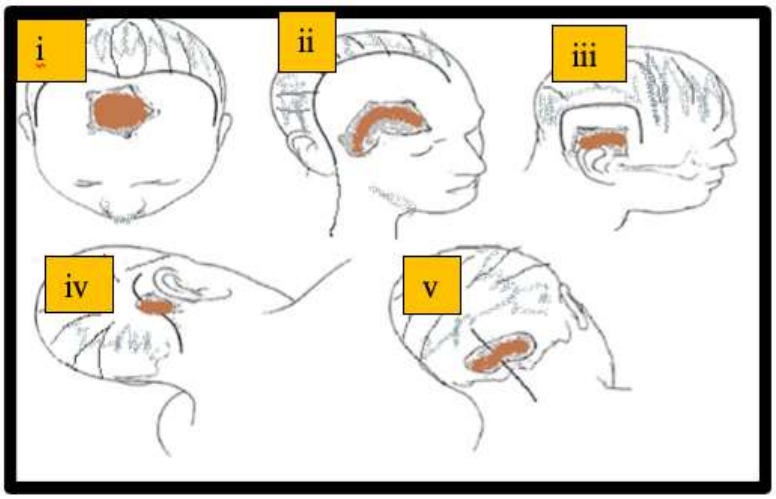


Figure 1 shows Types of standard craniotomies.[(i) anterior parasagittal, ii) fronto sphenotemporal (pterional), iii) subtemporal, iv) lateral suboccipital, and v) midline suboccipital].

These craniotomies are derived from the regional craniotomies by miniaturization of the area of exposure or combination of their different parts

The neurosurgical procedure for decompression of a primary brain lesion requires a craniotomy which is skeletally fixed with three or four pins fixation device. Usually a Mayfield frame which is three- pin device is used for fixation. The standard monitoring and invasive blood pressure monitoring starts before application of pins to monitor the surge in hemodynamics as well as be vigilant for any complications like bleeding and venous air embolism.

Excessive head rotation in terms of hyperflexion and hyperextension during position for craniotomies can lead to serious complications which can be prevented if carefully monitored and measured. (2) In healthy individuals excessive head and neck movement can lead to mechanical stress of arteries and veins supplying the brain and spinal cord. Hyperflexion of the head and neck may decrease blood flow in vertebral and carotid arteries, leading to brain stem and cervical spine ischemia, resulting in quadriparesis and quadriplegia. Patients with osteophytes, arthritis or vascular atherosclerosis are also at risk for cerebral ischemia, secondary to inappropriate head and neck movement. During positioning, the head can typically be safely rotated between 0 degrees and 45 degrees away from the body. (1) If more rotation is needed, a roll or pillow placement under the opposite shoulder is recommended. It is recommended that two to three finger-breadths of thyromental distance is

recommended during neck flexion. The patient's preoperative ability to move the neck without neurological consequences, such as paresthesias, pain, or dizziness may limit or dictate the extent of intraoperative head and neck positioning. Hyperflexion, hyperextension, lateral flexion or rotation should be avoided.

Complications Related to Head and Neck Positions

Benefits include surgical comfort and optimal access to the target area. Risks and complications of head positioning include: cervical strain, leading to postoperative discomfort and pain; necrosis of the chin; brachial plexus injury; obstruction of the cerebral lymphatic and venous outflow, leading to face, neck, and airway swelling; macroglossia, leading to the airway obstruction; obstruction of cerebro-spinal fluid flow; and obstruction of vertebral or carotid arteries, leading to the brain stem ischemia and quadriplegia. **(**12,13)

Impairment of cerebral venous outflow, especially during prolonged surgery, can potentially cause intraoperative brain swelling, increased intracranial pressure (ICP), ischemia and cerebral infarction. (3)

There are six basic body positions utilized in neurological surgery namely; supine, lateral, prone, concorde, sitting and three-quarters. Most surgical procedures are performed with the patient in the supine position and with little consultation between the surgeon and anesthesiologist.

A) **Supine position**

It is the most commonly used position for cranial procedures of the surgeries of lesions located in anterior and middle cranial fossa. This is the simplest and easily achievable position as it does not require disconnection of tracheal tubes or invasive monitors. But the extreme head rotation or flexion required for certain procedures makes this position risky. Usually the lawn chair modification of the supine position is used in neurosurgery which involves a reverse Trendelenbourg of 10 to 15 degrees from horizontal axis to provide optimum venous drainage from the brain as well as slight leg elevation to improve venous return to the heart as shown in Figure 2. (1)

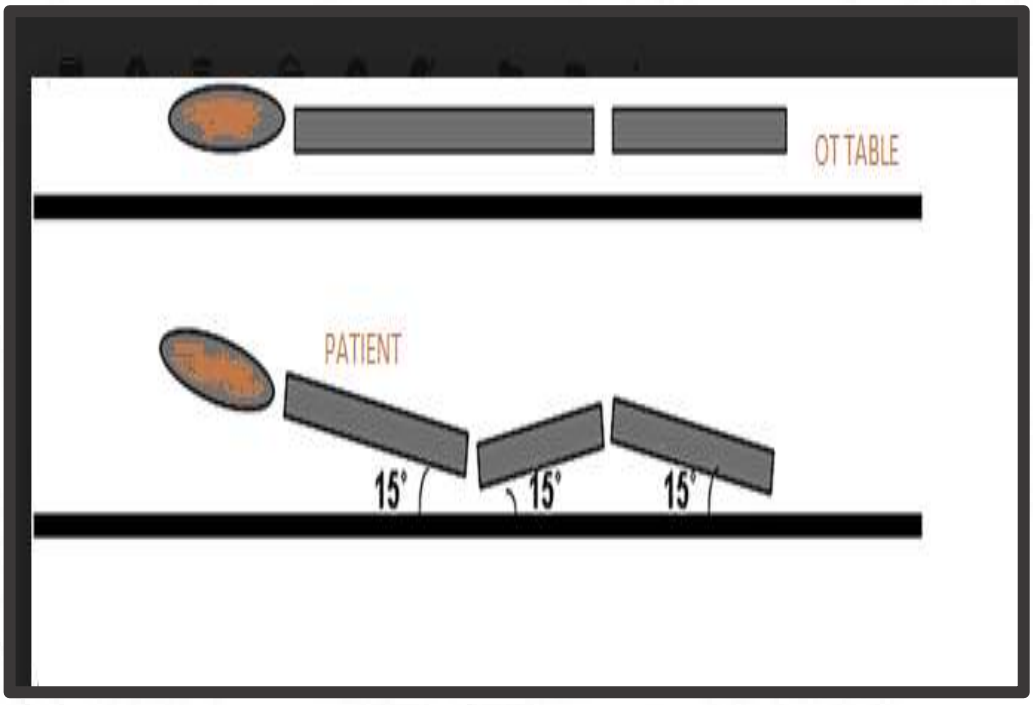


Figure 2A shows the Supine position employed in Neurosurgery

Figure 2B shows the Supine position employed in Neurosurgery

To improve venous drainage from the brain, the head should be positioned above the level of the heart using reverse Trendelenbourg positioning or with flexion of the table. The head can typically be safely rotated to 45 degrees relative to the body, but if more rotation is needed, a roll or pillow should be placed under the contralateral shoulder.

B) **Prone position**

The prone position is commonly used for approaches to the posterior fossa, suboccipital region, and posterior approaches to spine. (11) The benefits of this position are that it is a good position for posterior approaches, and there is a lower incidence of venous air embolism compared with the sitting position. (14,15)

The patient is usually anesthetized in the supine position, and is then turned prone on chest rolls or on a special frame. (Figure 3) The head should be kept in the neutral position. Positioning of the head at the body level, or higher, avoiding the head-down position and associated venous congestion are essential. (16) On the other hand, elevation of the head for posterior fossa surgery or cervical spine surgery may increase the risk for air embolism. (17-19)

Figure 3A shows the Prone position.

The Concorde position is a modification of the prone position. This is the best positioning for surgical approach to occipital transtentorial and supra cerebellar infratentorial area. (11) The head is typically skeletally fixed and flexed, but may be laterally flexed if needed.

C) **Lateral position**

The lateral position is used as a surgical approach for patients requiring temporal lobe craniotomy, skull base, and posterior fossa procedures. The benefits of this position are that it provides the best surgical approach to the temporal lobe. (1) The risks include brachial plexus injuries, stretch injuries, pressure palsies, and possible occurrence of ventilation-perfusion mismatch.

The park-bench position is a modification of lateral position and provides the surgeon with better access to the posterior fossa, as compared with the lateral position. Head is flexed at the neck and then rotated to look toward the floor (120º from vertical & laterally flexed 20º). At all points utmost care should be taken to prevent excessive neck rotation or flexion and extension to avoid complications in the post-operative period. (20)

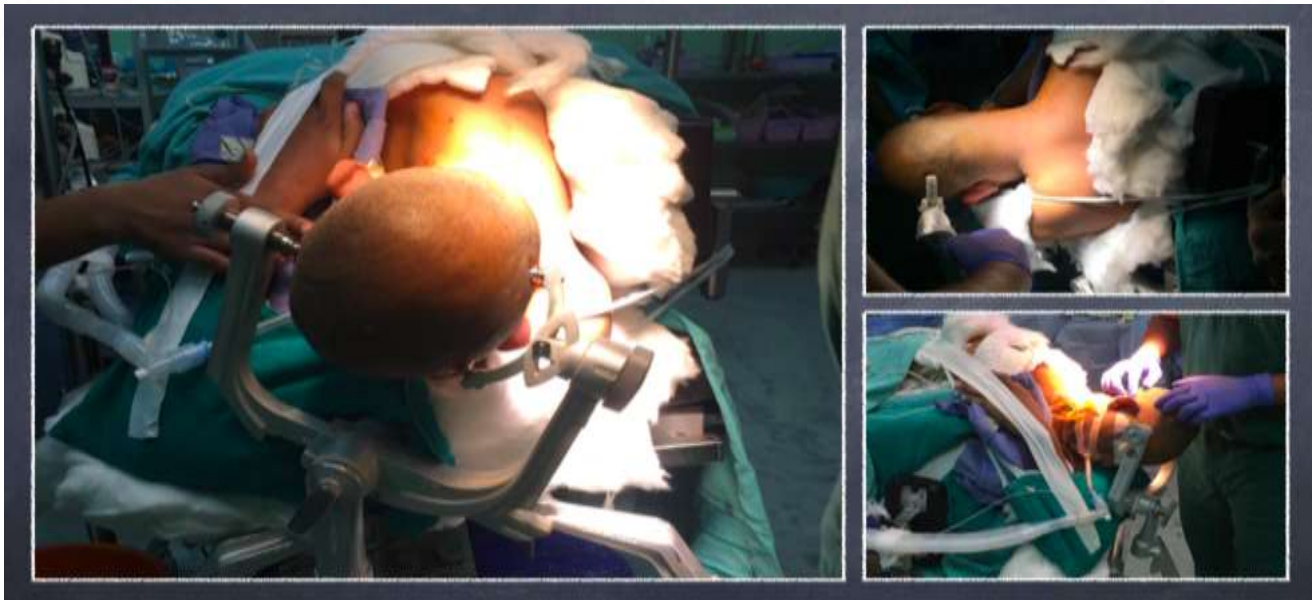


Figure 3B shows the park bench position.

The objectives of perioperative positioning are to balance optimal surgical exposure and to maintain normal body alignment. Many physical and physiological alterations can occur during patient position during anaesthesia. An important concern related to positioning is the inadverant obstruction to the cerebral venous drainage by affecting flow through the internal jugular vein (IJV) due to its kinking with excessive neck flexion and rotation. As the ICP is determined by intracranial contents (blood, cerebrospinal fluid and cerebral parenchyma) and the skull is a fixed vault, any increase in the volume of one or more components may increase ICP. Hence, in clinical practice it is important to prevent a rise in ICP to avoid intraoperative brain bulge. Also, obstruction to cerebral outflow can lead to cerebral infarction, airway edema and neck swelling. (3)

Cerebral venous drainage system

The internal jugular vein begins at the cranial base in the posterior compartment of the jugular foramen, continuous with the sigmoid sinus. (21) At its origin is its superior bulb, which is below the posterior part of the tympanic floor. The vein descends in the carotid sheath uniting with the subclavian vein, posterior to the sternal end of the clavicle to form the brachiocephalic vein. Posterior to the vein, from above are: the rectus capitis lateralis, cervical plexus, scalenus anterior, phrenic nerve, thyrocervical trunk, vertebral vein and the first part of the subclavian artery. On the left, it crosses anterior to the thoracic duct. Medial to the vein are the internal and common carotid arteries and the vagus nerve lies between arteries and vein, but posterior

to them. (21) Superficially the vein is overlapped above, then covered below by sternocleidomastoid and crossed by the posterior belly of the digastric and the superior belly of the omohyoid. The internal jugular vein lies in the groove between the sternal and clavicular heads of the sternocleidomastoid muscle, lateral and slightly anterior to the carotid artery. The vein is represented on the surface by a broad band connecting the ear lobule to the medial end of the clavicle.

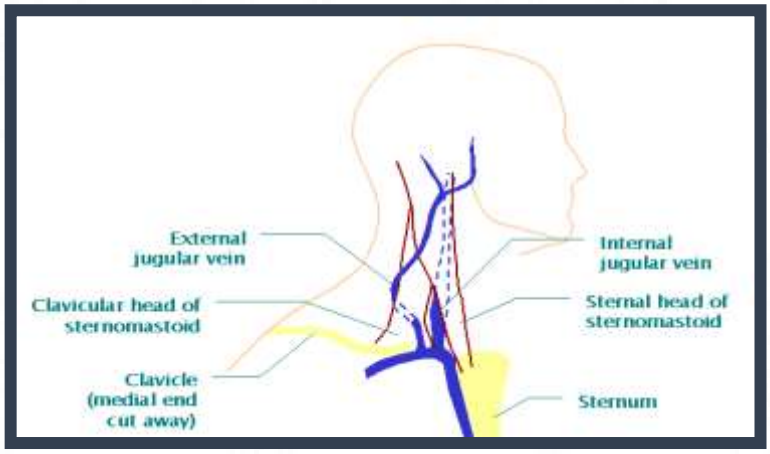


Figure 4 shows the anatomy of cerebral venous drainage and IJV (Venous sinus and IJV picture).

The IJV is very compliant that relatively small changes in pressure produce large changes in volume and thus in diameter. (22)

Armstrong showed that maneuvers that increase central venous return increase the IJV diameter. He also found that 15 degrees head down tilt significantly increased IJV diameter, as compared to a flat table. (23) Reduction in the diameter of the IJV occur with any external pressure on the IJV. Armstrong showed palpation of the carotid artery significantly reduced the

diameter of the IJV. This reduction in the IJV by carotid artery pressure is also seen in the head down tilt position. (24)

The two IJVs are the largest cervical veins that play an indispensable role in draining cerebral venous blood flow. Physiologically, the paired IJVs can interconnect with each other via anastomosing venous plexi, which are considered as main collateral channels that maintain a fluent venous drainage when the IJVs are restricted. Communications are also present between the IJVs and the other extracranial cervical veins such as the anterior condylar confluent and its branches. (21) In the condition of significant IJV narrowing, extrajugular venous collaterals will remarkably generate to compensate for the impeded primary venous outflow pathways. The IJV valve functions as a buffer that can prevent sustained retrograde transmitted venous blood and pressure into the cranium.

Patients with intracranial pathology like brain tumors have hemodynamic changes in the cerebral circulation which can get easily impaired. In these patients, internal jugular vein (IJV) represents the main cerebral venous output and any reduction in its flow could create an increase in cerebral blood volume and intracranial pressure (ICP).

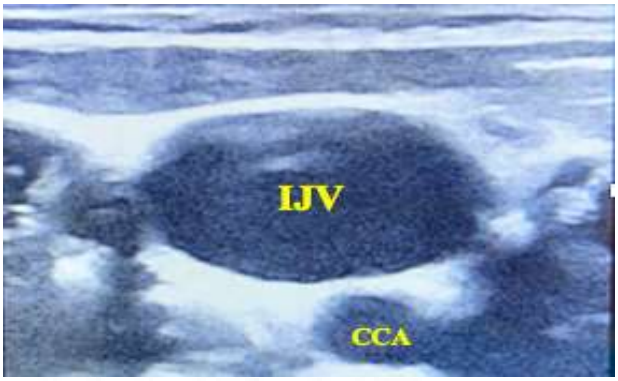
There is strong evidence showing that venous outflow abnormalities can contribute to the development of intracranial hypertension. (25) The degree of clinical presentations of IJV outflow disturbance may vary from none to severe based on individual variation and compensatory capability.

Imaging of Internal Jugular Vein anatomy and flow

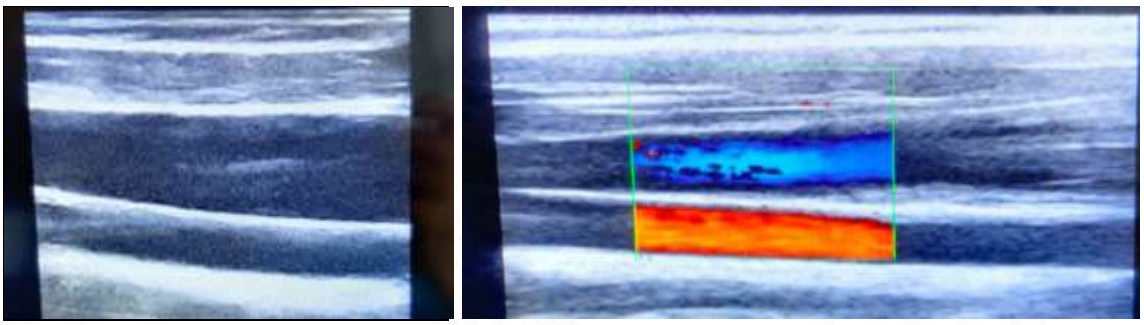
Normal sonographic anatomy of Internal Jugular Vein

Sonographically the IJV presents as an easily compressible vessel adjacent to the internal carotid artery at its dorsolateral aspect and following the common carotid artery laterally. (26) Transverse sections show the vessel as an ovaloid, triangular to multiangular, or half-moonshaped structure close to the internal and common carotid arteries and readily dilating in response to the Valsalva maneuver. At the level of the common carotid artery, the IJV is usually covered by the sternocleidomastoid muscle. On longitudinal sections, both the anterior and the posterior wall can be identified. When the vessel is demonstrated in a frontal or half-frontal plane, its medial wall usually cannot be separated from the adjacent carotid artery. In some cases, there is an indentation by the carotid artery at the level of its bifurcation.

If a duplex scanner is used, a typical venous flow pattern with individually varying pulsatility can be recognized throughout the vessel's lumen. The observation that patterns showing a particularly high modulation of the Doppler shift frequencies are often seen in subjects with a marked carotid indentation suggests that periodic compression of the venous lumen through the carotid volume pulse generates an IJV velocity pulse, as does the modulation of cardiac inflow. The same effect seems to be exerted by the wall pulsations of the adjacent common carotid artery and the innominate artery, which is crossed by the IJV ventrally.



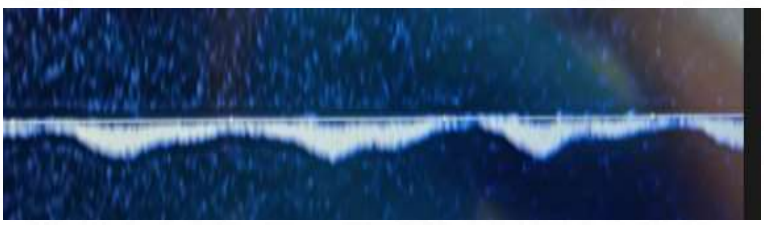
(A)



(B)

Figure 5 shows sonographic anatomy of IJV and its relationship with carotid artery. (A: cross-section, B: longitudinal section.)

(A)



(B)

Figure 6 shows doppler shift spectra of IJV (A : pulsatile, B: non-pulsatile).

Cerebral venous blood flows through the cerebral venous sinus into the sigmoidal sinus and jugular bulb and drains into the internal jugular veins (IJV) and vertebral venous plexus. The total mean (SD) venous blood flow at rest is approximately 766 (226) ml/ min in healthy human volunteers in the supine position, with the majority of flow through the IJV 720 (232) ml/min and remaining flow of 47 (33) ml/min through the vertebral veins. (3) The incidence of different cerebral venous drainage patterns has been analyzed and has been found to be predominantly jugular and hence any flow impairment secondary to partial or total occlusion could potentially result in an increase in cerebral blood volume and ICP. IJV flow can be calculated by the equation Flow (ml.min-1) = Cross-sectional area (cm^2) * Doppler velocity (cm/s) *60. (3) Also, in ventilated patients, PEEP can increase ICP and decrease mean arterial pressure, both resulting in decreased cerebral perfusion pressure (CPP), by increasing central venous pressure (CVP) and by impeding cerebral venous return to the right atrium. (3,30)

In the mid cervical region of the neck, IJVs are easily accessible by duplex ultrasound and hence its flow can be calculated. The concurrent increase in ICP with the change in position affecting the flow in the IJV can by studied with the help of noninvasive techniques of ICP measurement.

IJV flow in both the veins might be asymmetric even in healthy subjects. The right IJV (RIJV) has been found to be dominant for cerebral venous drainage in many studies done previously.

Lichtenstein D et. al, in their prospective study of measurement of IJV cross sectional area with the help of a linear array ultrasound probe in 80 patients during a three-month period found that there was a dominance of right IJV in 68% patients. They used the criteria for cross sectional area (CSA) only and did not include the doppler flow velocity. (27)

Bos M.J et. al, in their prospective nonrandomized study of comparison of diameter, cross sectional area and position of right and left IJV in 151 anaesthetized, mechanically ventilated patients in Trendelberg position found that in 72% patients the right IJV was dominant over the left IJV (LIJV) and the anterior position of the left IJV in relation to left carotid artery (CA) was more commonly detected as compared to right side. These findings highlight the importance of caution when cannulating the left IJV and the value of head rotation in producing more favorable relationship of the IJV to the CA for the purposes of IJV cannulation. (28)

Tenenbein PK et. al, studied the IJV diameter to predict the jugular bulb dominance in 25 patients with the help of an ultrasound and correlated it with the cerebral angiogram assessment. They found that the right IJV is the dominant in 76% patients by ultrasound which was also found to correlate with findings on cerebral angiography. It was hence suggested the use of ultrasound is a simple and accurate method of determining the ideal jugular bulb to cannulate. (29)

Troianos CA et. al, did an ultrasound examination in 1,136 awake volunteers to examine the relation between IJV and carotid artery (CA). They found that 54% of patients had IJV overlying more than 75% of CA and this was seen more with patients older than 65 years. (30)

Muller HR et. al, observed the cross-sectional area and time averaged mean flow velocity in a cohort of 100 patients aged 21 to 70 years using a duplex scanner. The average of right and left flow was 740±209 ml/min which was found to be lower in females than males by 8.7% and had no correlation with age. (31)

Marr K et. al, studied jugular venous flow quantification in 45 healthy subjects between age group of 18 and 89 years where IJV was scanned in transverse plane at three levels bilaterally at just below the facial vein entry (J3), approximate mid thyroid region (J2) and approximately one cm above the IJV valve (J1) with semi-automated doppler equipment and manual blood volume calculations with measurement of cross sectional area. The correlation between two techniques was low for venous Blood Flow Velocity (BFV) (r=0.44-0.67). They concluded that the current Doppler equipment does not provide accurate automated calculation of extracranial venous BFV. (32)

Table 1 Studies on IJV anatomy and flow.

Source (References)	Year of study	Type And Number Of Subject	Study	Conclusions
Muller HR et. al, (31)	1990	Awake volunteers (100)	IJV flow velocity	Average RIJV and LIJV flow was 740±209 ml/min which was more in males
Troianos CA et. al, (30)	1996	Awake volunteers (1136)	Relationship of IJV with CA	IJV overlies >75% CA IN 54% esp. in older patients(> 60years)
Lichtenstein D et. al, (27)	2001	Critically ill (80)	Measurement of CSA of IJV	Asymmetry in 62.5%. Right was dominant in 68%
Tenenbein PK et. al, (29)	2006	Cerebral angiography followed by neurosurgery (25)	Diameter of IJV and jugular bulb dominance by cerebral angiography	RIJV>LIJV (75%). Rt jugular dominance by angio(44%)
Bos M.J et. al, (28)	2015	Elective heart surgery (151)	USG examination of RIJV and LIJV in mechanically ventilated in trendelenberg position	RIJV dominant over LIJV (75%). Anterior position to CA of LIJV more common (15.1% vs 5.4%, P = .01).
Marr K et. al, (32)	2019	Healthy subjects (45)	IJV flow calculation with semiautomated doppler vs manual flow calculation	Automated doppler equipment does not provide accurate assessment

Optic nerve sheath diameter (ONSD)

Non-invasive ICP (nICP) measurement, namely ONSD and Transcranial Doppler, is an emerging technique, still under development in adult and paediatric population (33,34,35). 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 optic nerve, as the part of central nervous system, is covered by a leptomeningeal sheath, which is expandable in the anterior segment, behind the globe. When ICP rises, cerebrospinal fluid (CSF) is pushed towards the tiny rim of subarachnoid space between the sheath and the nerve, causing an expansion of the dural covering. These changes are more marked in the anterior part of the nerve sheath behind the globe. As with any physiological change, the ONSD changes dynamically with changes in ICP. The widening is most marked at 3 mm from the globe, beyond 3 mm the presence of arachnoid trabeculations prevent widening of ONS (36). Consequently, the accumulation of CSF within the perineural space due to increased ICP can result in distension of the ONS and the optic nerve protrusion or flattening of the posterior globe. (37)

Ultrasound examination of the ONSD is performed using a 7.5-10.5MHz linear ultrasound probe using the lowest possible acoustic power that could measure the ONSD. (38) The probe is oriented perpendicularly in the vertical plane and at around 30 degrees in the horizontal plane on the closed eyelids of both eyes of individuals in supine position with head elevated to 30

degrees. Application of ultrasound gel is done on the surface of each eyelid. The measurements are then made in the axial and sagittal planes 3 mm behind the retina of both eyes. Apart from its use in measurement of ICP in intracranial hemorrhage, ischemic stroke, meningitis, encephalitis, idiopathic intracranial hypertension, it's use has also been extended to acute mountain sickness, reversible encephalopathy syndrome, ischemic optic neuritis and symptomatic intracranial hypotension. (40,41)

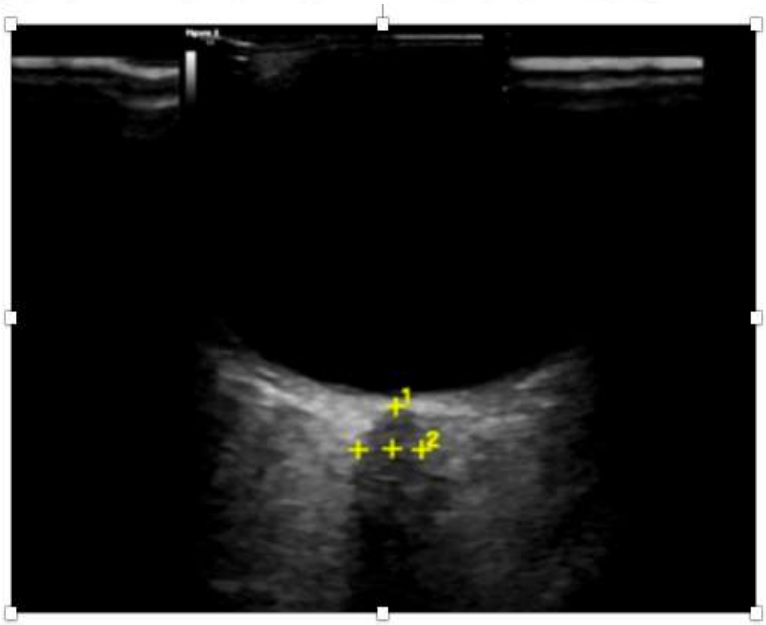


Figure 7 shows Ultrasound measurement of optic nerve sheath diameter.

Dynamic assessment of the ONSD has also been done in cases like spontaneous intracranial hypotension (SIH) and normal pressure hydrocephalus. It can be done at two different time points in two different positions, first in supine position followed by two minutes after standing. It can also be done 5 minutes after lumbar puncture. (42)

Ultrasonography of the optic nerve sheath

Optic nerve sheath ultrasound is a simple, safe, easy and bedside diagnostic test and has the potential to replace invasive ICP monitoring in cases of raised intracranial hypertension. (43) Helmke and Hansen used ultrasound in cadavers to prove that in the area just behind the eyeball, elevated pressure can increase the sheath diameter by >50%.

The cut-off value for normal ONSD, measured 3 mm posterior to the globe, ranges from 5.2 to 5.9 mm. Tamburrelli et. al, used 4.5 mm as the cut-off for normal, found a sensitivity of ONSD to identify an ICP >15 mmHg of 88% and a specificity of 90%. (36) Previous studies have demonstrated that ONSD can be used as a non-invasive indicator of raised ICP. (42) Tayal et. al, conducted a prospective, double-blind study in 55 patients and found that an ONSD of 5.0 mm or more correlated with CT findings suggestive of raised ICP (43). Sahoo and Deepak Agrawal have reported a cut-off of 6.3 mm for predicting an ICP >20 mmHg in patients of neurocritical care by using Codman intraparenchymal probes (n = 20). (44)

Cranial CT findings of shift, edema or effacement suggestive of elevated ICP were used to evaluate ONSD accuracy. In the recent clinical studies, ONSD has been correlated with clinical symptoms and CT abnormalities, both surrogate indicators of elevated ICP. (45,46) A systematic review revealed that ONSD is a good diagnostic test for accurately detecting raised ICP compared to CT, for ruling out raised ICP in a low-risk group and high specificity for ruling

out raised ICP in a high-risk group. ONSD measured by ultrasound has also been correlated with ONSD by MRI. (47)

A prospective, blind, observational study conducted by Moretti R et. al, in 53 adult patients with primary intracranial hypertension and subarachnoid hemorrhage (48) showed ONSD threshold of 5.2 mm as a predictor of ICP >20mm Hg proved to be an attractive combination of sensitivity and specificity (94% and 76%, respectively) and proved the reliability of ONSD for noninvasively measuring ICP.

Toscano M, et. al, retrospectively analysed data from ultrasound ONSD in 21 sedated critical patients with neurological diseases to identify early malignant hypertension with brain death found to reliably predict the impending brain death where it showed higher ONSD values as compared with control. (49) Their main conclusion was that routinely monitoring ONSD daily is useful in ICU when invasive ICP monitoring is not available, to recognize intracranial hypertension in neurocritical patients.

Romagnuolo, et. al, showed that the ONSD does not change with patient position(50). Interobserver variation is quite low and the measurements are highly reproducible, even for novice operators taught in a single training session.

Robba, et. al, studied the effect of prone position on ICP with the help of TCD and ONSD in 30 patients undergoing spine surgery which concluded a significant increase in ICP from supine to prone. (51) They also stated that the

mean ONSD measurement was the most effective technique in distinguishing a hypothetical change in ICP between supine and prone positioning.

Table 2: Studies on ONSD.

Source (References)	Year of study	Type And Number Of Subject	Study	Conclusions
Newman WD et. al, (52)	2002	Shunted HCP (23 children)	ONSD for functioning of shunt	Cut off of 4.5. Functioning shunt had mean ONSD of 2.9 vs 5.6 for nonfunctioning($p<0.0001$)
Romagnuolo L et. al, (50)	2005	Healthy volunteers (30)	ONSD in trendelenberg and reverse trendelenberg with 30 degrees angulation	No significant difference with position
Moretti R et. al, (48)	2009	ICH and SAH	ONSD study for ICP	ONSD cut off of 5.2 for ICP>20mmHgwith high specificity and sensitivity
Robba et. al, (51)	2016	Spine surgery (30)	ONSD and TCD values from supine to prone	Significant increase of ONSD and TCD value from supine to prone
Toscano M et. al, (52)	2017	Sedated critical ill patients (21)	ONSD for malignant hypertension in brain death	High ONSD (0.55 cm) with impending brain death.

The change in patient positioning can impair the cerebral venous drainage and lead to intraoperative brain bulge. The brain relaxation under anaesthesia has been evaluated by various subjective and objective methods. Once the bone and dura are opened, the status of brain relaxation can be evaluated by direct inspection and palpation. Different grading methods (53,54) for subjective assessment have been proposed and the most popular being the four-point scale, grading the brain as;

1: Completely relaxed,

2: Satisfactorily relaxed,

3: Firm brain, and

4: Brain bulge.

We planned to use the above grading in our study for assessment of brain relaxation.

HYPOTHESIS

Currently employed technique of positioning the patients for neurosurgery in lateral and prone positions does not affect the IJV dimensions, flow and concurrently intracranial pressure compared to supine position measured by ultrasound technique**.**

AIMS

AND OBJECTIVES

Our primary objective will be to evaluate the hypothesis that change in surgical position from supine to either prone or lateral does not affect the cerebral venous drainage measurement of the flow in IJV and ICP by optic nerve sheath diameter (ONSD) using ultrasound.

The secondary objectives will be,

a) To compare the dimensions and flow between the right IJV and left IJV and hence evaluate the dominant side for cerebral venous drainage and its effect due to patient positioning.
b) To compare the influence of anaesthesia and mechanical ventilation on the cerebral venous drainage before and after induction of general anaesthesia in neurosurgical patients.
c) Surgical assessment of brain relaxation in craniotomy procedures.
d) Degree of intraoperative venous ooze during the surgical procedure assessed subjectively by the operating surgeon.

MATERIALS

AND METHODS

We designed the prospective observational study to evaluate the changes in IJV dimensions, flow and ICP with respect to different surgical positions in patients who underwent elective craniotomy for primary brain tumours 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 centre. This study was approved by our Technical Advisory Committee (SCT-/S/2018/761) and Institutional Ethics Committee (SCT/IEC/1238/AUGUST-2018, 7.09.2018).

Data for the study was collected for the period starting from August 2018 to March 2020.

Study Design: Prospective observational study. The total number of patients (n) recruited were 90.

Patient enrolment: The patients for the study were selected randomly from elective neurosurgical operation theatre list and recruited after fulfilling the following inclusion and exclusion criteria. Informed written consent was obtained from those who fulfilled the recruitment criteria and those willing for the study were included in the study.

Grouping of the patients was done according to the final surgical positioning as follows ;

Group S : patients who were operated in supine position.

Group P : patients who were operated in prone position.

Group L: Patients who were operated in lateral position.

Inclusion criteria:

- ➢ Consenting adult patients with age ≥18 years and less than 60 years.
- ➢ ASA (American Society of Anaesthesiology) risk assessment grades I, II and III.
- ➢ Neurosurgical procedures for primary brain tumors.
- ➢ Glasgow coma scale score (GCS) 14-15.

Exclusion criteria

- ➢ ASA (American Society of Anaesthesiology) risk assessment grades 3,4 and 5.
- ➢ Glasgow coma scale score (GCS) ≤13.
- ➢ Recurrent tumors.
- ➢ Patients < 18 years or more than 60 years.
- ➢ Patient with unstable cervical spine, neck trauma and those having tracheostomy tube.
- ➢ Patients with ocular trauma or a known history of ocular pathology (as glaucoma or cataract).
- ➢ Autonomic instability.
- ➢ H/o vascular diseases, stroke, carotid artery stenosis.
- ➢ Pregnant & nursing mothers.
- ➢ Presence of significant co morbidities like diabetes, hypertension, liver disease, Ischemic heart disease, stroke, chronic renal disease, bronchial asthma or lung diseases.

Study protocol

On the day of the surgery all the recruited patients were kept a per-operative fasting protocol of nil per mouth for 8 hours for solids and 2 hours for clear fluids. Premedication consisted only Inj. Glycopyrrolate 0.2 mg intramuscularly was administered 45 minutes prior to shifting. Patients were continued on their preoperative medications like antiepileptic drugs, steroids 60 minutes prior to shifting to operation theatre as per institute protocol.

After shifting to operation theatre, WHO Safety check list assessment was done. Patient was positioned in supine with small pillow below the occiput of the head. Preinduction monitoring lines were attached consisting of five lead electrocardiogram (ECG), pulse oximetry, non-invasive blood pressure (NIBP) and baseline values were recorded. An intravenous line was secured under local anaesthesia using 16 G cannula in the peripheral vein and intravenous fluid was started at 2 ml/kg of lactated Ringer's solution.

Technique for IJV visualisation and calculation of flow

With the patient placed in supine position comfortably, a baseline ultrasound examination of the neck vessel was done. Baseline IJV flow was recorded on both sides before the induction of anaesthesia (T0). A horizontal line drawn across the neck at the level of the cricoid (C6) bilaterally till the posterior border of sternocleidomastoid muscle aimed to intersect the IJV on both sides (Figure1). After skin prep and application of ultrasound jelly, a high frequency (10 to 15 MHz) linear array probe (Esaote, Mylab™ Guide, Italy) was placed initially on the right side along the horizontal line drawn and the IJV in its short axis was identified based on 2D as well as color flow based on the compressibility, absence of arterial pulsations, wave characteristics and relation to carotid artery. The image was frozen and the cross-

sectional area (CSA) was recorded using caliper by tracing the borders. Then the probe was rotated to insonate the long axis of IJV. After obtaining the long axis, pulse wave doppler cursor was used to get the doppler waveform and the peak velocity doppler velocity were obtained. (Figure 8,9) The process was repeated on the left side and values were recorded. Three recordings were obtained and the average was taken as final measurement and entered in proforma.

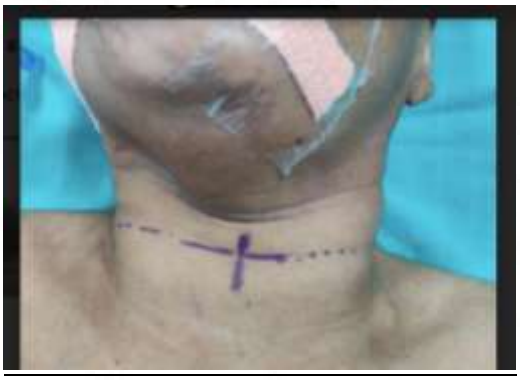


Figure 8 depicts the level of the cricoid (C6) intersects the IJV.

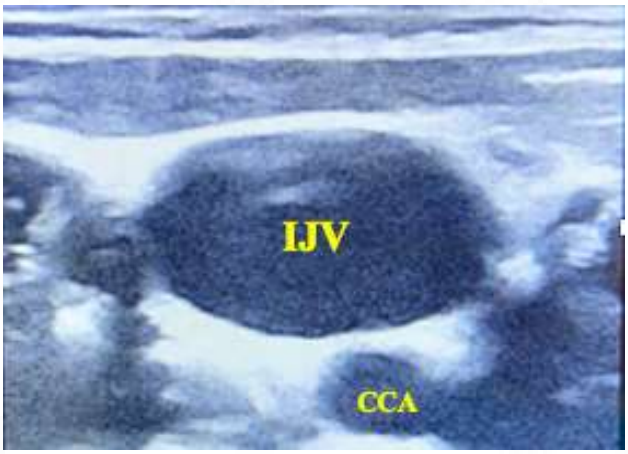


Figure 9 shows B-Mode (2d) of IJV and Right CCA at the level of cricoid cartilage.

The IJV also easily gets compressed with pressure which can alter the measurements so minimum pressure was applied while measuring the flow. All the modalities including B-mode (2D), colour flow doppler (CFD) and pulsed wave Doppler (PWD) was used to measure the IJV flow (Figure 10) . Use of PWD will show a continuous

venous waveform of venous flow when cursor is placed on IJV (Figure 11). The flow in the carotid artery will be more pulsatile with a clear systolic peak, a dicrotic notch and a diastolic wave.

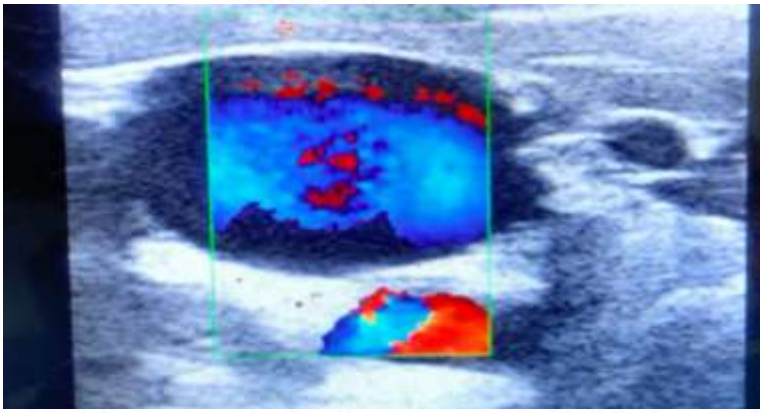


Figure 10 shows B-Mode (2d) of IJV and Right CCA at the level of cricoid cartilage with color flow doppler (CFD).

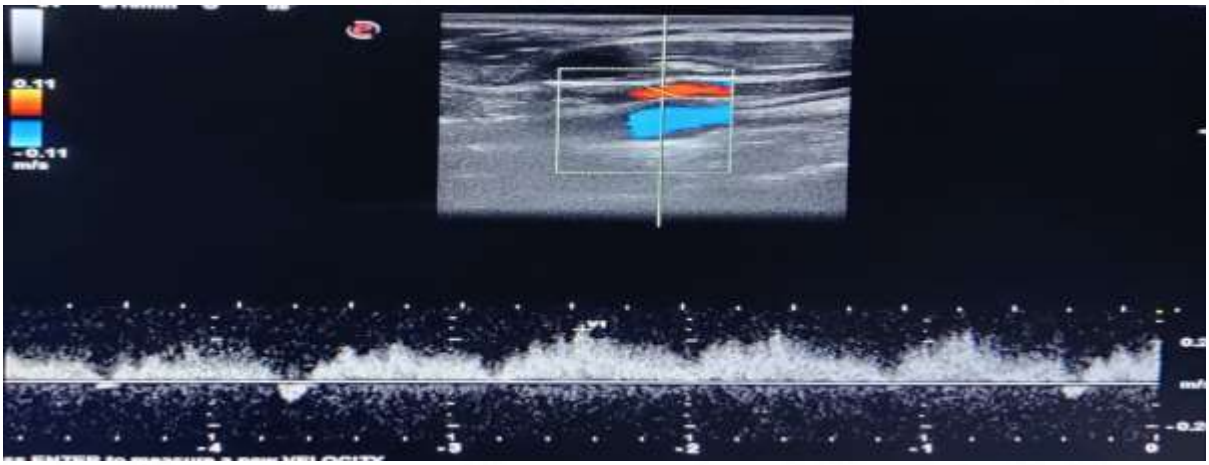


Figure 11 shows Pulsed wave doppler of the right internal jugular vein (IJV) at the level of cricoid cartilage in longitudinal section.

After identifying the IJV on the scan the cross-sectional area got displayed in the center on the scan and the picture is frozen with maximum dilatation of the vein with minimum pressure possible. (Figure 12) The IJV cross-sectional area was obtained by using the ultrasound caliper to manually trace the circumference of the

vessel. The least possible amount of transducer pressure is used to press on the IJV, and the measurements are obtained at the end of inspiration.

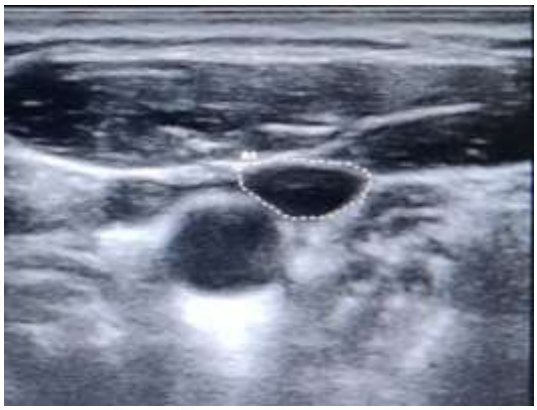


Figure 12 shows measurement of cross-sectional area of IJV.

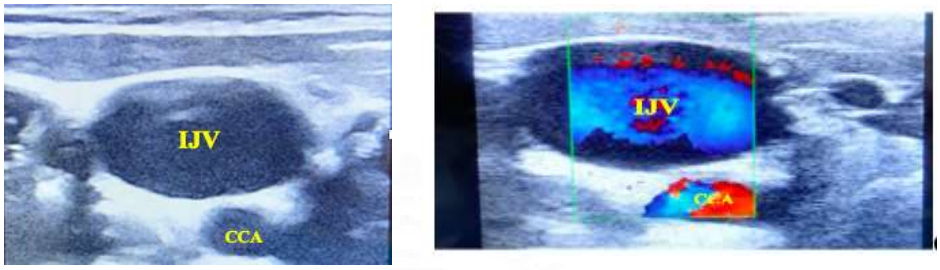
Then the probe was turned 90 degrees and adjusted to have a longitudinal section of the vessel as horizontally as possible. In this position, doppler velocity is obtained. Three separate measurements are taken for Doppler velocity to minimize errors. Mean velocity is multiplied by mean area to obtain the volume flow.

The IJV flow was then calculated by the equation: Flow (ml/min) = Cross-sectional area (cm^2) * Doppler velocity (cm/s) * 60.

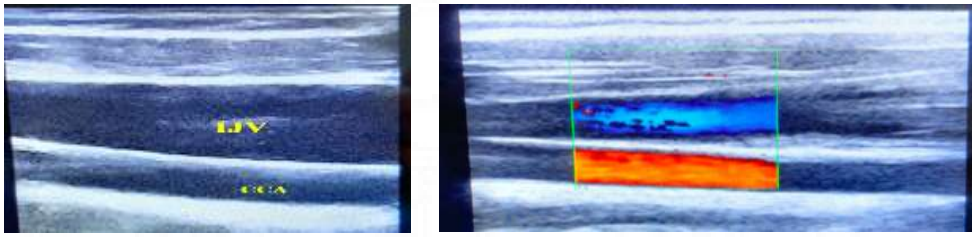
After IJV flow on one side is done the probe is kept on the skin over the contralateral vein without moving the patients head in between and the flow in this vessel is measured with the same technique.

After baseline recording general anaesthesia was induced. After preoxygenation for 3-5 minutes general anaesthesia was induced with fentanyl (2 µg/kg) and propofol (titrated to loss of consciousness). After adequacy of mask ventilation was ensured, vecuronium (0.1 mg/kg) was given. After 3 minutes, patients were intubated with appropriate size endotracheal tube via direct laryngoscopy/ video laryngoscopy/ fibreoptic bronchoscopy based on patient's physiological or pathological considerations. Gas sampling was done through the side port attached to

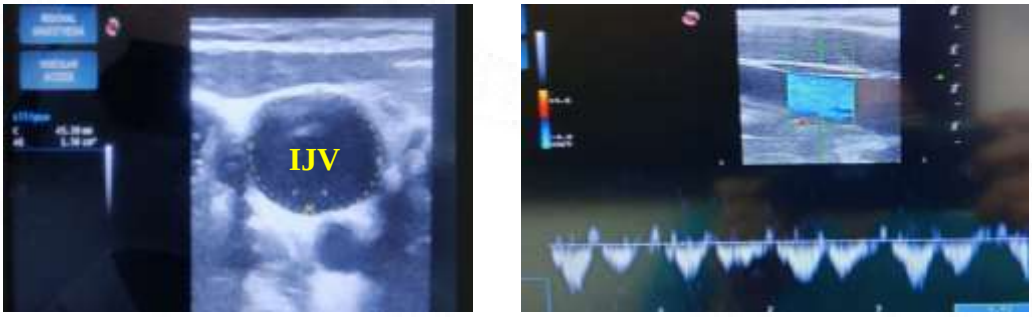
the ventilator circuit to monitor the end tidal carbon dioxide and anaesthetic gas levels. Invasive arterial line in the radial artery and central venous line was inserted via Peripherally inserted central line (PICC) or subclavian vein Nasopharyngeal temperature probe was attached and the body temperature was maintained throughout the procedure between 36-37 ^{0}C. Anaesthesia was maintained with air, oxygen, and inhalational agent with MAC of 0.8-1, $ETCO_2$ of 30-35mm Hg, airway pressure was maintained below 15-22 cm H_2O Systolic blood pressure (SBP) maintained within 20% of baseline throughout the procedure with vasopressors. Once the patients vitals were stable for 10 minutes under anaesthesia, ultrasound was used to record the IJV CSA and doppler velocity in supine position similar to the baseline measurement and recorded as T1 time point. In addition to IJV measurements, non-invasive ICP measurement using optic nerve sheath dimension was done using the technique described below.



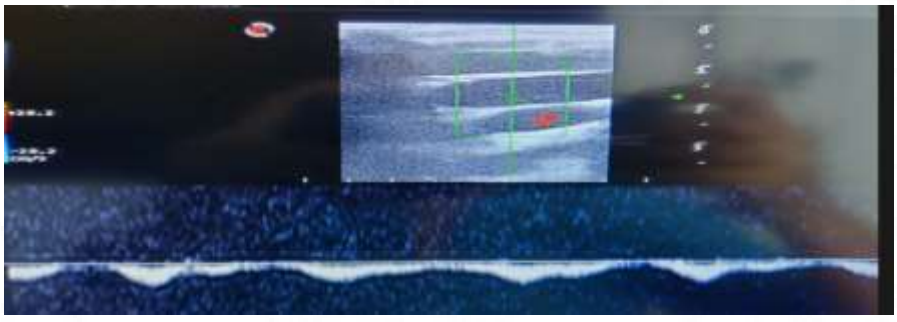
(A)



(B)



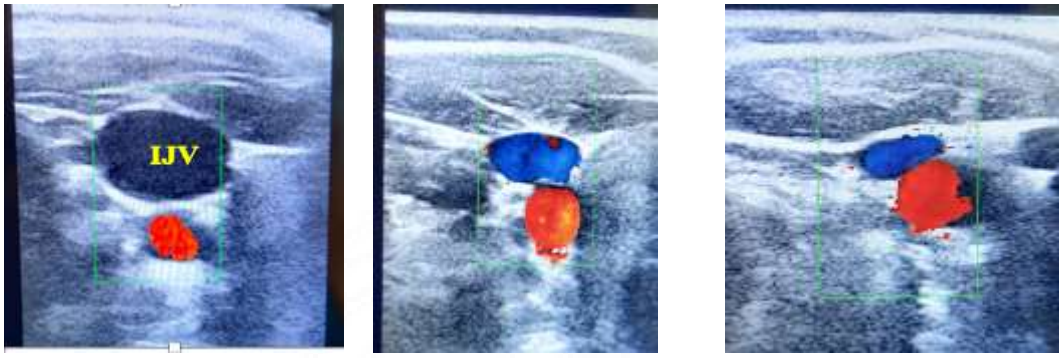
(C) (D)



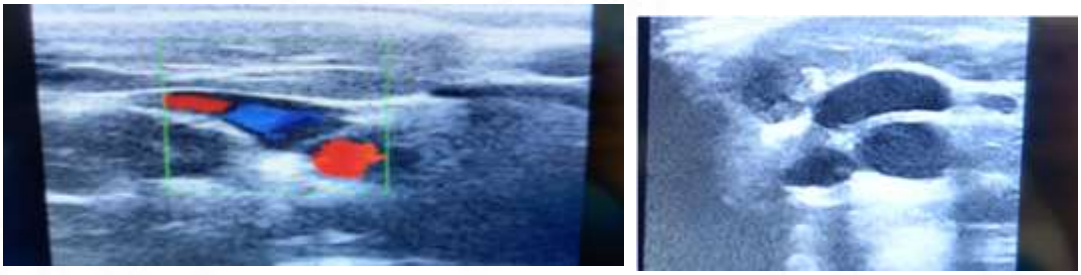
(E)

Figure 13 shows Right IJV visualisation of a patient in Group S (supine) position

[(A)cross section of IJV, (B) longitudinal section of IJV, (C) cross sectional area measurement of 1.56 cm^2, (D) Doppler velocity measurement of 21.93 cm/s before positioning, (E) doppler velocity measurement of 13.97 cm/s after final positioning.]



(A)



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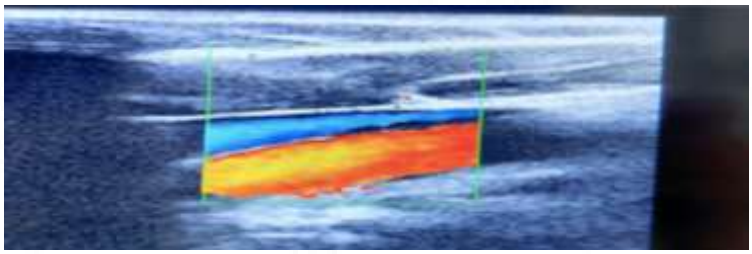
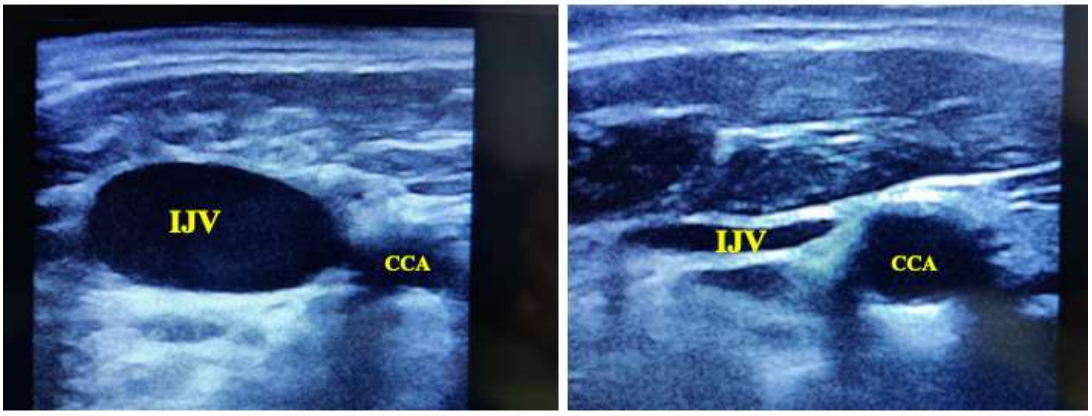


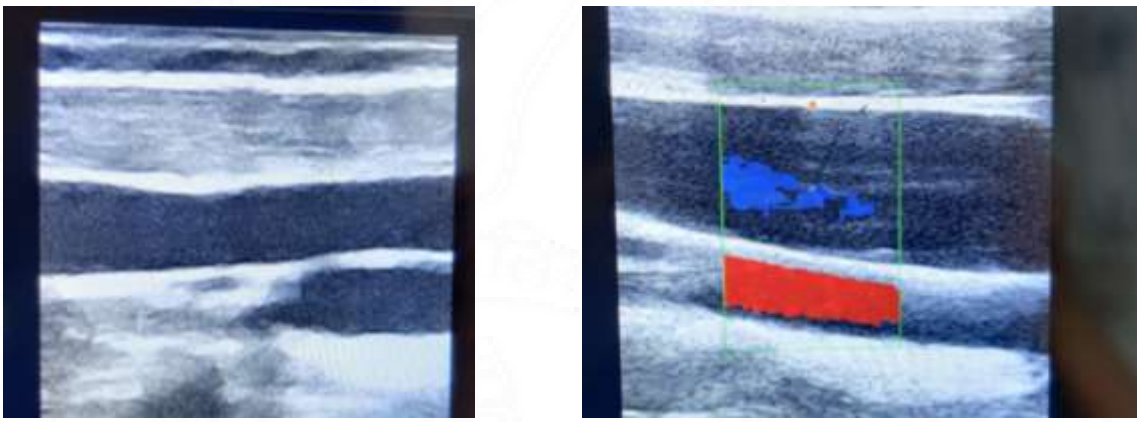
(C)

(D)

Figure 14 shows Left IJV visualisation of a patient in Group P (Prone) position [(A) cross section of IJV (B) longitudinal section of IJV (C) Doppler velocity of 26.9 cm/s decreased to 15.3 cm/s after final positioning.]



(A)



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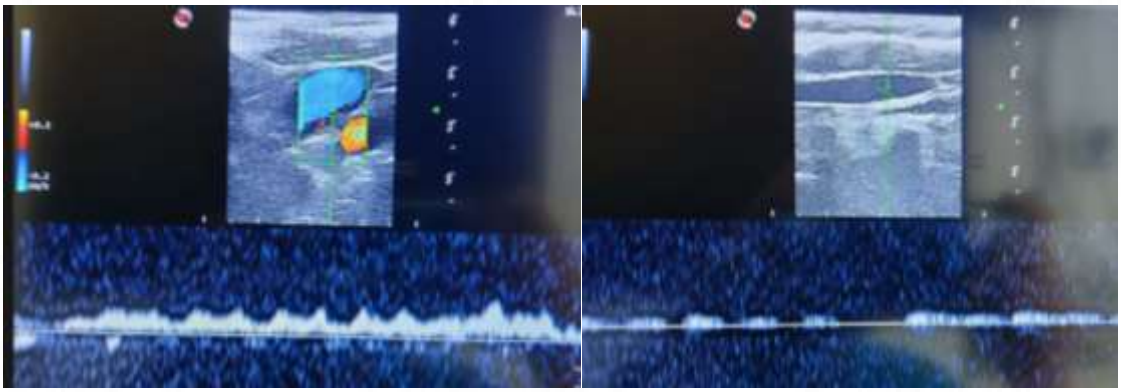


(C)

Figure 15 shows Left IJV visualisation of a patient in Group L (Lateral) position for [(A) cross sectional area before positioning was 0.98 cm^2 to 0.21 cm^2 after final position (B)longitudinal section of IJV(C)Doppler velocity before positioning was 14.65 cm/s which decreased to 10.18 cm/s.]

Technique of Optic Nerve sheath diameter (ONSD) measurement

For ONSD, a thick layer of gel was applied over the closed upper eyelid. The probe used for measurement of IJV (10 MHz, Esaote Mylab™ guide, Italy) was placed only on the gel in the temporal area of the eyelid to prevent pressure being exerted on the eye. The eye was checked for proper closure to prevent any corneal or conjunctival injury. The position of the probe was adjusted to give a suitable angle for displaying the entry of the optic nerve into the globe. The power of ultrasound was reduced to 75%. ONSD was measured 3 mm behind the globe using an electronic caliper along an axis perpendicular to the optic nerve. Three measurement for ONSD of each eye was taken & average of all reading was considered.

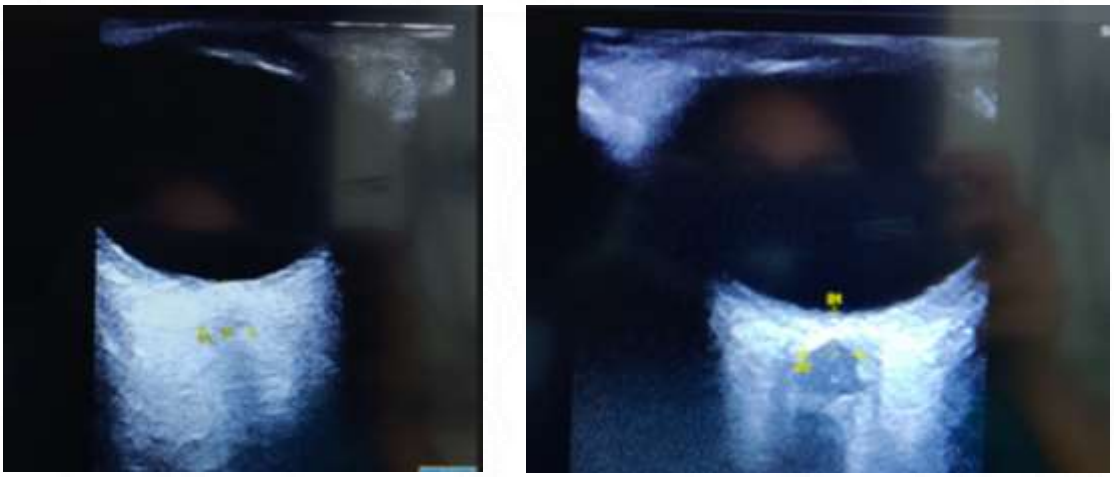


Figure 16 shows ONSD measurement.

After the measurement patients was positioned for the final surgical position by the team of surgeons and anesthesiologist and the head clamp will be fixed. Once the patient is placed in the position, and after 5 min of hemodynamic stability is achieved, the hemodynamic, respiratory variables and ultrasound measurements was done again. (T2)

Data Collection

Baseline Heart rate, blood pressure, oxygen saturation (SpO2), peak inspiratory pressure (PIP), End tidal carbon dioxide (ETCO2) and Minimum alveolar concentration (MAC) of the inhalational agent were noted. Intra operative brain relaxation score, degree of venous ooze was assessed by the surgeons subjectively with the four-point assessment scale for brain relaxation. Once the bone and dura are opened, the status of brain relaxation can be evaluated by direct inspection and palpation. the four-point scale, grading the brain was used. (53,54)

1: Completely relaxed,

2: Satisfactorily relaxed,

3: Firm brain, and

4: Brain bulge.

Internal jugular vein diameter, doppler velocity and flow in supine and after final positioning and Optic nerve sheath diameter (ONSD) from both eyes in supine before and after anaesthesia induction and after final surgical positioning.

Data entry was done by manually by the Principle Investigator into the study proforma.

STATISTICAL ANALYSIS

Sample Size Calculation

Assuming a maximum variation of within 20% from the baseline value in change in internal jugular venous flow from supine to the final position, to be equivalent, with alpha as 5% and beta as 80%, the calculated average sample size for this equivalent study was 30 in each of the Group S, Group P and Group L. A total of ninety patients were recruited.

Statistical Methods

All statistical analyses were obtained using SPSS software version 25.0 (Chicago, SPSS inc.). Descriptive data are expressed in frequency, percentage, mean and standard deviation. For demographic data, categorical variables were compared using Chi Square test.

Changes in continuous variables in successive observation between the Group S(supine), Group P(prone) and Group L (lateral) was done with repeated measure ANOVA. Inter-group and intragroup analysis was done in cross-sectional area(CSA), doppler velocity and flow at three different time points of T1(baseline), T2(after anaesthesia) and T3(after final positioning) with repeated measure ANOVA. $P<0.05$ was considered significant.

For comparing the hemodynamic parameters like heart rate, Systolic Blood pressure, Diastolic blood pressure and Mean arterial pressure within the group Group S(supine), Group P(prone) and Group L(lateral) at repeated measures ANOVA with post hoc analysis and Bonferroni correction was used. $P<0.05$ was considered significant.

For comparing the capnography (ETCO2) and airway pressure within the group Group S(supine), Group P(prone) and Group L(lateral) at repeated measures ANOVA with post hoc analysis and Bonferroni correction was used. $P<0.05$ was considered significant.

RESULTS &

OBSERVATIONS

According to the calculated sample size, ninety patients fulfilling the study criteria scheduled to undergo elective neurosurgical procedure at our institute were randomly selected and were recruited in three groups of thirty each as:

Group S for supine position,

Group P for prone position and

Group L for lateral position as per the planned surgical position.

Study could be completed successfully in all the ninety recruited patients and there were no dropouts or exclusion.

The following are the results of the study.

1) **Demographic Data**

The demographic details of age, weight, height, Body mass index (BMI), gender and ASA status of all the 90 patients in three groups are demonstrated in Table 1.

Table 3 shows the comparison of the demographic data of 90 patients belonging to the three groups.

Variable	Group S Total Number =30	Group P Total Number =30	Group L Total Number=30	p-value
Age (years) Mean±SD	34.7±15.5	34.0±13.9	36.4±13.7	0.135
Weight (Kg) Mean±SD	61.1±15.7	63.2±8.2	62.9±8.2	0.742
Height (cm) Mean±SD	160.1±10.5	161.8±10.1	160.3±8.5	0.747
BMI (kg/m^2) Mean±SD	23.8±3.7	24.0±2.6	24.4±2.5	0.747
Gender (Male:Female) Number (%)	20:10 (66.7% : 33.3%)	21:9 (70 %: 30%)	15:15 (50% : 50%)	0.231
ASA Physical status (I:II:III) Number (%)	23:5:2 (76.7% : 16.7% : 6.7%)	20:7:3 (66.7% : 23.3% : 10%)	19:8:3 (63.3% : 26.7 %: 10 %)	0.850

Group S= Supine, Group P= Prone, Group L= Lateral, $P<0.05$ is Significant. Analysis by χ^2 test.

The demographic details of 90 patients enrolled are shown in Table 1. The mean age was 34.7±15.5 years in Group S, 34.0±13.9 years in Group P and 36.4±13.7 years in

Group L. The weight of 90 patients between the groups were comparable with a mean weight of 61.1±15.7 kg in Group S, 63.2±8.2 kg in Group P and 62.9±8.2 Kg in Group L . Obese patients with body mass index(BMI) of more than 30 were excluded and the Group S had mean BMI of 23.8±3.7, Group P had 24.0±2.6 and Group L had 24.4±2.5. There were 20 males out of 30(66.7%) in Group S and 21 males(71%) in Group P indicating that most patients were males in both groups. Group S had 23 patients(76.7%) in ASA I, 5 patients(16.7%) in ASA II and 2 patients(6.7%) in ASA III. Group P had 20 patients(66.7%) in ASA I, 7 patients(23.3%) in ASA II and 3 patients(10%) in ASA III. Group L had 19 patients(63.3%) in ASA I, 8 patients(26.7%) in ASA II and 3 patients(10%) in ASA III indicating most patients belonging to ASA I and II in all three groups. The demographic data was comparable between the groups and the study was completed successfully in all 90 patients.

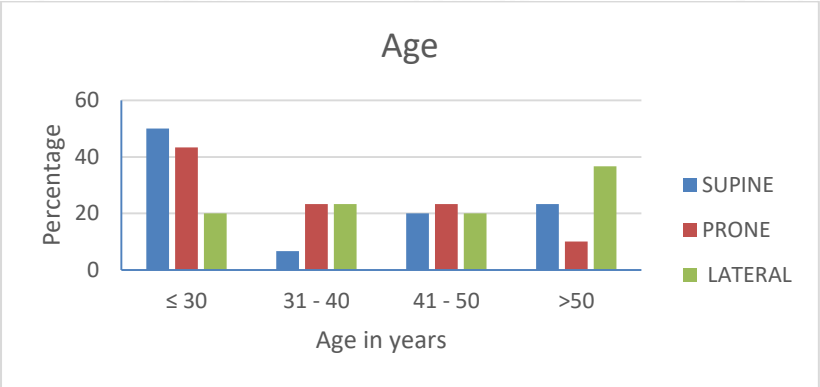


Figure 17 depicts the age distribution of patients among the three groups.

15 patients in Group S (50%) and 13 patients in Group P(43%) were less than 30 years indicating most patients being young in both the groups. Group L had 11 patients(36.7%) of more than 50 years age indicating a majority in the older age group in this group.

2) Tumor characteristics of patients in three study groups

Table 4 shows the tumor characteristics of enrolled 30 patients in supine position (Group S).

Diagnosis		Number(N=30)	Percentage (%)
Frontal			
	Meningioma	3	10
	Glioma	6	20
	DNET/SEGA	2	6.6
Temporal/Parietal/Insular			
	Meningioma	2	6.6
	Glioma	7	23.3
Parasagital meningioma		3	10
Colloid Cyst/septum pellucidium lesion		3	10
Suprasellar Mass		2	6.6
Sphenoid wing Meningiomas		2	6.6

In the supine position, 6 patients had frontal (20%) and 7 had temporal (23.3%) glioma accounting for the majority in this group. The other tumors were frontal and temporal meningioma (10% and 6.6%), parasagittal meningioma (10%), colloid cyst (10%) and sphenoid wing meningioma (6.6%)

Table 5 shows the tumor characteristics of enrolled 30 patients in prone position (Group P).

Diagnosis		Number(N=30)	Percentage (%)
Parietal			
	Meningioma	1	3.3
	Glioma	1	3.3
	DNET/SEGA	2	6.6
Occipital			
	Meningioma	2	6.6
	Glioma	1	3.3
Posterior Parasagital meningioma		2	6.6
Cerebellar lesions		6	20
InfratentorialMeningioma/Pineal region tumor		4	13.3
Fourth ventricular lesions/quadrigeminal cistern lesions		5	16.6
Brainstem lesions		3	10
Cerebellar Pontine angle lesion		2	6.6

In prone position, most patients presented with cerebellar lesions (20%), followed by fourth ventricular lesions (16.6%), infratentorial meningioma (13.3%), brainstem lesions (10%), cerebellar pontine angle tumors (6.6%), parietal and occipital gliomas (3.3% and 3.3%)

Table 6 shows the tumor characteristics of enrolled 30 patients in lateral position (Group L).

Diagnosis		Number(N=30)	Percentage (%)
Parieto-occipital			
	Meningioma	5	16.6
	Glioma	4	13.3
Tentorial meningioma		2	6.6
Periventricular lesion		1	3.3
Cerebellar Pontine angle		19	63

Most common tumor in Group L was Cerebellar-pontine angle with 19 patients (63%), parietooccipital meningioma (16.6%), parietooccipital (13.3%) tumors and periventricular tumor(3.3%).

3) Hemodynamic changes in three study groups

Heart rate, Systolic Blood pressure, Diastolic blood pressure and Mean arterial pressure of three study groups have been demonstrated in table 5, 6, 7 and 8.

Table 7 shows the changes in Heart Rate in three study groups.

HEART RATE(beats/min)	Group S(N=30) Mean±SD	Group P(N=30) Mean±SD	Group L(N=30) Mean±SD	p
T0	99.1±16.2	92.3±11.7	90.5±14.8	0.055
T1	96.8±13.3	91.6±11.8	94.0±15.1	0.336
T2	94.1±14.3	90.3±12.8	95.2±13.3	0.342
P-value	0.223	0.607	0.355	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test-Repeated measure ANOVA

In Group S, the mean baseline heart rate was found to be highest and was 99.1±16.2 /minute which decreased to 96.8±13.3/minute after anaesthesia and to 94.1±14.3/minute after final positioning. In Group P, the mean baseline heart rate was found to be 92.3±11.7 /minute which decreased to 91.6±11.8/minute after anaesthesia and to 90.3±12.8/minute after prone positioning. In Group L, the mean baseline heart rate was found to be 90.5±14.8 /minute which increased to 94.0±15.1/minute after anaesthesia and to 95.2±13.3/minute after final positioning. The changes in heart rate were not statistically significant between the time periods recorded and were comparable between the groups.

Table 8 shows the changes in Systolic BP(SBP) in three study groups.

Systolic blood pressure (mmHg)	Group S(N=30)	Group P(N=30)	Group L(N=30)	p
	Mean±SD	Mean±SD	Mean±SD	
T0	133.7±12.4	132.2±13.9	127.5±11.8	0.149
T1	132.1±12.9	129.8±15.0	124.7±12.3	0.103
T2	128.3±14.0	128.1±15.4	113.4±14.8	<0.001
P-value	0.198	0.574	<0.001	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test-Repeated measure ANOVA.

The baseline SBP was 133.7±12.4 mmHg in group S before anaesthesia which minimally decreased to 132.1±12.9 mmHg after induction and 128.3±14.0 mmHg after final positioning. The baseline SBP in group P is 132.2±13.9 mmHg which became 129.8±15.0 mmHg after anaesthesia and remained almost similar as

128.1±15.4 mmHg after final prone positioning. The Group L had the lowest baseline SBP as 127.5±11.8 mmHg which had become 124.7±12.3 mmHg and had a decrease to 113.4±14.8 mmHg which was statistically significant(<0.001); however the percentage change noted was a decrease of 12% was within our criteria of maximum allowable change of 20% from the baseline.

Table 9 shows the Diastolic Blood Pressure (DBP) in three study groups.

Diastolic blood pressure (mmHg)	Group S(N=30)	Group P(N=30)	Group L(N=30)	p-value
	Mean±SD	Mean±SD	Mean±SD	
T0	79.1±7.0	79.7±7.4	76.7±8.7	0.298
T1	74.6±8.7	75.2±9.8	76.2±7.3	0.780
T2	71.7±9.6	70.7±9.0	71.2±8.8	0.915
p	<0.001	<0.001	0.003	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test-Repeated measure ANOVA.

In group S, the mean baseline DBP was 79.1±7.0 mmHg which had minimally declined to 71.7±9.6 mmHg after final positioning. In Group P, a similar mean DBP was 79.7±7.4mmHg which became 70.7±9.0 mmHg after prone positioning. In group L, the mean DBP was 76.7±8.7 mmHg which became 71.2±8.8 mmHg. The DBP was comparable between the groups. Though the changes after final positioning appeared to be statistically significant, the overall decrease was less than 20%.

Table 10 shows the changes in Mean arterial Pressure (MAP) in three study groups.

MAP	Group S(N=30)	Group P(N=30)	Group L(N=30)	p
	Mean±SD	Mean±SD	Mean±SD	
T0	97.3±8.0	97.2±8.6	93.6±8.4	0.158
T1	93.8±8.4	93.4±10.3	92.4±7.8	0.818
T2	90.6±9.9	89.8±9.8	85.3±9.3	0.079
p	0.002	0.010	<0.001	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

The MAP in group S before induction was 97.3±8.0 mmHg before induction which became 93.8±8.4 mmHg after anaesthesia and 90.6±9.9 mmHg after final positioning. Though the changes were statistically significant(p=0.002) the maximum percentage change was only 6.7±11.2 %. The group P had a baseline MAP of 97.2±8.6 mmHg which had become 89.8±9.8 mmHg which was statistically insignificant and the percentage change was 7.4±13.6%. The baseline MAP in Group L was 93.6±8.4 mmHg and final MAP was 85.3±9.3 which was statistically significant(p<0.001), but the percentage change being 8.4±10.2% was within our criteria of maximum allowable change of 20% from the baseline. The MAP characteristics at various time points were comparable between the groups and statistically insignificant.(P<0.05)

Table 11 shows the percentage change in Mean arterial Pressure (MAP) in three study groups.

Change in MAP	Group S(N=30)	Group P(N=30)	Group L(N=30)	p
	Mean±SD	Mean±SD	Mean±SD	
T0-T1	3.5±8.6	3.8±12.5	1.3±6.6	0.535
T1-T2	3.2±10.1	3.6±12.6	7.1±9.7	0.316
T0-T2	6.7±11.2	7.4±13.6	8.4±10.2	0.861

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

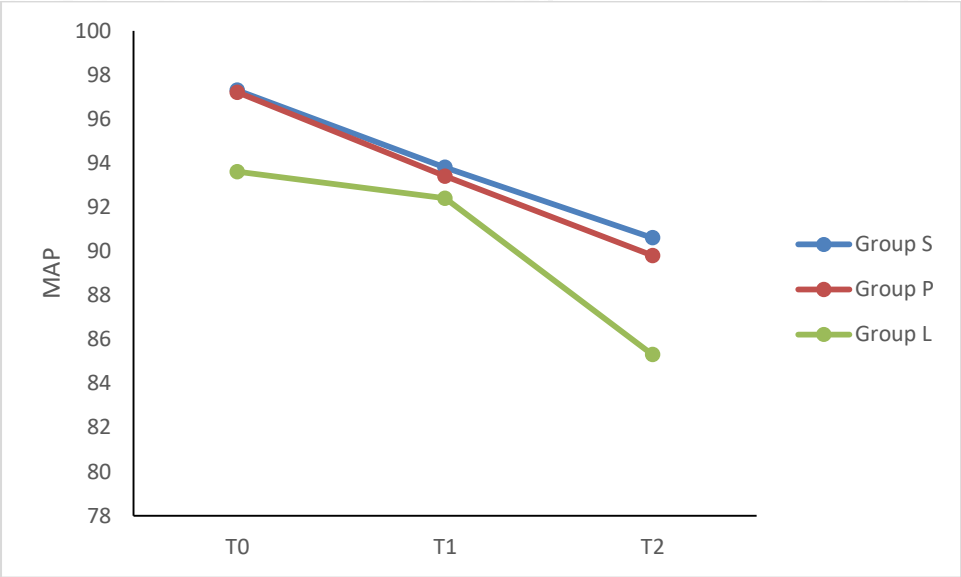


Figure 18 shows MAP changes in three study groups.

The MAP in group S before induction was 97.3±8.0 mmHg before induction which became 93.8±8.4 mmHg after anaesthesia and 90.6±9.9 mmHg after final positioning. Though the changes were statistically significant(p=0.002) the maximum percentage change was only 6.7±11.2 %. The group P had a baseline MAP of 97.2±8.6 mmHg which had become 89.8±9.8 mmHg which was statistically insignificant and the

percentage change was 7.4±13.6%. The baseline MAP in Group L was 93.6±8.4 mmHg and final MAP was 85.3±9.3 which was statistically significant(p<0.001), but the percentage change being 8.4±10.2% was within our criteria of maximum allowable change of 20% from the baseline.

Table 12 shows the Capnography (EtCO2) in three study groups.

ETCO2 (mmHg)	Group S(N=30) Mean±SD	Group P(N=30) Mean±SD	Group L(N=30) Mean±SD	p
T1	33.0±2.6	35.8±4.0	34.0±3.9	0.060
T2	31.9±2.2	33.1±2.6	32.4±3.0	0.200
p	0.001	0.001	0.004	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test-Repeated measure ANOVA.

The baseline EtCO2 was 33.0±2.6 mmHg after induction which became 31.9±2.2 mmHg after final positioning in Group S. The EtCO2 in group P was 35.8±4.0 mmHg which reduced to 33.1±2.6 mmHg after prone positioning. In Group L, the baseline EtCO2 was 34.0±3.9 mmHg which had become 32.4±3.0 mmHg at T2 time point. The EtCO2 values between the groups were statistically insignificant.

Table 13 shows the Airway pressure in three study groups.

AIRWAY PRESSURE (cm H_2O)	Group S(N=30)	Group P(N=30)	Group L(N=30)	p
	Mean±SD	Mean±SD	Mean±SD	
T1	17.8±2.0	18.4±1.8	17.7±2.1	0.354
T2	18.7±2.6	18.8±2.5	18.7±2.6	0.988
p	0.037	0.264	0.030	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test-Repeated measure ANOVA.

The baseline airway pressure was 17.8±2.0 cmH2O after induction which became 18.7±2.6 mmHg after final positioning in Group S. In group P, it was 18.4±1.8 cmH2Owhich changed to 18.8±2.5cmH2O after prone positioning. In Group L, it was 17.7±2.1cmH2O which had become 18.7±2.6 cmH2O at T2 time point. The baseline and changes in capnography and airway pressure was not found to be statistically significant between the three groups.

4) Variations of cross section area, doppler flow velocity and flow in supine position in Internal jugular vein (IJV) in three groups

Variations of cross section area, doppler flow velocity and flow in supine position in Right Internal jugular vein (IJV).

The cross-sectional area, doppler flow velocity and their manual flow calculation of right IJV at three different time points of 30 patients recruited in group S for surgery in supine position are depicted in table 11 and their percentage changes have been calculated and demonstrated in table 12.

Table 14 shows the variations of cross section area, doppler flow velocity and flow in supine position on the right sided internal jugular vein(N=30) .

TIME POINTS	CROSS SECTIONAL AREA(cm^2)	DOPPLER VELOCITY (cm/s)	FLOW(ml/min)
	MEAN ±SD	MEAN±SD	MEAN±SD
T0	1.06±0.56	20.23±6.44	1276.73±731.31
T1	1.31±0.72	18.75±7.09	1903.00±3487.90
T2	0.94±0.50	15.17± 6.57	772.73±413.55
P-VALUE	0.001	0.001	0.086

P<0.05 is Significant. Test- Repeated measure ANOVA

The flow in right IJV Right IJV reduced from 1276.73±731.31 ml/min to 772.73±413.55 ml/min after final positioning but was not found to be statistically

significant (P = 0.086), though there was a significant(p=0.001) reduction in cross section area from 1.31±0.72 cm^2 after anaesthesia to 0.94±0.50 cm^2 and doppler velocity from 18.75±7.09 cm/s to 15.17± 6.57 cm/s (p<0.001).

Table 15 shows the percentage change of cross section area, doppler flow velocity and flow in supine position on the right sided internal jugular vein(N=30).

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	33.45	6.23	61.88	-10.03	-21.61	17.59	27.60	-18.71	72.16
T1-T2	-30.91	-48.44	-0.56	-15.67	-42.25	0.25	-41.62	-55.82	-25.90
T0-T2	-8.31	-31.42	23.11	-20.34	-46.42	-5.19	-38.33	-53.01	1.26

P<0.05 is Significant. Test- Repeated measure ANOVA.

Variations of cross section area, doppler flow velocity and flow in supine position in left Internal jugular vein (IJV)

The cross-sectional area, doppler flow velocity and their manual flow calculation of left IJV at three different time points of 30 patients recruited in group S for surgery in supine position are depicted in table 13 and their percentage changes have been calculated and demonstrated in table 14.

Table 16 shows the variations of cross section area, doppler flow velocity and flow in supine position on the left sided internal jugular vein(N=30).

TIME POINTS	CROSS SECTIONAL AREA(cm^2)	DOPPLER VELOCITY(cm/s)	FLOW(ml/min)
	MEAN±SD	MEAN±SD	MEAN±SD
T0	0.68±0.33	18.95±6.82	735.10±372.87
T1	0.80±0.45	17.43±7.94	741.37±342.44
T2	0.63±0.46	14.84±6.32	496.73±338.77
P-VALUE	0.027	0.040	0.001

P<0.05 is Significant. Test- Repeated measure ANOVA.

There was a statistically significant reduction of flow in left IJV (p=0.001) from 741.37±342.44 ml/min to 496.73±338.77 ml/min, with a percentage reduction by -27.08±43.79 %. The baseline flow in left IJV was found to be 735.10±372.87 ml/min, which was lesser than right IJV. The cross sectional area in left IJV was 0.68±0.33 cm^2 which became 0.80±0.45 cm^2 after anaesthesia and 0.63±0.46 cm^2 after final positioning and this was statistically significant with p value of 0.027. The doppler velocity had decreased from 17.43±7.94 cm/s to 14.84±6.32 cm/s which was statistically significant(p= 0.040)

Table 17 shows the percentage change in variations of cross section area, doppler flow velocity and flow in supine position on the left sided internal jugular vein(N=30).

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	7.68	-12.50	38.03	-7.11	-25.68	8.78	6.71	-13.90	30.73
T1-T2	-20.24	-44.64	10.75	-17.80	-35.47	27.74	-22.51	-67.30	0.62
T0-T2	-6.43	-43.09	26.03	-15.51	-38.64	18.77	-37.54	-60.77	12.91

P<0.05 is Significant. Test- Repeated measure ANOVA.

Variations of cross section area, doppler flow velocity and flow in prone position on the right sided internal jugular vein

The cross-sectional area, doppler flow velocity and their manual flow calculation of right IJV at three different time points of 30 patients recruited in group P for surgery in prone position are depicted in table 14 and their percentage changes have been calculated and demonstrated in table 15.

Table 18 shows the variations of cross section area, doppler flow velocity and flow in prone position on the right sided internal jugular vein(N=30).

TIME POINTS	CROSS SECTIONAL AREA(CM^2)	DOPPLER VELOCITY (CM/S)	FLOW(ML/MIN)
	MEAN ±SD	MEAN±SD	MEAN±SD
T0	0.68±0.29	21.58±9.26	924.25±589.30
T1	1.03±0.48	20.96±7.02	1272.93±729.48
T2	0.98±0.64	15.12±6.87	886.17±731.78
P-VALUE	0.002	<0.001	0.003

P<0.05 is Significant. Test- Repeated measure ANOVA.

In the 30 patients who were positioned prone as the final position, there was an increase in cross-sectional area from 0.68±0.29 cm^2 to 0.98±0.64 cm^2 by 13.27±94.75% which was statistically found to be significant (P =0.002). The doppler velocity, though reduced from 21.58±9.26 cm/s to 15.12±6.87 cm/s which was highly significant(p<0.001). The flow at baseline was 924.25±589.30 ml/min which increased to 1272.93±729.48 ml/min after anaesthesia. In final prone position the flow reduced to 886.17±731.78 ml/min.

Table 19 shows the percentage change in cross section area, doppler flow velocity and flow in prone position on the right sided internal jugular vein(N=30).

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	27.15	7.51	99.00	-6.00	-22.19	31.58	29.19	-4.91	132.63
T1-T2	-18.80	-38.24	38.99	-25.82	-44.14	-15.05	-29.98	-51.06	-6.19
T0-T2	39.28	-21.25	102.08	-34.43	-44.97	-9.44	-1.74	-47.38	43.60

P<0.05 is Significant. Test- Repeated measure ANOVA.

Variations of cross section area, doppler flow velocity and flow in prone position on the left sided internal jugular vein

The cross-sectional area, doppler flow velocity and their manual flow calculation of left IJV at three different time points of 30 patients recruited in group P for surgery in prone position are depicted in table 17 and their percentage changes have been calculated and demonstrated in table 18.

Table 20 shows the variations of cross section area, doppler flow velocity and flow in prone position on the left sided internal jugular vein.

TIME POINTS	CROSS SECTIONAL AREA(cm^2)	DOPPLER VELOCITY(cm/s)	FLOW(ml/min)
	MEAN±SD	MEAN±SD	MEAN±SD
T0	0.53±0.25	18.58±9.34	580.77±404.13
T1	0.69±0.33	15.11±5.65	603.79±334.44
T2	0.68±0.36	11.81±7.97	458.41±274.07
P-VALUE	0.005	<0.001	0.082

P<0.05 is Significant. Test- Repeated measure ANOVA.

In left IJV, the cross-sectional area was again found to significantly increase by from 0.69±0.33 cm^2 to 0.68±0.36 cm^2 which was associated with associated with reduction in doppler flow velocity from 15.11±5.65 cm/s to 11.81±7.97 cm/s which was statistically significant (p value <0.001). The flow at baseline was 580.77±404.13 ml/min which increased to 603.79±334.44 ml/min after induction which then insignificantly reduced to 458.41±274.07 ml/min.

Table 21 shows the percentage change of cross section area, doppler flow velocity and flow in prone position on the left sided internal jugular vein.

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	30.43	-15.75	71.32	-17.89	-25.80	-5.19	2.70	-29.95	80.28
T1-T2	0.00	-17.22	25.12	-29.71	-48.45	-10.62	-23.53	-44.81	-3.47
T0-T2	35.76	-22.18	85.69	-40.38	-58.40	-15.93	-17.04	-50.48	19.90

P<0.05 is Significant. Test- Repeated measure ANOVA.

Variations of cross section area, doppler flow velocity and flow in lateral position on the right sided internal jugular vein

The cross-sectional area, doppler flow velocity and their manual flow calculation of right IJV at three different time points of 30 patients recruited in group L for surgery in lateral position are depicted in table 19 and their percentage changes have been calculated and demonstrated in table 20

Table 22 shows the variations of cross section area, doppler flow velocity and flow in lateral position on the Right sided internal jugular vein.

TIME POINTS	CROSS SECTIONAL AREA(cm^2)	DOPPLER VELOCITY(cm/s)	FLOW(ml/min)
	MEAN±SD	MEAN±SD	MEAN±SD
T0	0.87±0.32	21.49±5.57	1110.88±499.79
T1	1.09±0.32	17.22±7.27	1101.90±495.20
T2	0.70±0.38	15.85±7.29	714.94±570.88
P-VALUE	<0.001	0.002	0.001

P<0.05 is Significant. Test- Repeated measure ANOVA.

The cross-section area in right IJV in group L was 0.87±0.32 cm^2, which increased to 1.09±0.32 cm^2 after anaesthesia and significantly($p<0.001$) reduced to 0.70±0.38 cm^2. The doppler velocity was 21.49±5.57 cm/s which decreased to 17.22±7.27 cm/s and further reduced to 15.85±7.29 cm/s which was statistically significant($p=0.002$). The calculated baseline flow was found to be 1110.88±499.79 ml/min, which remained 1101.90±495.20 ml/min after anaesthesia, but significantly reduced to 714.94±570.88 ml/min ($p=0.001$). The baseline flow in right IJV was found to be more (1110.88±499.79 ml/min) as compared to left IJV 552.70±304.11

Table 23 shows the percentage change of cross section area, doppler flow velocity and flow in lateral position on the right sided internal jugular vein.

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	24.05	-0.92	61.08	-11.67	-44.93	11.18	-5.22	-25.03	32.13
T1-T2	-39.58	-57.51	-13.10	-5.41	-31.97	19.84	-50.02	-67.35	-11.08
T0-T2	-20.54	-43.72	-7.97	-36.90	-49.68	-8.97	-48.07	-68.42	4.91

P<0.05 is Significant. Test- Repeated measure ANOVA.

Variations of cross section area, doppler flow velocity and flow in lateral position on the left sided internal jugular vein

The cross-sectional area, doppler flow velocity and their manual flow calculation of left IJV at three different time points of 30 patients recruited in group L for surgery in lateral position are depicted in table 21 and their percentage changes have been calculated and demonstrated in table 22.

Table 24 shows the variations of cross section area, doppler flow velocity and flow in lateral position on the left sided internal jugular vein

TIME POINTS	CROSS SECTIONAL AREA(cm^2)	DOPPLER VELOCITY(cm/s)	FLOW(ml/min)
	MEAN±SD	MEAN±SD	MEAN±SD
T0	0.57±0.30	18.25±10.26	552.70±304.11
T1	0.83±0.36	12.82±4.51	614.80±324.93
T2	0.48±0.25	11.29±3.52	313.80±171.24
P-VALUE	<0.001	<0.001	<0.001

P<0.05 is Significant. Test- Repeated measure ANOVA.

The cross-section area in left IJV in group L was 0.57±0.30 cm^2, which increased to after anaesthesia 0.83±0.36 cm^2 and significantly(p<0.001) reduced to 0.48±0.25 cm^2. The doppler velocity was 18.25±10.26 cm/s which decreased to 12.82±4.51 cm/s and further reduced to 11.29±3.52 cm/s which was statistically significant(p=0.002). The calculated baseline flow was found to be 552.70±304.11 ml/min, which remained 614.80±324.93 ml/min after anaesthesia, but significantly reduced to 313.80±171.24 ml/min (p<0.001).

Table 25 shows the percentage change of cross section area, doppler flow velocity and flow in lateral position on the left sided internal jugular vein.

TIME POINTS	CROSS SECTIONAL AREA (% CHANGE)			DOPPLER VELOCITY (% CHANGE)			FLOW (% CHANGE)		
	Median	Q1	Q3	Median	Q1	Q3	Median	Q1	Q3
T0-T1	65.52	9.80	100.00	-30.62	-46.94	9.08	1.66	-7.45	52.82
T1-T2	-33.33	-69.11	-15.46	-12.83	-24.37	20.56	-43.90	-64.79	-22.71
T0-T2	-30.62	-57.29	64.64	-34.99	-59.09	22.16	-46.16	-58.34	-32.38

P<0.05 is Significant. Test- Repeated measure ANOVA.

Comparison of Cross section area in three study groups

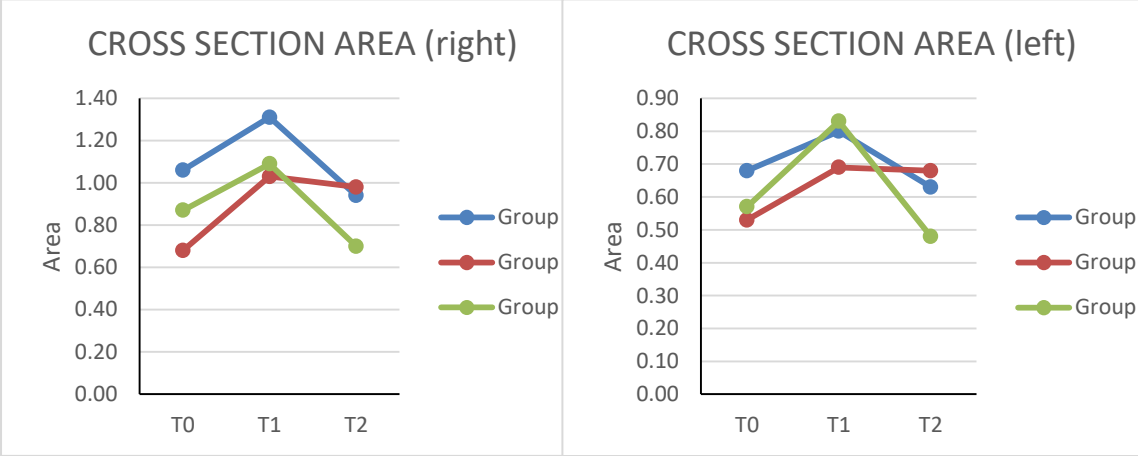


Figure 19 and 20 compares the cross section in Group S, Group P and Group L in Right and Left IJV.

The cross-sectional area was found to decrease in supine position in both Right as well as left IJV by 30% and 20% respectively. This phenomenon was also observed in

the lateral position where it reduced by 39% in Right IJV and 33 % in Left IJV. Conversely, the CSA slightly decreased in prone position by 13% in right IJV.

Comparison of Doppler flow velocity in three study groups

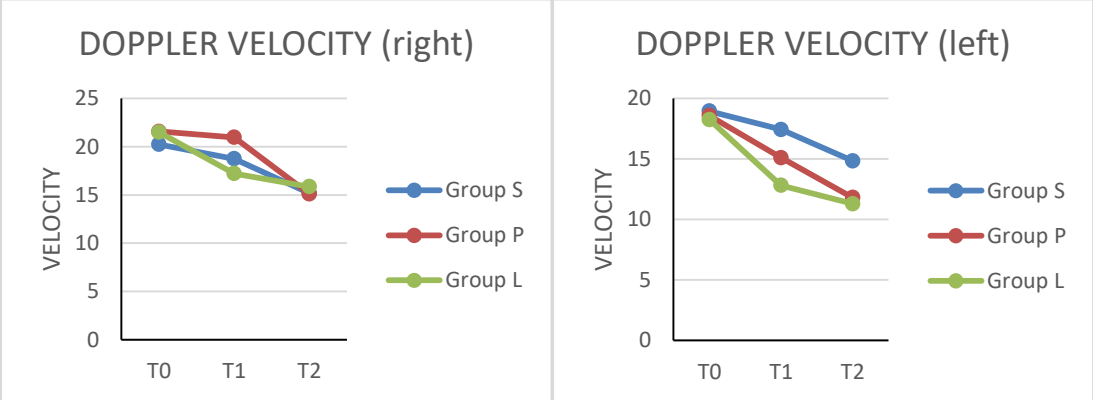


Figure 21 and 22 compares the doppler velocity in Group S, Group P and Group L in Right and Left IJV.

A significant reduction in Doppler velocity was found in all positions with the maximum decrease in right IJV in lateral position by 33.75±45.59 where it decreased from 21.49±5.57 to 15.85±7.29 after final positioning.

Comparison of Flow in three study groups

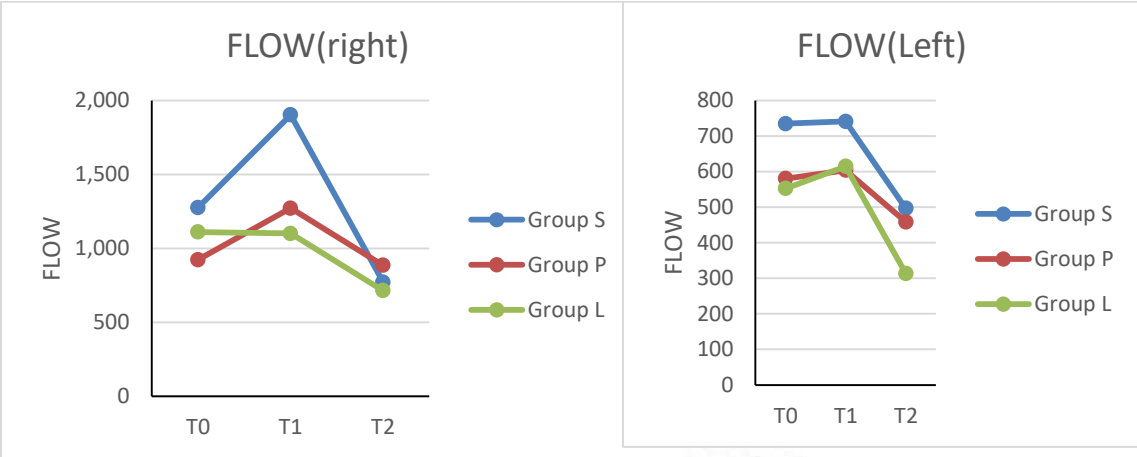


Figure 23 and 24 compares the flow in Group S, Group P and Group L in Right and Left IJV.

There was a significant reduction of flow in all three groups which was found to be statistically significant.

Table 26 shows the changes in Mean flow of right and left IJV in Group S, Group P and Group L.

Mean flow of right and left IJV in Group S, Group P and Group L

FLOW(ml/min)	Group S(N=30)	Group P(N=30)	Group L(N=30)	p
	Mean±SD	Mean±SD	Mean±SD	
T0	1005.9±463.7	752.5±384.8	831.8±337.4	0.047
T1	1322.2±1767.2	938.4±431.4	858.4±347.0	0.205
T2	634.7±245.5	672.3±391.0	514.4±305.3	0.142
p	0.036	0.002	<0.001	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

The mean flow of both right and left IJV in Group S was 1005.9±463.7 at baseline, which increased to 1322.2±1767.2 after anaesthesia, which decreased after positioning to 634.7±245.5 which was statistically significant (p value=0.036). In group P, the mean flow was 752.5±384.8, which after induction, increased to 938.4±431.4, but decreased to 672.3±391.0 which was statistically significant(p value 0.002). The baseline flow in Group L was 831.8±337.4, which minimally increased to 858.4±347.0 after anaesthesia and decreased significantly to 514.4±305.3.(p value <0.001)

Table 27 shows the changes in Mean flow of right and left IJV in Group S, Group P and Group L.

Mean Flow(ml/min)	Group S(N=30) % change	Group P(N=30) % change	Group L(N=30) % change
T0-T2	-37%	-10%	-38%
T1-T2	-48%	-28%	-40%

Group S= Supine, Group P= Prone, Group L= Lateral.

The % change of mean flow of both right and left IJV in Group S from baseline to final position was -37% and after anaesthesia to final position was -48%. In group P, it was -10% from baseline to final position and -28% after anaesthesia to prone position. In Group L, from baseline to final position was -38%, from supine under anaesthesia to final lateral position was -40%.

5) Variations in Optic nerve sheath diameter in Group S, Group P and Group L on both Sides

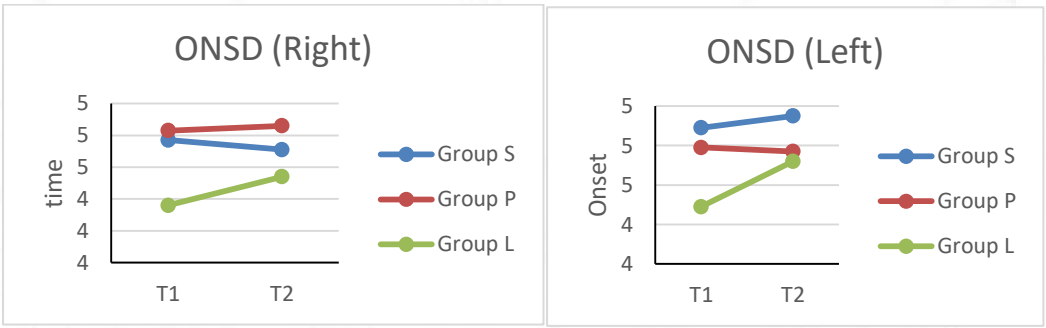
Optic nerve sheath diameter in Group S, Group P and Group L on Right Side

Table 28 shows the change in ONSD on the right side in Group S, P and L.

ONSD (Right)	Group S(N=30) Mean±SD(cm)	Group P(N=30) Mean±SD(cm)	Group L(N=30) Mean±SD(cm)	p
T1	4.77±0.52	4.83±0.91	4.36±0.30	0.009
T2	4.71±0.61	4.86±0.76	4.54±0.43	0.152
ONSD Percentage change	-1.22±8.75	1.29±9.08	4.15±6.87	0.047
p	0.402	0.790	0.003	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

Figure 25 and 26 shows the ONSD changes in Right and Left eyes in Group S, Group P and Group L.



The optic nerve sheath diameter on the right side after anaesthesia was found to be 4.77±0.52 cm which minimally increased to 4.71±0.61 cm after final supine position. In prone position it was 4.86±0.76 cm from 4.83±0.91 cm, whereas it significantly increased in lateral position from 4.36±0.30 cm to 4.54±0.43 cm (p value= 0.003).

Optic nerve sheath diameter in Group S, Group P and Group L on Left Side.

Table 29 shows the change in ONSD on the right side in Group S, P and L.

ONSD (Left)	Group S(N=30) Mean±SD	Group P(N=30) Mean±SD	Group L(N=30) Mean±SD	p-value
T1	4.89±0.63	4.79±0.74	4.49±0.48	0.043
T2	4.95±0.65	4.77±0.72	4.72±0.47	0.319
ONSD Percentage change	1.98±11.64	0.30±13.38	5.84±13.58	0.239
p-value	0.568	0.833	0.020	

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

On the left side, in supine position the mean ONSD was 4.89±0.63 cm which minimally increased to 4.95±0.65 cm after final positioning whereas the baseline ONSD measurement in prone position was 4.79±0.74 cm which became 4.77±0.72 cm after final positioning. In lateral position there was a significant change in ONSD from 4.49±0.48 cm to 4.72±0.47 cm with p value of 0.02. The ONSD changes from supine to final positions under anaesthesia was found to be statistically significant only in lateral position (p value= 0.020)

Comparison of Baseline flow in Internal jugular vein in Group S, Group P and Group L.

IJV was found to be dominant in 68 patients (75.6 %), whereas left IJV was dominant in 22 patients (24.4%) in our study.

Table 30 shows dominance of IJV flow between the Groups S, P and L.

IJV flow (ml/min)	Position						Total (N=90)		χ^2	df	p
	Group S(N=30)		Group P(N=30)		Group L(N=30)						
	N	%	N	%	N	%	N	%			
Right	24	80	19	63.3	25	83.3	68	75.6			
Left	6	20	11	36.7	5	16.7	22	24.4	3.730	2	0.155
Total	30	100	30	100	30	100	90	100			

Group S= Supine, Group P= Prone, Group L= Lateral, P<0.05 is Significant. Test- Repeated measure ANOVA.

6) Comparison of subjective assessment of brain relaxation in Group S, Group P and Group L.

Table 31 shows dominance of IJV flow between the Groups S, P and L.

Surgical assessment score	Group S(N=30)	Group P(N=30)	Group L(N=30)
Perfectly relaxed Number(%)	11 (53%)	13 (43%)	11 (36%)
Satisfactory relaxation Number(%)	9 (30%)	13 (43%)	12 (40%)
Firm brain Number(%)	7 (23%)	1 (3%)	5 (17%)
Tight brain Number(%)	3 (10%)	3 (10%)	2 (6.6%)
p-value	0.4	0.5	0.2

Group S= Supine, Group P= Prone, Group L= Lateral.

In Group S, 11 patients (53%) had a perfectly relaxed brain by the subjective surgical assessment scale, 9 patients (30%) had satisfactory relaxation, 7(23%) had firm brain and 3(10%) had brain bulge. In group P, about 80% had satisfactory brain relaxation and lesser number of patients had a firm (3%) and tight brain (10%). In lateral position, 11 patients(36%) had good brain relaxation and 12(40%) had satisfactory relaxation, whereas 5 patients(17%) had firm brain and 2(6.6%) had tight brain.

Table 32 shows the apparent bleeding and venous oozing at the surgical site between the Groups S, P and L.

	Group S(N=30)	Group P(N=30)	Group L(N=30)
Excessive bleeding observed (Number of patients)	9 (30%)	10 (33%)	16 (53%)
P- value	0.3	0.5	0.04

Group S= Supine, Group P= Prone, Group L= Lateral. P<0.05 is Significant.

16 patients (53%) in Group L had excessive apparent bleeding and venous oozing at the surgical field, whereas 9 patients(30%) in group S and 10 patients in Group P.

DISCUSSION

One of the primary goals of neuroanaesthesia in the perioperative management of patients is to provide optimal head and neck position during neurosurgical procedures that would facilitate adequate venous drainage, maintain CBF and cerebral oxygenation while prevent the rise in ICP. (25,55) There is paucity of data for objective measurement of IJV flow during various surgical positioning under anaesthesia and positive pressure ventilation in neurosurgical population. The flow through the IJV is the predominant exit of intracranial blood under normal conditions and hence the factors affecting it can cause perioperative problems during neurosurgery. (56) The most common factor recognized is the improper positioning of head and neck.

The primary findings of our study are;

a) The baseline measurement showed that right IJV had higher dimension (CSA) and flow than the left side implicating a right-sided dominance in most of the included patients. (76%)

b) The dimensions of IJV in the prone group on right side was lesser compared to other two groups; but on the left side they were comparable.

c) The mean total IJV flow at baseline in supine was higher compared to prone and lateral groups.

d) After induction of anaesthesia, the CSA of IJV increased in all the groups on both the right and left side, but more significantly seen in prone and lateral groups compared to supine. However, there was a significant increase in IJV flow on right side in supine and prone groups, but only marginal increase in lateral group. The magnitude of increase on the left side was not similar to right side despite similar changes in CSA between right and left side.

e) After positioning, the CSA on both sides decreased significantly in all three groups, but maximum decrease was seen in lateral followed by supine and least change was seen in prone position. Similarly, the IJV flow also decreased significantly with maximum in supine (48%) and lateral (40%) and less in prone (28%).

f) The non-invasive ICP measured using ONSD did not show significant increase in supine and prone position, but increased significantly in lateral position.

We hypothesized that the currently applied techniques of patient positioning for neurosurgery in lateral and prone positions do not affect the IJV dimensions, flow and concurrently intracranial pressure compared to supine position measured by ultrasound technique. In contrast to our hypothesis, we found significant alterations in the IJV dimensions, and flow in all three neurosurgical positions namely supine, prone and lateral groups. Moreover the non-invasive ICP measurement based on ONSD increased after lateral position when compared to final prone and supine position for surgery.

A) <u>Changes Observed in Supine Position:</u>

Neurosurgical procedure done in supine position is considered to be physiological among all the positions in neurosurgery. The supine position with mild head up position of up to 30^{o}-40^{o} is routinely employed to prevent increase in the ICP, facilitate CSF and venous drainage, to provide adequate brain relaxation, minimize oozing and to provide a clear surgical field. It is believed that the impact on the cerebral blood flow and venous drainage of the brain is least with supine compared to prone and lateral positions. In supine position ,we found that the mean flow of both

right and left IJV in supine position was 1005.9±463.7 ml/min at baseline, which increased to 1322.2±1767.2 ml/min after anaesthesia and decreased after positioning to 634.7±245.5. It was found to be statistically significant (p value=0.036).

Vailati, et. Al, performed a study on the effect of bilateral IJV flow after IJV catheterization in fifty patients with intracranial lesions using ultrasound. They measured the IJV diameter, flow before and after catheterization at two different head positions, 0^o and 30^o head up tilt. They found a significant reduction of IJV flow and CSA of IJV at 30^o compared to 0^o degrees before cannulation of IJV. The results of our study also were similar to their study. The researchers have postulated that alteration in the cerebral blood volume after head elevation due to both arterial flow and enhanced venous drainage could have contributed to their findings. (57)

In another study, Ciuti G et. al, investigated the vessel area, mean velocity, and flow for the vertebral and internal jugular veins in the supine and sitting positions in twenty-five awake healthy volunteers using ultrasound guidance. (5) Each session started with the subject in supine position and it shifted to sitting position. They concluded that in the sitting position, flow decreases, both in vertebral veins and internal jugular veins, as the total vessel area decreases (from 0.46± 0.57 to 0.09 ±0.08 cm^2), even if the mean velocity increases (from 12.58 ±10.19 to 24.14 ±17.60 cm/s). Contrary to what happens to the blood inflow, outflow in the supine position, through vertebral and internal jugular veins, is more than twice the outflow in the sitting position (739.80 ±326.32 versus 278.24 ± 207.94 mL/min). In our study also we documented a decrease in cross section area in supine with head elevation under anaesthesia which could be attributed to gravity assisted collapsibility of the veins.

The increase in the IJV flow following induction of anaesthesia in all the three groups as well as the decrease in IJV flow after positioning in Supine group can be

explained by the physiological changes in cerebral venous flow related to alterations in venous flow resistance. In the study on the effects of pneumoperitoneum on the IJV and subclavian dimensions, Pinar et. al, have documented that the IJV CSA was higher at end inspiration whereas it decreased at end expiration under anaesthesia with mechanical ventilation compared to baseline before anaesthesia. They have not measured the IJV flow. (58) Their finding shows that there is a tendency for exaggeration of normal respiratory variation under anaesthesia due to positive pressure ventilation. We have also noted that the averaged CSA of IJV on both sides increased in all three groups and correspondingly the venous flow 5 minutes following the induction of anaesthesia and mechanical ventilation.

We have noted that the IJV CSA and flow decreased on assumption of the final surgical position in supine group. Elevation of head above the heart level in neurosurgery is considered to be beneficial to improve the venous outflow. However experimental evidence showed that there is gradual collapse of the IJV on head elevation and with greater degree of elevation greater is the collapse. It was also noted that the resistance to the venous outflow increased in standing compare to supine position. Gisolf, et. al, found that the major cerebral venous outflow in supine is via IJV and in the standing position the vertebral flow is the predominant outflow due to collapse of IJV. They also found that increasing the CVP reduced the outflow resistance. (59) In other studies, positive pressure ventilation of upto 30 mmHg, positive end expiratory pressure of 10 cmH_2O were all found to mitigate the effects of IJV collapse in head up position. (12,60)

Head rotation causes compression and occlusion of the ipsilateral IJV. (61-63) This can result in raised intracranial pressure and increased bleeding during neurosurgical procedures. Burbrige MA et. al, measured the effect of head rotation on

IJV patency in 25 adult patients using ultrasound imaging with color Doppler to determine the angle at which the ipsilateral IJV occludes in adults under general anaesthesia. (62) They concluded that an adult being mechanically ventilated under general anaesthesia will occlude their left IJV at an average of 55.6° and their right IJV at an average of 53.3°. They concurrently did not study the effect of this head rotation on ICP. In our study, it was ensured at all times that allowable head rotation was not more than the recommended 45° and two finger space between the angle of the mandible and clavicle was maintained after final positioning.

B) <u>Changes Observed in Prone Position:</u>

Prone position is commonly employed for approach to lesions of posterior fossa and of occipital lobe upto vertex and posterior spine surgeries. The type of positioning of the torso and the head as well as degree of elevation, head rotation, frames used for position, pressures like intrathoracic and intra-abdominal pressures can affect the venous outflow. We have included only patients with intracranial pathology and not spine surgery although in posterior fossa surgeries, the surgeon dissects the C1 and C2 vertebra also. We have observed that there was reduction in the CSA, doppler velocity and a 28% reduction in the mean venous flow in IJV.

Our findings are in contrast to the results of the study by Yeoh TY et. al. The reseachers had conducted a ultrasound study of IJV blood flow in ten healthy volunteers who were awake. The volunteers were positioned prone in bolsters with head in neutral position. Comparison of right and left IJV diameter, doppler velocity and IJV flow between supine and prone have shown that all the three variables were increased in prone position though not statistically significant. They found that in right IJV, cross sectional area significantly increases to 1.8 cm2 ±1.0 cm^2 in prone from 1.2±0.6 cm^2($p=0.015$), doppler velocity has minimum decrease from 19.9±7

cm/s to 19.3±7.9 cm/s and flow increases from 1924.2. ±1139.7 to 1430.1± 803.0 ml/min. In left IJV, the cross sectional area had again significantly increased from 1.0±0.3 cm^2 to 1.4 ±0.4 cm^2 with p value <0.001, doppler velocity decreased from 18.1±8.4 cm2 to 13.6±7.7 cm^2, which was statistically significant (p value 0.043) and flow had become 1178.4 ±832.1 ml/min from 1112.9 ±578.1 ml/ min (p=0.738). This study was conducted in awake, healthy volunteers and the effect of anaesthesia and mechanical ventilation on IJV was hence not studied. Moreover, the prone position was simulated and thus the definite surgical positioning that is employed during the neurosurgical procedures was not studied which may not be always ideal.

Studies have shown increase in ICP in prone position compared to supine. (51) Prone position can also cause increase in ICP, arterial pressure, cerebral perfusion pressure and cerebral oxygenation. (64) The mechanisms for increase in ICP in prone position have not been clearly described. As per various studies there is increase in cerebral blood flow and CPP despite increase in ICP in prone position. Moreover, in prone position with mechanical ventilation the central venous pressure is increased and greater is the change with application of PEEP. (65,66,67) In addition increase in intraabdominal or intrathoracic pressure, head down position have been associated with increased CVP, IJV cross sectional area. (68) Another study has found that head elevation in prone can shift the fluids from intracranial cavity to periphery and reduces ICP. (69)

Højlund J et. al, demonstrated that cross-sectional area of the IJV is greater in the prone than in the supine position in healthy volunteers. (70) They postulated that most likely, this effect results from an increased central venous pressure in the prone position, which is due to compression of the organs situated in the abdomen

(particularly, the inferior vena cava). They also found that during positive pressure breathing the prone position with sideways rotated head reduces MCA Vmean ~10% in spite of an elevated MAP. They concluded that prone positioning with rotated head affects both CBF and cerebral venous drainage indicating that optimal brain perfusion requires head centering.

Tsutsumi et. al, demonstrated venous flow in cerebral sinuses in the prone position. (68) Using Magnetic Resonanace venography (MRV) imaging, they demonstrated an intriguing phenomenon—there was no flow in non-dominant transverse and sigmoid sinuses in the majority of individuals examined in the supine position, despite the fact that these sinuses were not occluded. Flow through these sinuses were restored in prone position. The authors did not provide reasonable explanation for these findings. They did not assess healthy subjects, but they were examining patients presenting with headache, dizziness, and tinnitus. It is already known that in many of such patients, abnormal jugular valves can be found. Usually, such valves present with pathological leaflets that are too close to each other, which results in relative stenosis of the IJV. Although clinical relevance of over competent jugular valves is unclear, many studies have demonstrated that such malformed valves impair cerebral venous drainage.

Hence our study is probably the first one to evaluate the changes in IJV CSA and flow in prone position under anaesthesia. We have maintained the airway pressure, $EtCO_2$ constant from supine to prone position. All the patients were given minimal head up tilt of 15-20 degrees. We believe the reduction in IJV CSA and flow in prone position is caused either by the collapse of the IJV due to gravity or improved intrathoracic compliance or shift of venous drainage of via the vertebral

venous system. Further studies are needed to evaluate the physiology of venous drainage in prone patients.

C) **Changes Observed in Lateral Position**:

In lateral position we found that the baseline mean flow of combined right and left IJV was 831.8±337.4, which minimally increased to 858.4±347.0 after anaesthesia and decreased significantly to 514.4±305.3 (p value <0.001). The percentage flow from baseline to final position was -38%, from supine under anaesthesia to final lateral position was -40%. In addition we found that the CSA and doppler flow velocity decreased from supine to lateral position under anaesthesia and positive pressure ventilation. There was minimal increase in airway pressure (+ 1 cm H_2O)and $EtCO_2$ (-2 mm Hg) with change of position.

Studies exists on the effects of lateral position on cerebral oxygenation, ICP, CPP , but none is found on the effects of lateral positions on venous flow. Ledwith et al, found that brain tissue oxygenation ($PbtO_2$) decreased and ICP increased in right and left lateral position with head of bed (HOB) elevation in neurocritical care of acute TBI patients. (71) Another similar study found increases in ICP and decreases in CPP in lateral positions in TBI patients in neurocritical care. (72)

The only study we came across the literature search on IJV flow changes in lateral position was by Yeoh TY et. al, who in a healthy volunteer study found that in the right park bench position, the right internal jugular vein cross-sectional area decreased significantly from 1.2 to 0.9 cm2 (p = 0.027) without substantial changes in mean venous flow rate (p = 0.91) when compared with supine. They attributed their finding to significant increase in doppler velocity as the flow through blood vessel

depends on the product of velocity and cross- sectional area of the vessel. But the major drawback of their study is it was done in patients without intracranial pathology and in awake state and without application of any head clamps, mechanical ventilation and bolsters and straps applied which is seen in operation theater environment. Hence our study is very important as it represents the real clinical scenario seen by the neuroanesthesiolgists in their day today practice.

D) **Changes in non-invasive ICP Measurement using Optic Nerve sheath Diameter**.

Positioning can be a risk factor for the development of increased ICP and direct ICP monitoring can be done but it is invasive and carries risks. Thus, its use in elective procedures is not indicated and a non-invasive method to assess ICP would be desirable. Many attempts have been made to find a convenient, non-invasive estimator for ICP. Among these, ONSD by ultrasound and Transcranial doppler has demonstrated to be repeatable and accurate for intraoperative use. In particular, the correlation of ONSD and ICP has been established by several authors.

In our study, the optic nerve sheath diameter on the right side after anaesthesia was found to be 4.77±0.52 cm which minimally increased to 4.71±0.61 cm after final supine position. In prone position it was 4.86±0.76 cm from 4.83±0.91 cm, whereas it significantly increased in lateral position from 4.36±0.30 cm to 4.54±0.43 cm (p value= 0.003). On the left side, in supine position the mean ONSD was 4.89±0.63 cm which minimally increased to 4.95±0.65 cm after final positioning whereas the baseline ONSD measurement in prone position was 4.79±0.74 cm which became 4.77±0.72 cm after final positioning. In lateral position there was a significant change in ONSD from 4.49±0.48 cm to 4.72±0.47 cm with p value of 0.02. Hence, the ONSD changes from supine to final positions under anaesthesia was found to be statistically

significant only in lateral position. The gold standard for ICP measurement is intraventricular catheter but it is invasive and can have many complications. Hence, we used ONSD which is a promising technique and can be easily employed under anaesthesia. The reading after positioning were taken after 10 minutes of final positioning which can be a short time period for the potential position related increase in intracranial pressure to be reflected on ocular sonography.

Romagnuolo et. al, showed that the ONSD does not change with patient position. Interobserver variation is quite low and the measurements are highly reproducible, even for novice operators taught in a single training session. (50) In their study, in supine position, the mean ONSD was 4.6±0.71 (SD) mm in the right eye and 4.5±0.56 (SD) mm in the left eye. In Trendelenburg's position, the mean ONSD was 4.4F0.72 (SD)mm in the right eye and 4.7 F 0.53 (SD) mm in the left eye. In reverse Trendelenburg's position, the mean ONSD was 4.4 F 0.49 (SD) mm in the right eye and 4.8 F 0.76 (SD) mm in the left eye. There was no significant difference in OSND between positions for either eye by analysis of variance. They hence concluded that optic nerve sheath diameter measurement by ultrasound does not significantly change with Trendelenburg's or reverse Trendelenburg's position in comparison with the supine position in healthy individuals. The limitation of the study was a small sample size of ten patients and allowance of only 1 minute for ICP equilibration of ICP after positioning.

Robba et. al, studied the effect of prone position on ICP with the help of TCD and ONSD in 30 patients undergoing spine surgery which concluded a significant increase in ICP from supine to prone. (51) They stated that an optimal cut-off for discriminating between prone and supine positions was 0.43 cm. In their study, the baseline mean ONSD value was 0.40±0.01 mm which had become 0.48±0.01mm

(P<0.0001) after prone positioning. They also stated that the mean ONSD measurement was the most effective noninvasive technique, with the highest sensitivity and specificity, in distinguishing a hypothetical change in ICP between supine and prone positioning. They studied only 30 patients and in blood pressure monitoring was not done by an invasive measurement of arterial BP. The arterial line can help in more aggressive monitoring for blood pressure which has an important role on cerebral hemodynamics. Moreover, arterial line allows for repeated sampling which help to decipher the gradient between $PaCO_2$ and $EtCO_2$ which has a direct effect on ICP. Our study had employed beat to beat pressure monitoring with arterial line for effective titration of blood pressure and ventilation.

Anaesthetic agents can have a direct effect on basal vascular tone due to a wide variety of cellular and molecular mechanisms regulating vascular reactivity. Intravenous anaesthetics exert their vascular actions only at supra clinical concentrations, whereas volatile anaesthetics can exert their vascular actions at clinical concentrations. Therefore, direct actions of volatile anaesthetics on vascular smooth muscle cells and endothelial cells would contribute to the alterations in hemodynamics and organ blood flow during their administration. To study these effects in clinical setting we obtained a baseline IJV flow before anaesthesia and ten minutes after induction. In our study we found that there was a minimal increase in cross sectional area, but not much change in doppler velocity and hence the change in mean flow velocity after anaesthesia in all three groups were not found to be significant. The changes between the group were comparable.

The interactions between the intracranial and the respiratory systems during mechanical ventilation and PEEP application have been studied by several authors showing conflicting results. (51) Continuous positive airway pressure has shown to

decrease CPP and CBF in head injured patients. However, Pulitano et. al, in his study demonstrated that PEEP application (from zero to PEEP=8) in paediatric patients undergoing major neurosurgical interventions for tumour removal does not increase ICP, suggesting that PEEP application may be safe, provided that blood pressure is maintained. (73,74) Finally, Mascia and colleagues suggested that ICP significantly increases when PEEP is applied, only in patients where PEEP induces alveolar hyperinflation (non-recruiters) with a consequent increase in partial pressure of carbon dioxide and ICP, whereas ICP remains constant in patients where PEEP causes alveolar recruitment (recruiters) and unchanged PCO_2(75). To overcome these problems, we had not instituted PEEP in our patients and had instituted controlled mechanical ventilation with tidal volumes 8 ml/kg and respiratory rate of 12-14/minute to achieve a $PaCO_2$ value of 30 to 40 mmHg. The hemodynamics, respiratory variables were maintained between the groups as well as before and after positioning. Hence our study did not have confounding systemic factors that could have affected the results.

E**) <u>Effect of Positioning of Assessment of Brain Relaxation & Intraoperative Bleeding</u>**

In Group S, 11 patients (53%) had a perfectly relaxed brain by the subjective surgical assessment scale, 9 patients (30%) had satisfactory relaxation, 7(23%) had firm brain and 3(10%) had brain bulge. In group P, about 80% had satisfactory brain relaxation and lesser number of patients had a firm (3%) and tight brain (10%). In lateral position, 11 patients(36%) had good brain relaxation and 12(40%) had satisfactory relaxation, whereas 5 patients(17%) had firm brain and 2(6.6%) had tight brain 16 patients (53%) in Group L had excessive apparent bleeding and venous

oozing at the surgical field, whereas 9 patients (30%) in group S and 10 patients in Group P. Though patients positioned in supine and lateral had higher incidence of tight brain it was not found to be statistically significant in our study; probably our sample size was smaller to cause significant differences. The bleeding and venous oozing was more apparent in lateral group which was found to be statistically significant.

The IJV flow changes could have been one of the contributing factors for brain bulge leading to excessive bleeding. (53,54) The checklist for brain bulge was followed which consisted of maintenance of optimum airway pressure, blood pressure, depth of anaesthesia, analgesia, temperature PaO_2, $PaCO_2$ on ABG, glycemic status of the patient and absence of seizures. In our study, we found that IJV flow which was being measured decreased significantly in most patients. Hence, tight brain can be attributed to the IJV compression and objective IJV flow measurement by ultrasound can be a valuable method to assess it.

LIMITATIONS

Our study also has few minor limitations.

1. Being operator dependent, ultrasound technique is prone for technical errors and as well inter observer variability. So, to avoid this limitation, a well-trained Neuroanaesthesiologist for USG, had determined all parameters. The USG examinations were done by the Pi and CoPi in all cases.
2. The gold standard for ICP measurement is intraventricular catheter but it is invasive and can have many complications. It cannot be applied immediately before positioning of patients. Hence, we used ONSD which is a promising technique and can be easily employed under anaesthesia. However, ONSD did not change and we cannot tell if the reduced venous flow after positioning had an impact on ICP values.
3. Cerebral venous flow is complex and is affected by various physiological factors. It would have been more informative and interesting to include other parameters in our study such as total venous outflow (IJV and vertebral veins), IJV flow variation rate, cerebral arterial flow and cerebral perfusion pressure.
4. We did not take an ONSD reading before anaesthesia which could have been more useful in understanding the baseline ICP of the patient before induction and its change with anaesthesia. Both intravenous and inhalation anaesthetics are known to affect the cerebral haemodynamics but mainly at supramaximal concentration, whereas we had standardized the anaesthesia regimen for our patients to overcome this problem.

5. The IJV flow and ONSD reading was recorded 10 minutes after final position. Though this time has been established to be sufficient for ICP equilibrium to occur, it would have been more useful to repeat the measurement at a later stage also. This was not practical in our study as the neurosurgical procedures for craniotomy and excision warrants the sterile draping of the head and neck area leading to its inaccessibility at a later stage.
6. We have not studied the effect of sitting position on IJV flow as the number of cases done in sitting posture in our centre is of limited number.

However, despite some limitation we were able to find the change in IJV with the change with position though the changes in ONSD were not found to be statistically significant.

SUMMARY

One of the primary goals of neuroanaesthesia in perioperative management of patients is to provide optimal head and neck position during neurosurgical procedures that would facilitate adequate venous drainage, maintain CBF and cerebral oxygenation while prevent the rise in ICP. This study was conducted to evaluate the effects of different positions employed in neurosurgical population to facilitate surgery on cerebral venous drainage and intracranial pressure under anaesthesia and controlled mechanical ventilation with the help of an ultrasound with doppler function. This prospective observational study included a total of 90 patients aged between 18-65 years belonging to ASA I, II and III with GCS14 /15 who underwent elective neurosurgery for primary intracranial lesions.

Our results showed that changing the position of the patients from baseline to final surgical position resulted in significant alterations in the IJV dimensions, and flow in all three commonly employed neurosurgical positions namely supine, prone and lateral groups. The IJV flow bilaterally decreased significantly with maximum fall seen in supine (48%) and lateral (40%) positions and less severe in prone (23%). The decrease in flow was associated with concomitant decrease in cross sectional area of IJV which was seen maximum in lateral with park bench position which is usually employed for retro sigmoid suboccipital craniotomy and less with other positions. Our study did not evaluate the mechanisms and the effects of this reduction in flow on the brain as well as alternate pathways of venous drainage present or not to compensate for reduction in IJV flow. Further studies based on MRI or advanced imaging techniques may be required to improve our understanding on the above points. The non-invasive ICP measurement of optic nerve sheath diameter with the help of ocular ultrasound was most significantly decreased again in lateral position. These changes were observed despite maintaining the recommended head rotation of 45^{0}, two finger

breaths between the angle of mandible and clavicle, avoidance of intrathoracic or abdominal pressure and avoidance of recommended increase in airway pressure with stable hemodynamics . We found that ultrasound guided assessment of IJV flow is a useful and feasible bedside technique to quantify the neurosurgical position related changes in IJV venous drainage.

CONCLUSION

We undertook the current study to evaluate the hypothesis that IJV dimensions and flow does not change with supine, prone and lateral positions used in neurosurgery. However, we found that the IJV cross sectional area, velocity and flow all increased following induction of anaesthesia from awake state, but significantly reduced following final neurosurgical position especially in the lateral compared to supine and prone position. Though we did not find significant change in the non-invasive measurement of ICP, and brain relaxation score, the surgical bleeding was more in the latter group.

Our study is probably the first one to evaluate effects of position in neurosurgery under anaesthesia using ultrasound. We did not elucidate the cause of reduced venous drainage, and the importance alternate pathways in maintaining cerebral venous flow, postulated in literature. We believe future studies would provide insights. We also found ultrasound is a very useful modality in evaluation of IJV flow in neurosurgical population.

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APPENDICES

Technical Advisory Committee (Clinical Studies)

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

TAC Registration No: SCT-/S/2018/761

Date:09.07.2018

Project title: EFFECT OF DIFFERENT SURGICAL POSITIONS ON THE CHANGES IN CEREBRAL VENOUS DRAINAGE AND INTRACRANIAL PRESSURE (ICP) IN PATIENTS UNDERGOING NEUROSURGERY

Principal Investigator:
Dr. Keta Thakkar, Resident, Department of Aneasthesiology, SCTIMST Degree: MBBS, MD(Anaesthesiology) , DNB(Anaesthesiology), PDCC (Neuroanesthesiology)
Co-Principal Investigator(s)
Dr. Manikandan S (Guide), Professor, Department of Aneasthesiology, SCTIMST Degree:: MBBS, MD (Anaesthesiology and Critical Care), PDCC (Neuro-anesthesiology)
Co-guide)
Dr. Ranganatha Praveen S (Co-guide), Assistant Professor, Department of Aneasthesiology, SCTIMST Degree: MBBS, MD (anaesthesiology and critical care), DM (Neuro-anesthesiology)
Dr. Mathew Abraham, Professor and Head, Department of Neurosurgery, SCTIMST Degree: MBBS, MS (General Surgery), MCH (Neurosurgery), FRCS

Members who participated in the TAC meeting on 16/06/2018

Dr. Rupa Sreedhar (Chairperson)
Dr. Prasantakumar Dash
Dr. Krishna Kumar K
Dr. Sankara Sarma P
Dr. Bijulal S
Dr. Jayadevan ER
Dr. Syam K
Dr. Varghese T. Panicker
Dr. K. Shivakumar (Member Secretary)

Dr. Varghese T Panicker, Dr. Rupa Sreedhar, Dr. Jayadevan ER, Dr. Syam K, Dr. Krishna Kumar K, and Dr. Bijulal S stayed away from the proceedings when the projects in which they are involved as investigator were discussed (#762, 768, 769, 772, 775, 776, 778, 782, 784, 785).

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.

Signature of the Member Secretary, TAC (Clinical Studies)

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
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Institutional Ethics Committee

(IEC Regn No. ECR/189/Inst/KL/2013/RR-16)

SCT/IEC/1238/AUGUST-2018 07.09.2018

Dr. Keta Thakkar
Resident
Department of Anaesthesiology
SCTIMST, Thiruvananthapuram

Dear Dr. Keta Thakkar,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "EFFECT OF DIFFERENT SURGICAL POSITIONS ON THE CHANGES IN CEREBRAL VENOUS DRAINAGE AND INTRACRANIAL PRESSURE (ICP) IN PATIENTS UNDERGOING NEUROSURGERY (IEC/1238)" on 17th August, 2018.

The following documents were reviewed:

Original submission

1. Covering letter addressed to the Chairman, IEC, SCTIMST dated 20.07.2018 with checklist
2. TAC Approval Letter
3. IEC Application Form
4. Project Proposal
5. Forwarding Letter from the HOD
6. Proforma
7. Declaration Form
8. Patient Information Sheet and Informed Consent Form in English and Malayalam
9. CV of Principal Investigator and Co- Principal Investigators

Revised submission

1. Covering letter addressed to the Member Secretary, IEC, SCTIMST dated 31.08.2018 with checklist
2. TAC Approval Letter
3. IEC Application Form
4. Project Proposal
5. Forwarding Letter from the HOD
6. Proforma
7. Declaration Form
8. Patient Information Sheet and Informed Consent Form in English and Malayalam
9. CV of Principal Investigator and Co- Principal Investigators

The following members of the Ethics Committee were present at the meeting held on 17th August, 2018 at G. Parthasarathi Board Room, AMCHSS, SCTIMST

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. R V G Menon	M Tech, PhD	Male	Lay Person (Chairman)	No
2.	Dr. V. Raman Kutty	M D, M Phil, M P H	Male	Health Sciences Expert/Clinician	Yes
3.	Dr. K R S Krishnan	M.E., Ph.D.	Male	Medical Technology	Yes
4.	Dr. Rema M. N	MD	Female	Basic Medical Scientist	No
5.	Dr. Mala Ramanathan	PhD	Female	Social Scientist (Member Secretary)	Yes

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,

Mala Ramanathan
Member Secretary, IEC

PATIENT INFORMATION FORM

Title of the study:

Effect of different surgical positions on the changes in cerebral venous drainage and intracranial pressure (ICP) in patients undergoing neurosurgery.

Name of the Investigators:

Dr. Keta Thakkar (PI), Dr. Manikandan S, (Guide and Co Pi),
Dr. Ranganatha Praveen S(Co Guide), Dr Mathew Abraham (Co-Investigator)

You are being requested to participate in this study which is undertaken to observe the effect of the surgical position necessary to undergo the proposed neurosurgical procedure on the changes in the cerebral venous drainage and intracranial pressure with the help of ultrasound. The cerebral venous drainage is calculated non invasively by Doppler ultrasonography by measuring the blood flow in the internal jugular vein. The intracranial pressure is also measured non invasively by optic nerve sheath diameter (ONSD) using ultrasound. We have planned to include about 70 patients undergoing neurosurgical procedure from this hospital to the study.

What is cerebral venous drainage and how is it measured?

The venous blood from the brain drains into the heart mostly via the internal jugular veins (IJV). This venous flow in the internal jugular vein can be easily studied non invasively in the neck region with the help an ultrasound having Doppler function. We plan to observe the changes in this flow in different surgical position used in neurosurgery for brain tumours with the help of ultrasonography by measuring changes in the internal jugular venous flow.

What is ONSD?

The optic nerve sheath is a covering around optic nerve which is an extension of the covering from the brain. Any pressure rise within the brain causes corresponding changes in the optic nerve sheath diameter. This is measured with the help of ultrasound machine placed over the patients eyelids.

It is followed widely since it is non invasive and bedside procedure without any adverse complications of invasive procedures.

If you take part what will you have to do?

On the day of surgery, you will be taken inside the Operation Theatre. Monitors to check your heart beat, blood pressure and oxygen saturation level will be attached. A small venous cannula will be inserted under local anaesthesia in the hand for fluid and drug administration. Protocol of induction of anaesthesia will be according to standard protocol followed in the hospital. After you will be fully sedated, and paralyzed, you will be connected to ventilator. Once the stable level of anaesthesia will be achieved, flow across the internal jugular vein will be seen and non-invasive monitoring of ICP will be done by optic nerve sheath diameter. After final surgical positioning again the internal jugular flow and optic nerve sheath diameter will be studied for any changes. Surgery will be allowed to proceed with the same level of anaesthesia.

Does Ultrasound use for IJV flow & ONSD measurement have any side effects?

As a non-invasive procedure, it doesn't carry any risk to patient. Adverse events related to ultrasound used for measuring flow in internal jugular vein are nil. ONSD measurement by ultrasound probe is also a non invasive procedure with negligible risks. All measures are taken to prevent any eye injury.

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. In addition, if you experience any side effects, the study will be stopped and you will be given treatment for the side effects.

What will happen if you develop any study related injury?

We do not expect any injury to happen to you since the anaesthesia technique and monitoring tools would be same even if you were not part of the study. 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?

Ultrasound used routinely used for identification of the internal jugular vein for central venous cannulation cannulation and ONSD are used as a part of anaesthesia monitoring of ICP in neurosurgical patients in our institute.No additional charges will be incurred in participating in the study.

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. Keta Thakkar (Principal investigator) mobile number: 9879520603. Email: keta0819@gmail.com.

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

രോഗിക്കുള്ള കാര്യവിവരണ പത്രം

പഠനശീർഷകം:

ന്യൂറോ ശസ്ത്രക്രിയക്ക് വിധേയരാകുന്ന രോഗികളുടെ തലയിലെ അശുദ്ധരക്കക്കുഴലുകളിൽനിന്നുള്ള പ്രവാഹത്തിന്റെയും തലയോട്ടിക്കുള്ളിലെ മർദ്ദത്തിന്റെയും (ഐസിപി) വ്യതിയാനങ്ങളിൽ ശസ്ത്രക്രിയക്കുവേണ്ടിയുള്ള വ്യത്യസ്ഥ നിലകളുടെ പ്രഭാവം

ഗവേഷകരുടെ പേര്

ഡോ. കേത താക്കർ, ഡോ മണികണ്ഠൻ എസ്, (മാർഗ്ഗദർശിയും സഹ ഗവേഷകനും)

ഡോ. രംഗനാഥ പ്രവീൺ (സഹമാർഗ്ഗദർശി)

എസ്, ഡോ. മാത്യു എബ്രഹാം (സഹഗവേഷകൻ)

ന്യൂറോ ശസ്ത്രക്രിയാനടപടികളുടെ സമയത്ത് സ്വീകരിക്കുന്ന നിലകൾ, തലയിലെ അശുദ്ധരക്കക്കുഴലുകളിൽനിന്നുള്ള പ്രവാഹത്തിന്റെയും തലയോട്ടിക്കുള്ളിലെ മർദ്ദത്തിന്റെയും വ്യതിയാനങ്ങളിൽ വരുത്തുന്ന സ്വാധീനം അൾട്രാസൗണ്ടിന്റെ സഹായത്തോടെ നിരീക്ഷിക്കുന്ന പഠനത്തിൽ പങ്കെടുക്കാൻ താങ്കളോട് അഭ്യർത്ഥിക്കുന്നു. ശരീരത്തിൽ പ്രവേശിക്കാതെ, ഡോപ്ലർ അൾട്രാസോണോഗ്രഫിയുപയോഗിച്ച് തലച്ചോറിന്റെ ഉള്ളിലുള്ള ജൂഗുലാർ അശുദ്ധരക്തക്കുഴലിലെ രക്തപ്രവാഹം അളന്നുകൊണ്ട് തലയിലെ അശുദ്ധരക്തക്കുഴലിലെ രക്തമൊഴുക്ക് കണക്കാക്കുന്നു. തലയോട്ടിക്കുള്ളിലെ സമ്മർദ്ദവും ശരീരക്കിൽ പ്രവേശിക്കാതെ ആൾട്രാസൗണ്ടുപയോഗിച്ച് ഒപ്ടിക് നെർവ് ഷീത്തിന്റെ വ്യാസമളന്ന് (ഒഎൻഎസ്ഡി) കണക്കാക്കുന്നു. ഈ ആശുപത്രിയിൽനിന്നും ന്യൂറോ ശസ്ത്രക്രിയക്ക് വിധേയരാകുന്ന 70 രോഗികളെ പഠനത്തിൽ ഉൾപ്പെടുത്താൻ ഞങ്ങൾ ആസൂത്രണം ചെയ്യുന്നു.

തലയിലെ അശുദ്ധരക്കക്കുഴലുകളിൽനിന്നുള്ള പ്രവാഹം എന്നാലെന്ത് അതെങ്ങിനെ അളക്കും?

തലച്ചോറിലെ അശുദ്ധരക്തക്കുഴലിൽനിന്നുള്ള രക്തം ഹൃദയത്തിലേക്ക് ഉള്ളിലുള്ള ജൂഗുലാർ അശുദ്ധരക്തക്കുഴലിലൂടെയാണ്(ഐജെവി) പ്രധാനമായും ഒഴുകുന്നത്. ഈ അശുദ്ധരക്തക്കുഴലിൽനിന്നുള്ള ഒഴുക്ക് കഴുത്തിന്റെ ഭാഗത്തുവച്ച് ഡോപ്ലർ പ്രവർത്തനമുള്ള അൾട്രാസൗണ്ടിന്റെ സഹായത്തോടെ ശരീരത്തിൽ പ്രവേശിക്കാതെ പഠിക്കാൻ കഴിയും. കലച്ചോറിലെ മുഴകൾക്കുള്ള ന്യൂറോശസ്ത്രക്രിയയിലുപയോഗിക്കുന്ന വ്യത്യസ്ഥ നിലകളിലെ പ്രവാഹത്തിന്റെ മാറ്റങ്ങൾ, അൾട്രാസോണോഗ്രഫിയുടെ സഹായത്തോടെ ഉള്ളിലുള്ള ജൂഗുലാർ അശുദ്ധരക്തക്കുഴലിലെ പ്രവാഹത്തിന്റെ വ്യതിയാനങ്ങൾ അളന്നുകൊണ്ട് നിരീക്ഷിക്കാൻ ഞങ്ങളുദ്ദേശിക്കുന്നു.

എന്താണ് ഒഎൻഎസ്ഡി?

തലച്ചോറിന്റെ ആവരണത്തിന്റെ തുടർച്ചയാണ് ഒപ്ടിക് നെർവ് ഷീത്ത്. തലയോട്ടിക്കുള്ളിലെ ഏതൊരു മർദ്ദത്തിന്റെ ആധിക്യവും ഒപ്ടിക് നെർവ് ഷീത്തിന്റെ വികാസത്തെ (ഒഎൻഎസ്ഡി) ബാധിക്കും. അൾട്രാസൗണ്ട് മെഷീനിന്റെ സഹായത്തോടെ

ഒപ്ടിക് നെർവ് ഷീത്തിന്റെ വികാസം (ഒഎൻഎസ്ഡി) അളക്കാനായി അൾട്രാസൗണ്ട് മെഷീനിന്റെ നിരീക്ഷണ ഉപകരണം രോഗിയുടെ മുകളിലെ കൺപോളകളിൽ വയ്ക്കും. ശരീരത്തിനുള്ളൽ പ്രവേശിക്കാതെ കിടയ്ക്കക്കരുകിൽ വച്ചുനടത്തുന്ന ഒരു പ്രതിലോമകര മായ സങ്കീർണ്ണതകളുമില്ലാത്ത ഈ നടപടി വ്യപകമായി ഉപയോഗിക്കപ്പെടുന്നതാണ്.

പങ്കെടുക്കുകയാണെങ്കിൽ താങ്കൾ എന്തുചെയ്യണം ?

ശസ്ത്രക്രിയാ ദിവസം താങ്കളെ ശസ്ത്രക്രിയാമുറിയിൽ പ്രവേശിപ്പിക്കും. താങ്കളുടെ ഹൃദയമിടി പ്പ്, രക്തസമ്മർദ്ദം, പ്രാണവായുവിന്റെ നിലവാരം എന്നിവ പരിശോധിക്കാനുള്ള ഉപകരണങ്ങൾ ഘടിപ്പിക്കും. പ്രാദേശീകമായ മയക്കലിന് വിധേയമാക്കി ദ്രാവകങ്ങളും മരുന്നും നൽകാനാ യുള്ള ഒരു ചെറിയ കുഴൽ കൈയിലെ രക്തക്കുഴലിൽ കടത്തും ആശുപത്രിയിലെ പതിവ് നട പടിക്രമമനുസരിച്ച് പൊതുവായ മയക്കലിനുള്ള മരുന്ന് നൽകും. താങ്കൾ ബോധരഹിവും നിശ്ച ലവുമായശേഷം താങ്കളെ കൃത്രിമ ശ്വസനയന്ത്രവുമായി ബന്ധിക്കും. മയക്കൽ നില സ്ഥിരമായതിനുശേഷം ഉള്ളിലുള്ള ജൂഗുലാർ വെയിനിലെ (ഐജെവി) പ്രവാഹവും ഐസിപി നിരീക്ഷണവും ശരീരത്തിൽ പ്രവേശിക്കാതെ ഒപ്ടിക് നെർവ് ഷീത്തിന്റെ അളവെടുത്തുകൊണ്ട് ചെയ്യും. ശസ്ത്രക്രിയക്കുവേണ്ടിയുള്ള നില ശരിയാക്കിയശേഷം വീണ്ടും ഉള്ളിലുള്ള ജൂഗുലാർ വെയിനിലെ പ്രവാഹം ഒപ്ടിക് നെർവ് ഷീത്തിന്റെ അളവെടുത്ത് മാറ്റങ്ങളെന്തെങ്കിലുമുണ്ടോ എന്ന് പഠിക്കും. അതേ നലയിലുള്ള മയക്കലോടെ ശസ്ത്രക്രിയ തുടങ്ങാൻ അനുവദിക്കും.

ഐജെവി പ്രവാഹവും ഒഎൻഎസ്ഡിയും അളക്കാൻ അൾട്രാസൗണ്ട് ഉപയോഗിക്കുന്നത് പാർശ്വഫലങ്ങളുണ്ടാക്കുമോ?

ശരീരത്തിൽ പ്രവേശിക്കാതെയുള്ള നടപടിയായതിനാൽ അത് രോഗിക്ക് ഒരപായവുമുണ്ടാക്കില്ല. ഉള്ളിലുള്ള ജൂഗുലാർ വെയിനിന്റെ അളവെടുപ്പിനായി അൾട്രാസൗണ്ട് ഉപയോഗിക്കുന്നതുകൊണ്ടുള്ള മോശമായ സംഭവങ്ങളൊന്നും ഇല്ല. കണ്ണിനുമുകളിൽ അൾട്രാസൗണ്ട് നിരീക്ഷണ ഉപകരണം ഉപയോഗിക്കുന്നത് ശരീരത്തിൽ പ്രവേശിക്കാതെയാകയാൽ അപയസാദ്ധ്യതയും തുച്ഛമാണ്. കണ്ണിന് പരുക്കുണ്ടാകാതിരി ക്കാൻ എല്ലാ നടപടികളും സ്വീകരിക്കും.

പഠനമാരംഭിച്ചശേഷം താങ്കൾക്ക് പിൻമാറാമോ?

താങ്കളുടെ പഠനത്തിലുള്ള പങ്കാളിത്തം തികച്ചും സ്വമേധയായാണ്, പഠനത്തിലെ പങ്കാളിത്ത ത്തിൽ നിന്നും പിൻമാറാൻ തീരുമാനമെടുക്കാൻ താങ്കൾക്ക് സ്വാതന്ത്ര്യമുണ്ട്. താങ്കളങ്ങിനെ ചെയ്താലും താങ്കളുടെ ഈ ആശുപത്രിയിലെ പതിവ് ചികിത്സയെ ഒരുവിധത്തിലും ബാധിക്കി ല്ല. കൂടാതെ താങ്കൾക്ക് എന്തെങ്കിലും പാർശ്വഫലളങ്ങൾ അനുഭവപ്പെടുകയാണെങ്കിൽ പഠനം നിർത്തുകയും പാർശ്വഫലളങ്ങൾക്ക് അധികചികിത്സ നൽകുകയും ചെയ്യും.

പഠനവുമായി ബന്ധപ്പെട്ട് താങ്കൾക്ക് എന്തെങ്കിലും പരുക്കുണ്ടായാലെന്ത് സംഭവിക്കും ?

താങ്കൾ പഠനത്തിൽ പങ്കെടുത്തില്ലെങ്കിലും ഉപയോഗിക്കുന്ന മയക്കൽ സങ്കേതങ്ങളും നിരീ ക്ഷണ ഉപകരണങ്ങളും ഒന്നുതന്നെയാകയാൽ ഞങ്ങളുടെ പഠനത്തിൽ പങ്കെടു ക്കുന്നതുകൊണ്ട് താങ്കൾക്ക് പരുക്കുണ്ടാകുമെന്ന് ഞങ്ങൾ പ്രതീക്ഷിക്കുന്നില്ല. പക്ഷേ പഠനവു മായി ബന്ധപ്പെട്ട് താങ്കൾക്കെന്തെങ്കിലും പാർശ്വഫലളങ്ങളോ പ്രശ്നങ്ങളോ ഉണ്ടായാൽ പാർശ്വ ഫലളങ്ങൾക്ക് താങ്കൾക്ക് ചിലവുണ്ടാകാതെ ചികിത്സിക്കും. എന്നിരുന്നാലും സാമ്പത്തികമായ നഷ്ടപരിഹാരം നൽകാനാവില്ല.

ഉപകരണങ്ങൾ ഉപോയോഗിക്കുന്നതിന് താങ്കൾ പണം ചിലവാക്കണോ?

ഉള്ളലുള്ള ജൂഗുലാർ വെയിൻ കാനുലേഷനും ഒഎൻഎസ്ഡിയും ശസ്ത്രക്രിയക്കുള്ള മയക്കൽ നടപടികളുടെ ഭാഗമാണ്. അതിനാൽ രോഗിക്ക് അവയുപയോഗിക്കുന്നതിന് അധിക ചിലവുണ്ടാകില്ല.

താങ്കളുടെ വ്യക്തിവിവരങ്ങൾ രഹസ്യമായിരിക്കുമോ?

പഠനഫലങ്ങൾ ഒരു വൈദ്യശാസ്ത്ര ജേർണലിൽ പ്രസിദ്ധീകരിക്കുമെങ്കിലും താങ്കളെ വ്യക്തിപരമായി തിരിച്ചറിയാനിടയാക്കുന്നതൊന്നും പ്രസിദ്ധീകരണത്തിലോ, പഠനഫലങ്ങളുടെ പ്രദർശനത്തിലോ ഉണ്ടാവില്ല. എന്നിരുന്നാലും, താങ്കളുടെ കൂടുതൽ അനുവാദമില്ലാതെ പഠനവുമായി ബന്ധപ്പെട്ടയാളുകൾ താങ്കളുടെ ചികിത്സാരേഖകൾ പിശോധിച്ചേക്കാം.

താങ്കൾക്ക് കൂടുതൽ എന്തെങ്കിലും ചോദ്യങ്ങൾ ഉണ്ടെങ്കിൽ ദയവായി ഡോ. കേത താക്കർ (പ്രധാന ഗവേഷക) യോട് ചോദിക്കുക, (ഫോൺ: 9879520603). ഇമെയിൽ. keta0819@gmail.com

സാങ്കതീക ഉപദേശക സമിതിയെ ബന്ധപ്പെടുന്നതിന് ദയവായി ഡോ. മാല രാമനാഥനോട് ചോദിക്കുക. ഫോൺ 04712524234, ഇമെയിൽ: iec.mem.sec@sctimst.ac.in

CONSENT FORM

Participant's name: Date of Birth / Age (in years):

I_____, son/daughter of _____
Declare that (Please tick boxes)

- I have read the above information provided to me regarding the study: Effect of different surgical positions on the changes in cerebral venous drainage and intracranial pressure in patients undergoing neurosurgery. [ ]
- 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:

കാര്യബോധത്തോടെയുള്ള സമ്മതപത്രം

പങ്കെടുക്കുന്നയാളുടെ പേര് ജനനതിയതി, വയസ്സ് (വർഷത്തിൽ)

ഞാൻ, _____,മകൻ/മകൾ.....

(ദയവായി കോളങ്ങളിൽ ടിക് ചെയ്യുക)

ന്യൂറോ ശസ്ത്രക്രിയക്ക് വിധേയരാകുന്ന രോഗികളുടെ തലയിലെ അശുദ്ധരക്കക്കുഴലുകളിൽനിന്നുള്ള പ്രവാഹത്തിന്റെയും തലയോട്ടിക്കുള്ളിലെ മർദ്ദത്തിന്റെയും (ഐസിപി) വ്യതിയാനങ്ങളിൽ ശസ്ത്രക്രിയക്കുവേണ്ടിയുള്ള വ്യത്യസ്ഥ നിലകളുടെ പ്രഭാവംഎന്ന പഠന സംബന്ധമായി എനിക്കു നൽകിയ വിവരങ്ങൾ വായിച്ചു

- എനിക്കുണ്ടായ സംശയങ്ങൾ പരിഹരിച്ചു [ ]
- എന്റെ ഈ പഠനത്തിലുള്ള പങ്കാളിത്തം സ്വമേധയായുള്ളതാണെന്നും, എനിക്ക് ഒരു കാരണവും കൂടാതെ ഏതുസമയത്തും, എനിക്കുള്ള വൈദ്യശുശ്രൂഷയെയോ നിയമപരമായ അവകാശങ്ങളെയോ ബാധിക്കാതെ പിൻവാങ്ങാമെന്നും ഞാൻ മനസ്സിലാക്കുന്നു. [ ]
- ഈ പഠനത്തിന്റെ ഗവേഷകർ, നൈതീക കമ്മിറ്റി, നിയന്ത്രണാധികാരികൾ എന്നിവർക്ക് എന്റെ ആരോഗ്യവിവരങ്ങൾ ഞാൻ പഠനത്തിൽനിന്നും പിൻവാങ്ങിയാലും പരിശോധിക്കാൻ എന്റെ സമ്മതം അവശ്യമില്ലെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു. ഇതിനു ഞാൻ സമ്മതിക്കുന്നു, [ ]
- എനിക്ക് പഠനത്തെപ്പറ്റി കൂടുതലറിയാനോ, പങ്കെടുക്കുന്നയാളുടെ അവകാശങ്ങളെപ്പറ്റി അറിയേണ്ടതായോ വന്നാൽ പ്രധാന ഗവേഷകയുടെ ബന്ധപ്പെടാനുള്ള നമ്പർ എനിക്ക് നൽകിയിട്ടുണ്ട് [ ]
- ഭാവിയിൽ മൂന്നാം കക്ഷികൾക്കോ പ്രസിദ്ധീകരണത്തിനോ നൽകുമ്പോൾ എന്റെ വ്യക്തിവിവരങ്ങൾ വെളിപ്പെടുത്തുകയില്ലെന്നും ഞാൻ മനസ്സിലാക്കുന്നു. [ ]
- സ്വമേധയാ പഠനത്തിൽ പങ്കെടുക്കാൻ ഞാൻ സമ്മതിക്കുന്നു. [ ]
- സമ്മതപത്രത്തിന്റെ ഒപ്പിട്ട ഒരു പ്രതി എനിക്ക് കിട്ടി. [ ]

പേര് സാക്ഷിയുടെ പേര്

ഒപ്പ്/ രോഗിയുടെ വിരലടയാളം/ ഒപ്പ്

നിയമപരമായ പ്രതിനിധി തീയതി

തീയതി

രോഗിയുമായുള്ള ബന്ധം

(സമ്മതം വാങ്ങുന്നയാൾ)

മെഡിക്കൽ റിസർച്ച് പ്രോജക്ടിനാവശ്യമായ സമ്മതപത്രത്തിനു വേണ്ടുന്ന 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. കേത താക്കർ (പ്രധാന ഗവേഷക)

(ഫോൺ: 9879520603).

സീനിയർ റസിഡന്റ്

സാങ്കതീക ഉപദേശക സമിതിയെ ബന്ധപ്പെടുന്നതിന് ദയവായി ഡോ. മാല രാമനാഥനോട് ചോദിക്കുക. ഫോൺ 04712524234, ഇമെയിൽ: iec.mem.sec@sctimst.ac.in

PROFORMA

Effect of different surgical positions on the changes in cerebral venous drainage and intracranial pressure in patients undergoing neurosurgery.

Age:

Sex:

Hospital ID:

Diagnosis:

Proposed surgery:

Date of surgery:

Surgical Position:

Check list:

Factors	**Include**	**Exclude**
Patient consent	Yes	No
Nature of procedure	Elective	
Age	18-60	< 18, >60
Autonomic instability	No	Yes
Ocular trauma or a known history of ocular pathology.	No	Yes
Long standing uncontrolled DM, hypertension, liver disease, Ischemic heart disease, stroke, chronic renal disease, bronchial asthma or lung diseases	No	Yes
H/o vascular diseases, stroke	No	Yes
Unstable cervical spine, neck trauma and those having tracheostomy tube	No	Yes
Pregnancy, Nursing	No	Yes

Baseline Parameters

Hemodynamic & ventilator parameters

Parameters	HR(bpm)	MAP(mmHg)	SpO2(%)	Peak inspiratory pressure	MAC	EtCO2
Values						

IJV Flow:				
	Time	Cross-sectional area (cm2)	Doppler velocity (cm.s-1)	Flow: Cross-sectional area (cm2) * Doppler velocity (cm.s-1) *60
Right IJV	1st reading (T0)			
	2nd (T1)			
	3rd (T2)			
Left IJV	1st reading(T0)			
	2nd (T1)			
	3rd (T2)			

ONSD	Right eye	Left eye
1st reading (T1)		
2nd (T2)		

- T0: Baseline, before induction
- T1: 10 minutes after induction of anaesthesia, in supine position and PEEP=0
- T2: after 10 minutes of final position and ventilation, at zero end expiratory pressure, PEEP=0

Surgical assessment of brain condition after dura opening (4 point scale):

1. Perfectly relaxed,
2. Satisfactory relaxation,
3. Firm brain, and
4. Tight brain

Name & Signature of Investigator:
Date:

Sr. No.	AGE	SEX	SIDE OF TUMOUR	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
1	30	M	LEFT	LT FRONTAL MENINGIOMA	FRONTAL C&E	10/21/2019	60	153	26
2	28	M	NA	COLLOID CYST	CRANIOTOMY AND EXCISION	10/23/2019	60	156	24
3	58	F	NA	SUPRASELLAR MASS	CRANIOTOMY AND EXCISION	10/16/2019	52	148	23.7
4	50	F	LEFT	LT FRONTAL GLIOMA	CRANIOTOMY AND EXCISION	10/21/2019	70	159	26
5	24	F	NA	SEPTUM PELLUCIDUM LESION	CRANIOTOMY AND EXCISION	10/14/2019	68	158	25
6	54	F	NA	SPHENOID WING MWNINGIOMA	CRANIOTOMY AND EXCISION	10/9/2019	58	152	25.1
7	34	M	NA	PARAFALCINE MENINGIOMA	CRANIOTOMY AND EXCISION	9/3/2019	66	155	27.5
8	60	M	LEFT	LT FRONTAL LESION	CRANIOTOMY AND EXCISION	8/14/2019	60	156	24
9	27	M	RIGHT	RT FRONTOTEMPO INSULAR GLIOMA	RT CRANIOTOMY EXCISION	7/29/2019	60	157	25.6
11	44	F	RIGHT	RT PETROSPHENOID MENINGIOMA	CRANIOTOMY AND EXCISION	8/26/2019	69	169	24.2
12	54	F	NA	COLLOID CYST	CRANIOTOMY AND EXCISION	10/11/2019	40	157	16.2
13	60	F	RIGHT	RT TEMPOROPARIETAL GLIOMA	RT CRANIOTOMY EXCISION	8/19/2019	84	158	28.4
14	20	M	RIGHT	RT FRONTAL DNET	CRANIOTOMY AND EXCISION	9/1/2019	86	170	29.8
15	49	F	RIGHT	RT FRONTAL MENINGIOMA	CRANIOTOMY AND EXCISION	9/30/2019	19	164	20.8
16	44	M	RIGHT	RT FRONTAL MENINGIOMA	CRANIOTOMY AND EXCISION	9/5/2019	65	154	27.4
17	18	M	LEFT	Lt SEGA	CRANIOTOMY AND EXCISION	8/28/2019	68	169	23.8
18	18	F	RIGHT	RT TEMPOROPARIETAL	CRANIOTOMY AND	9/2/2019	65	159	25

Sr. No.	AGE	SEX	SIDE OF TUMOUR	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
				GLIOMA	EXCISION				
19	18	M	RIGHT	RT PRECENTRAL LESION	CRANIOTOMY AND EXCISION	9/17/2019	78	166	25.1
20	53	M	RIGHT	RT FRONTAL GLIOMA	CRANIOTOMY AND EXCISION	3-Dec	63	160	23
21	33	M	LEFT	LT FRONTAL GLIOMA	CRANIOTOMY AND EXCISION	7/22/2019	96.1	189	26.9
22	41	F	RIGHT	RT TEMPORAL GLIOMA	CRANIOTOMY AND EXCISION	1/29/2019	62	171	21.2
23	41	M	NA	COLLOID CYST	CRANIOTOMY AND EXCISION	23-Nov	52	148	23.7
24	18	M	RIGHT	RT TEMPORAL GLIOMA	CRANIOTOMY AND EXCISION	10/29/2019	59	170	20.4
25	18	M	RIGHT	RT FRONTAL GLIOMA	CRANIOTOMY AND EXCISION	11/7/2019	50	165	18.1
26	17	M	RIGHT	RT FRONTAL GLIOMA	CRANIOTOMY AND EXCISION	11/8/2019	58	143	28
27	18	M	RIGHT	RT TEMPOROPARIETAL GLIOMA	RT CRANIOTOMY EXCISION	11-Nov	80	175	26.1
28	51	M	NA	MID 1/3 PARASAGITAAL MENINGIOMA	CRANIOTOMY AND EXCISION	11/21/2019	56	178	17.7
29	26	M	RIGHT	RT FRONTOTEMPO INSULAR GLIOMA	RT CRANIOTOMY EXCISION	11/29/2019	58	143	28
30	18	M	RIGHT	RT PRECENTRAL LESION	CRANIOTOMY AND EXCISION	12/17/2019	36	151	17.1

ASA STATUS	POSITION	POSITION	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)			
			T0	T1	T2	T0		T1	
						SYS	DIA	SYS	DIAS
I	1	SUPINE	90	98	99	124	70	128	68
II	1	SUPINE	110	100	110	138	80	130	80
I	1	SUPINE	64	80	100	110	64	160	64
II	1	SUPINE	88	90	100	120	80	140	90
I	1	SUPINE	110	100	100	140	80	140	80
I	1	SUPINE	110	100	80	138	80	128	78
I	1	SUPINE	108	110	80	140	80	128	68
I	1	SUPINE	99	98	88	130	80	132	88
II	1	SUPINE	84	90	70	118	80	160	80
I	1	SUPINE	101	88	80	146	90	136	80
I	1	SUPINE	100	80	84	140	80	118	68
I	1	SUPINE	120	100	89	118	80	122	76
I	1	SUPINE	100	110	90	130	77	124	66
III	1	SUPINE	120	118	110	130	70	120	64
I	1	SUPINE	80	90	100	130	80	130	70
I	1	SUPINE	80	90	100	140	80	140	80
I	1	SUPINE	120	110	124	150	90	140	88
I	1	SUPINE	82	90	108	120	68	110	68
I	1	SUPINE	108	110	90	140	80	160	68
II	1	SUPINE	80	90	88	140	70	130	70
I	1	SUPINE	88	120	120	130	80	138	70
I	1	SUPINE	101	90	80	140	80	130	80

ASA STATUS	POSITION	POSITION	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)			
			T0	T1	T2	T0		T1	
						SYS	DIA	SYS	DIAS
I	1	SUPINE	100	80	90	130	90	120	60
I	1	SUPINE	100	98	80	160	80	130	68
III	1	SUPINE	101	90	80	140	80	130	80
I	1	SUPINE	120	110	124	150	90	140	88
I	1	SUPINE	88	80	100	120	80	124	80
II	1	SUPINE	140	130	100	150	90	140	80
I	1	SUPINE	80	74	78	108	64	104	58
		ETCO2(mm Hg)		AIRWAY PRESSURE(cm H2O)				IJV FLOW	RIGHT
T2		T1	T2	T1	T2	CROSS SECTION AREA ®		cm2	DOPPLER VELOCITY
SYS	DIAS					T0	T1	T2	T0
124	68	34	32	16	17	1	1.6	0.82	31.9
150	80	35	32	14	14	1.63	1.77	1.24	29.93
170	90	30	31	18	18	0.44	0.61	0.76	11.68
110	68	36	34	20	22	1.4	1.87	1.24	15.5
130	70	32	32	22	21	0.45	0.56	0.36	29.82
140	80	34	32	21	22	0.61	1.61	0.73	22.63
110	60	30	30	21	21	2.63	2.89	1.59	16.68
120	68	33	31	16	28	1.19	1.67	1.55	12.51
120	60	35	33	17	20	1.5	1.11	1.8	21

ASA STATUS	POSITION	POSITION	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)			
			T0	T1	T2	T0		T1	
						SYS	DIA	SYS	DIAS
120	80	38	34	18	18	0.6	0.8	0.8	8
122	68	36	36	19	19	1.17	1.35	1.34	17.79
122	70	30	30	17	19	1.51	1.38	0.94	23.7
130	80	31	30	17	17	0.4	0.67	0.4	34.19
130	68	33	32	20	22	2.07	1.64	0.58	20.11
138	66	32	30	22	20	1.54	3.28	0.94	15.25
160	80	35	33	19	19	0.73	1.01	0.89	21.86
130	88	31	30	17	17	0.88	0.63	0.45	32.75
130	60	30	33	16	18	0.38	0.54	0.33	19.12
138	60	33	32	17	17	1.3	0.8	0.8	16
130	70	33	30	15	16	0.7	0.8	1.1	11
140	80	38	35	16	17	1	1.5	1.3	19
120	70	30	30	17	17	0.5	0.6	0.5	23
122	60	31	30	17	18	1.16	1.15	0.19	21.06
124	70	39	39	18	19	0.58	1.02	0.41	19.82
120	70	33	30	18	18	1.65	2.79	1.68	17.38
130	88	30	30	15	17	1.54	1.91	1.46	21.86
120	66	32	32	19	19	1.01	1.37	1.39	20.07
128	88	32	33	16	16	1.5	1.01	1.9	21

ASA STATUS	POSITION	POSITION	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)			
			T0	T1	T2	T0		T1	
						SYS	DIA	SYS	DIAS
102	54	30	30	17	17	0.38	0.64	0.33	16.12

								LEFT	
	(cm/s)	FLOW (right)	(ml/min)		CROSS SECTION AREA ®		(cm2)	DOPPLER VELOCITY	
T1	T2	T0	T1	T2	T0	T1	T2	T0	T1
19.13	16.51	1914	1836	812	0.73	0.76	0.64	21.31	15.78
20.76	20.66	2927	2204	1537	0.73	0.66	0.07	19.57	13.46
18.36	8.83	308	671	402	0.69	0.58	1.11	28.58	13.76
12.7	8.44	1302	1424	627	1.23	1.66	1.26	17.74	12.25
29	11.17	805	974	241	0.76	0.74	0.45	21.84	24.41
29.1	19.84	828	1845	868	0.38	0.64	0.12	8.8	8.34
13.01	11.35	2632	2255	1082	0.98	1.54	0.99	29.36	10.1
12.31	10.98	893	1233	1021	1.59	2.07	2.29	9.15	8.42
19	10	1890	1254	1080	0.8	0.7	0.4	14	19
12.8	7.17	288	614	344	1.26	1.7	0.45	14.43	18.3
13.97	9.64	1248	1126	775	0.79	1.36	1.02	14.99	11.17
13.27	20.62	2147	1098	1162	0.7	0.56	0.14	18.51	18.46
39.36	22	820	1582	528	1.04	0.4	1.09	18.36	50.02
11.68	18.81	2497	1149	654	0.86	0.9	0.84	16.26	13.72
12.2	15.31	1409	2400	863	0.22	0.98	0.3	32.16	15.05
13.12	10.37	957	795	553	0.36	0.53	0.45	19.54	21.06
34.75	38.85	1729	1313	1048	0.32	0.27	0.25	34.45	28.18
20.15	19.27	435	652	381	0.28	0.31	0.34	19.08	20.19
12	7	1248	576	336	0.7	0.9	1	16	11
14	10	462	672	660	0.8	0.8	0.5	16	15
17	11	1140	1530	858	0.3	0.5	1	10	14
30	10	690	1080	300	0.5	0.5	0.5	13	13
19.32	19.13	1465	1333	218	0.8	1.06	0.28	23.55	17.79
16.01	20.08	689	979	493	0.35	0.42	0.3	14.55	21.93
14.29	17.14	1720	2392	1727	0.88	0.79	1.01	21.42	16.53
17.86	18.3	2019	20146	1603	0.33	0.61	0.51	32.56	24.23
17	14	1216	1397	1167	0.57	0.72	0.36	11.26	8.49
20	10	1890	1256	1080	0.8	0.7	0.4	14	19
20.15	19.27	367	652	381	0.38	0.3	0.34	19.08	20.19

					ONSD RT		ONSD LT		SURGICALL ASSESMENT		
(cm/s)	FLOW (left)	(ml/min)			cm		cm				
T2	T0	T1	T2	T1	T2	T1	T2	1	2	3	4
11.68	933	719	448	4.46	4.7	4.76	4.47		L		
14.73	857	533	61	4.83	4.97	4.98	5.5	L			
5.43	1183	478	361	4.4	4.39	5.2	4.8		L		
16.33	1309	1220	1234	5.07	4.53	4.46	4.32		L		
15.82	997	1083	427	4.68	4.16	4.31	4.5		L		
14.04	200	320	101	4.4	4.9	4.5	5.1		L		
6.73	1726	933	399	4.86	5.52	5.38	5.2				l
10.6	872	1045	1456	4.6	4.23	5.12	4.8		L		
11	672	798	264	5	5	5	6		L		
18.5	1090	1866	499	5.72	5.38	4.53	4.82				l
14.9	710	912	911	3.57	3.64	4.61	4.45				
11.44	777	620	96	4.6	4.09	5.9	4.53	L			
18.87	1145	1200	1234	4.09	4.3	4.6	4.83		L		
11.68	839	740	588	5.27	4.53	4.62	4.6	L			
11.93	424	884	214	5.05	4.45	4.68	5.5		L		
24.92	422	669	672	4.6	4.22	5.42	5.54			L	
24.71	661	456	370	4.05	4.2	5.94	4.71		L		
27.21	320	375	555	4.46	4.68	4.1	3.94		L		
8	672	594	480	5	6	6	7			L	
10	768	720	300	6	6	4	5			L	
10	180	420	600	5	4	5	5		L		
12	390	390	360	4.5	4.5	4.4	4.6		L		
21.29	1130	1131	357	5.7	5.7	6.31	5.05		L		
13.97	305	552	251	4.23	3.79	5.49	5.62		L		
12.86	1130	783	779	5.21	5.5	5.5	5.35	L			
6.15	644	886	188	5	4.75	4.32	4.67		L		
14.96	385	366	323	4.9	4.9	4.3	4.4		L		
11	672	798	264	5	5	5	6		L		
27.21	320	375	555	4.46	4.58	4.1	4.14		L		

Sr. No.	AGE	SEX	SIDE	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
1	37	M	LEFT	LT PARIETAL SOL	LT CRANIOTOMY AND EXCISION	8/13/2019	66	158	26
2	49	M	NA	PINEAL REGION TUMOUR	RT PARIETOOCCIPITAL CRANIO+EXCISION	8/21/2019	78	170	27
3	49	M	RIGHT	rt CP ANGLE LESION	MLSO CRANIOTOMY EXCISION	10/16/2019	58	155	24
4	18	M	RIGHT	RT PARIETOOCCIPITAL LESION	CRANIOTOMY AND EXCISION	10/14/2019	75	176	24
5	20	F	RIGHT	RT CEREBELLAR LESION	CRANIOTOMY AND EXCISION	9/5/2019	80	167	28
6	22	M	LEFT	LT PARIETAL SOL	CRANIOTOMY AND EXCISION	9/19/2019	66	156	27
7	44	M	LEFT	LT PARIETOOCCIPITAL LESION	CRANIOTOMY AND EXCISION	9/5/2019	60	165	22
8	45	M	RIGHT	RT CEREBELLAR LESION	CRANIOTOMY AND EXCISION	9/3/2019	65	166	23
9	18	M	NA	PINEAL GLAND TUMOR	CRANIOTOMY AND EXCISION	8/26/2019	60	158	24
10	22	M	RIGHT	RT CP ANGLE LESION	CRANIOTOMY AND EXCISION	7/25/2019	64	168	22
11	39	M	NA	POSTERIOR 1/3 PARASAGITAL MENINGIOMA	CRANIOTOMY AND EXCISION	7/24/2019	70	168	24
12	21	F	LEFT	LT CP ANGLE LESION+C1-C2 IDEM	CRANIOTOMY AND EXCISION	8/20/2019	80	165	29
13	58	F	RIGHT	RT PARIETOOCCIPITAL GLIOMA	RT OCCIPITAL CRANIO+EXCISION	10/27/2019	78	177	24
14	18	F	NA	PONTINE LESION GLIOMA	CRANIOTOMY AND BIOPSY	12/31/2019	60	168	23
15	47	M	RIGHT	RT INFRATENTORIAL MENINGIOMA	CRANIOTOMY AND EXCISION	1/14/2020	55	158	22
16	40	M	NA	FOURTH VENTRICULAR LESION	MLSO CRANIOTOMY EXCISION	2/24/2020	69	168	24
17	47	M	NA	INFRATENTORIAL MENINGIOMA	CRANIOTOMY AND EXCISION	1-Jan	55	143	26
18	40	M	NA	PINEAL REGION TUMOUR	CRANIOTOMY AND EXCISION	3/10/2020	60	160	23

Sr. No.	AGE	SEX	SIDE	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
19	40	M	NA	FOURTH VENTRICULAR LESION	MLSO CRANIOTOMY EXCISION	2/24/2020	60	143	29
20	28	F	NA	QUADRIGEMINAL CISTERN ARACHNOID CYST	MODIFIED POPPINS CRANIOTOMY+EXCISION	2/25/2020	62	171	21
21	34	F	NA	TECTAL PLATE MENINGIOMA	CRANIOTOMY AND EXCISION	2/26/2020	55	148	25
22	18	M	NA	FOURTH VENTRICULAR LESION	CRANIOTOMY AND EXCISION	3/6/2020	60	170	21
23	60	F	LEFT	CEREBELLAR METASTASIS	CRANIOTOMY AND EXCISION	2/3/2020	55	165	20
24	33	M	LEFT	LT PARIETAL SOL	LT CRANIOTOMY AND EXCISION	7/22/2019	58	143	28
25	51	M	LEFT	LT PARIETAL SOL	LT CRANIOTOMY AND EXCISION	11/21/2019	65	175	21
26	18	F	NA	FOURTH VENTRICULAR LESION	MLSO CRANIOTOMY EXCISION	9/2/2019	60	178	19
27	20	F	RIGHT	RT CEREBELLAR LESION	CRANIOTOMY AND EXCISION	9/5/2019	60	156	24
28	18	M	RIGHT	RT PARIETOOCCIPITAL LESION	CRANIOTOMY AND EXCISION	10/14/2019	48	151	21
29	18	M	RIGHT	RT CEREBELLAR LESION	CRANIOTOMY AND EXCISION	2/19/2020	55	153	23
30	49	M	NA	INFRATENTORIAL MENINGIOMA	CRANIOTOMY AND EXCISION	8/21/2019	60	156	25

ASA STATUS	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)					
	T0	T1	T2	T0		T1		T2	
				SYS	DIA	SYS	DIAS	SYS	DIAS
II	65	68	76	124	88	130	70	150	80
II	65	75	77	100	64	140	80	170	90
II	87	90	99	122	80	140	88	110	68
I	100	101	100	138	82	110	68	130	70
I	101	100	80	130	80	124	70	140	80
I	99	110	80	136	80	120	70	110	60
I	98	98	90	128	88	130	88	120	68
I	88	90	70	120	80	120	66	120	60
I	89	88	80	146	90	128	88	120	80
I	99	80	84	142	80	102	54	122	68
I	110	101	89	120	80	124	68	122	70
I	99	100	90	132	77	120	70	130	80
III	100	110	110	128	70	142	80	130	68
I	88	92	99	132	80	152	90	138	66
I	88	90	100	146	80	122	80	160	80
II	110	101	110	148	90	158	90	130	88
I	82	90	99	122	68	124	64	130	60
I	100	100	90	138	80	100	70	138	60
II	78	78	88	133	70	160	64	130	70
I	67	68	69	128	80	140	90	140	80
I	100	99	98	140	80	140	80	120	70
I	98	80	90	132	90	128	78	122	60
I	101	98	80	158	80	128	68	116	68
III	88	90	80	142	80	132	88	130	70
I	100	110	124	152	90	160	80	120	70
I	98	80	100	122	80	136	80	110	70
III	100	100	100	158	90	118	68	118	68
I	88	74	78	124	64	122	76	100	50
II	92	98	99	100	70	124	66	150	68
II	90	90	80	126	80	120	64	116	80

ETCO2(mmHg)		AIRWAY PRESSURE(cm H2O)				IJV FLOW	RIGHT		
T1	T2	T1	T2	**CROSS SECTION AREA ®**		(cm2)	DOPPLER VELOCITY		(cm/s)
				T0	T1	T2	T0	T1	T2
38	36	16	16	0.75	0.9	1.4	23	36	11
38	33	20	18	0.46	1.44	1.1	11.51	16.63	21.01
34	34	22	22	1.74	1.91	2.4	15.75	14.21	7.68
36	34	20	20	0.27	0.17	0.54	12.4	27.48	8.03
35	36	20	22	0.64	0.68	0.48	33.07	25.84	21.95
33	32	20	21	0.44	0.69	0.13	24.42	20.75	14.23
30	32	20	26	0.77	0.76	0.8	34.4	15.56	10.99
36	35	18	20	0.76	1.87	0.47	26.88	26.92	15.3
42	38	18	19	0.82	1.24	2.1	46.9	31.2	24.42
44	38	20	19	0.5	0.9	0.5	15	19	9
39	36	18	19	0.7	0.6	2.7	16	11	9
33	33	18	17	0.5	0.4	0.3	22	13	10
36	30	22	22	0.36	1.13	0.69	15.87	23.34	18.72
39	32	20	20	0.98	1.24	2.1	40.6	31.2	26.2
33	30	20	19	0.56	1.08	0.89	14.62	12.23	13.42
38	34	16	17	0.98	1.2	0.7	16.24	12.32	12.19
38	33	17	18	0.59	1.71	1.06	19.54	18.05	14.34
30	32	18	17	0.64	0.92	0.9	15.04	27.73	14.48
30	30	16	16	0.72	0.92	1.32	20	22	11
32	33	18	18	0.44	1.4	1.12	12.52	14.6	10.01
38	35	16	16	0.46	0.6	0.12	18.54	14.22	8.03
33	30	17	18	0.6	0.68	0.48	24.48	20.64	14.3
46	39	19	19	0.86	1.87	0.9	27.8	26.9	15.3
40	30	18	18	0.7	0.8	1.1	11	14	10
38	32	16	17	1.01	1.37	1.39	20.07	17	14
34	32	19	21	0.88	0.63	0.45	32.75	34.75	38.85
32	34	17	20	0.63	0.68	0.58	33.07	25.84	21.95
34	30	18	12	0.24	0.16	0.5	12.4	20.48	9.03
32	30	16	18	0.96	1.2	1	20.1	19.22	18.18
33	30	18	18	0.46	1.64	1.12	11.51	16.63	21.01

						LEFT			
FLOW (right)	(ml/min)		CROSS SECTION AREA ®		(cm2)	DOPPLER VELOCITY		(cm/s)	FLOW (left)
T0	T1	T2	T0	T1	T2	T0	T1	T2	T0
1035	1944	924	0.43	0.95	0.89	26	25	16	670
317	1436	1388	0.55	0.76	0.76	12.51	16.33	11.48	412
1644	1628	1105	0.62	1.53	1.63	18.3	14.22	10.4	680
200	280	260	0.32	0.27	0.56	15.04	12.4	4.26	288
1269	1054	632	0.67	0.3	0.27	44.9	26.2	35.8	1804
644	859	110	0.13	0.18	0.1	16.27	11.38	5.88	126
1589	709	527	0.69	0.88	0.82	6.4	5.64	5.79	264
1225	3020	431	0.44	0.7	0.81	23.81	10.88	5.15	628
2307	2321	3076	0.31	0.64	0.9	20	17.61	7.05	372
450	1026	270	1.1	0.9	1.2	11	18	13	726
672	396	1458	0.3	0.4	0.4	17	12	9	306
660	312	180	0.8	0.9	0.4	23	18	17	1104
342	1582	775	0.37	1.01	1.39	15.26	10.06	5.08	338
2387	2321	3301	0.32	0.65	0.8	20.2	16.6	8.5	387
491	792	716	0.35	0.88	0.68	12.32	10.22	7.05	258
954	887	511	1.1	1.3	1.1	12.22	10.02	6.02	806
691	1851	912	0.53	0.61	0.62	17.74	16.74	16	564
577	1530	781	0.2	0.16	0.21	8.93	12.24	4.92	107
864	1214	876	0.42	0.92	0.8	26	22	15	655
330	1226	672	0.56	0.78	0.79	12.58	15.3	12.48	422
511	517	57	1.1	0.9	1.1	12.24	10.02	10.04	807
879	842	411	0.32	0.26	0.54	15.04	12.3	6.04	306
1434	3018	826	0.45	0.72	0.81	24.81	10.89	8.23	669
462	672	660	0.8	0.8	0.5	16	15	10	768
1216	1397	1167	0.57	0.72	0.36	11.26	8.49	14.96	385
1729	1313	1048	0.32	0.27	0.25	34.45	28.18	24.71	661
1269	1054	763	0.6	0.3	0.23	44.9	26.2	35.8	1812
178.56	196	270	0.31	0.26	0.56	15.14	12.42	8.26	288
1084	1355	1090	0.56	0.9	0.28	11.6	12.72	8.94	398
317	1436	1388	0.55	0.76	0.76	12.51	16.33	11.48	412

			ONSD RT		ONSD LT		SURGICALL ASSESMENT		
(ml/min)			cm		cm				
T1	T2	T1	T2	T1	T2	1	2	3	4
1425	854	6.8	6.5	4.2	6.5		L		
744	523	4.63	4.32	5.7	5		L		
1305	1017	4.75	4.53	4.84	4.54		L		
200	143	6.6	6	6.7	6.61				L
471	579	5.8	5.23	5.02	5.27		L		
122	35.8	4.54	4.27	3.99	3.94		L		
297	282	4.01	4.9	4.75	4.97				
456	396	5.57	4.89	4.83	4.49		L		
676	380	4.38	4.32	4.45	4.72			L	
972	936	6	6	5	5			L	
288	216	5	6	5	4				L
972	408	4	4	4	4			L	
609	1123	4.23	5.24	4.98	5.08		L		
646	386	4.6	4.8	4.5	4.5		L		
650	287	4.3	4.6	4.1	4.2				
781	396	5	5	4.8	4.2			L	
612	595	3.43	3.9	4.7	4.4			L	
117	61	4.2	4.3	4.3	4.3		L		
1214	770	4	4.1	4.1	4.1		L		
716	591	4.2	4.2	4.1	4.1				
541	662	4.1	4.1	5	5			L	
191	195	3.9	4.2	4	4		L		
470	399	4.9	5.1	4.8	4.8		L		
720	300	6	6	4	5			L	
366	323	4.9	4.9	4.3	4.4		L		
456	370	4.05	4.2	5.94	4.71		L		
473	574	5.8	5.23	5.02	5.27		L		
193.75	277.5	6.6	6.3	6.7	6.51				L
686	150	4.1	4.2	4.3	4.5		L		
744	523	4.63	4.32	5.7	5		L		

Sr. No.	AGE	SEX	SIDE	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
1	23	M	LEFT	LT CP ANGLE LESION	LT RSSO CRANIOTOMY AND EXCISION	9/27/2019	53	156	22
2	40	M	LEFT	LT PARIETO OCCIPITAL GLIOMA	OCCIPITO CRANIOTOMY+DECOMPRESSION	10/14/2019	52	147	24
3	54	M	LEFT	LT VESTIBULAR SCHWANOMMA	RSSO CRANIOTOMY+EXCISION	9/12/2019	68	160	26
4	48	F	LEFT	LT CP ANGLE LESION	RSSO CRANIOTOMY+EXCISION	9/22/2029	65	159	26
5	56	F	RIGHT	RT CP ANGLE LESION	RSSO CRANIOTOMY+EXCISION	10/21/2019	59	155	24
6	44	M	RIGHT	RT CP ANGLE LESION	RSSO CRANIOTOMY+EXCISION	11/20/2018	65	155	27
7	54	M	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	11/30/2019	62	156	25
8	53	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	11/4/2019	70	168	24
9	27	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	11/5/2019	66	170	23
10	32	M	LEFT	LT PARIETO OCCIPITAL GLIOMA	LT PARIETOOCCIPITAL CRAIOTOMY+EXCISION	3/3/2020	55	157	22
11	35	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	11/14/2019	80	168	28
12	58	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	3/11/2020	70	170	24
13	51	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	1/16/2020	58	164	21
14	61	F	LEFT	LT PERIVENTRICULAR LESION	LT PARIETOOCCIPITAL CRAIOTOMY+EXCISION	1/23/2020	60	154	25
15	46	M	LEFT	LT CP ANGLE LESION	LT RSSO CRANIOTOMY AND EXCISION	1/9/2020	68	169	24
16	51	M	RIGHT	RT TENTORIAL MENINGIOMA	CRANIOTOMY+ EXCISION	1/10/2020	66	159	26
17	60	F	RIGHT	RT PARIETO OCCIPITAL LESION	CRANIOTOMY+ EXCISION	1/27/2020	70	166	25
18	41	M	LEFT	LT CP ANGLE LESION	LT RSSO CRANIOTOMY AND EXCISION	1/2/2020	65	160	25
19	18	M	LEFT	LT CP ANGLE LESION	LT RSSO CRANIOTOMY AND EXCISION	2/19/2020	88	170	30
20	25	F	RIGHT	RT PARIETO OCCIPITAL LESION	RT PARIETO OCCIPITAL CRANIOTOMY+EXCISION	13-Mar	65	171	22
21	26	F	RIGH	RT PARIETO OCCIPITAL	RT PARIETO OCCIPITAL	2/27/2020	55	148	25

Sr. No.	AGE	SEX	SIDE	DIAGNOSIS	SURGERY	DATE OF SR	WEIGHT(KG)	HEIGHT(CM)	BMI(KG/CM2)
			T	LESION	CRANIOTOMY+EXCISION				
22	40	M	LEFT	LT PARIETO OCCIPITAL GLIOMA	OCCIPITO CRANIOTOMY+DECOMPRESSION	10/14/2019	59	170	20
23	48	F	LEFT	LT CP ANGLE LESION	RSSO CRANIOTOMY+EXCISION	9/22/2029	49	155	20
24	51	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	1/16/2020	55	140	28
25	23	M	LEFT	LT CP ANGLE LESION	LT RSSO CRANIOTOMY AND EXCISION	9/27/2019	65	175	28
26	32	M	LEFT	LT PARIETO OCCIPITAL GLIOMA	LT PARIETOOCCIPITAL CRAIOTOMY+EXCISION	3/3/2020	58	167	20
27	44	M	RIGHT	RT CP ANGLE LESION	RSSO CRANIOTOMY+EXCISION	11/20/2018	58	150	26
28	60	F	RIGHT	RT PARIETO OCCIPITAL LESION	CRANIOTOMY+ EXCISION	1/27/2020	55	157	22
29	35	F	RIGHT	RT CP ANGLE LESION	RT RSSO CRANIOTOMY+EXCISION	11/14/2019	60	153	24
30	40	M	LEFT	LT PARIETO OCCIPITAL GLIOMA	OCCIPITO CRANIOTOMY+DECOMPRESSION	10/14/2019	68	160	26

ASA STATUS			POSITION	POSITION	HEART RATE(beats/min)			BLOOD PRESSURE(mmHg)	
					T0	T1	T2	T0	
								SYS	DIA
II		3R	3	RT LATERAL	101	118	110	130	80
I		3R	3	RT LATERAL	54	90	100	135	70
II		3R	3	RT LATERAL	65	90	88	120	58
I		3R	3	RT LATERAL	100	110	89	99	52
I		3L	3	LT LATERAL	100	90	100	120	82
I		3L	3	LT LATERAL	105	100	68	120	80
I		3L	3	LT LATERAL	78	100	88	110	70
II		3L	3	LT LATERAL	110	120	110	130	80
I		3L	3	LT LATERAL	68	88	80	122	82
III		3R	3	RT LATERAL	99	100	88	120	72
I		3L	3	LT LATERAL	88	82	80	128	80
I		3L	3	LT LATERAL	89	88	80	110	70
III		3L	3	LT LATERAL	100	54	100	128	80
I		3R	3	RT LATERAL	68	65	100	135	70
I		3R	3	RT LATERAL	88	100	100	128	80
I		3L	3	LT LATERAL	110	100	124	130	70
I		3L	3	LT LATERAL	80	105	108	138	88
I		3L	3	RT LATERAL	88	78	90	120	82
II		3R	3	RT LATERAL	80	110	88	140	86
I		3L	3	LT LATERAL	80	68	120	120	86
I		3L	3	LT LATERAL	100	100	100	150	90
II		3R	3	RT LATERAL	99	100	100	130	66
I		3R	3	RT LATERAL	100	110	120	139	90
III		3L	3	LT LATERAL	100	98	88	133	80
I		3R	3	RT LATERAL	120	90	100	120	76
II		3R	3	RT LATERAL	88	88	82	129	77
II		3L	3	LT LATERAL	100	80	88	120	79
I		3L	3	LT LATERAL	82	100	78	120	78
I		3L	3	LT LATERAL	88	110	99	150	78
II		3R	3	RT LATERAL	88	88	90	150	70

				ETCO2(mmHg)		AIRWAY PRESSURE(cmH2O)			
T1		T2		T1	T2	T1	T2	CROSS SECTION AREA ®	
SYS	DIAS	SYS	DIAS					T0	T1
118	70	108	58	38	34	14	14	0.78	0.98
125	72	90	70	32	31	18	18	1.09	1.04
110	58	108	70	33	34	20	22	0.59	1.02
103	70	102	52	38	32	22	21	1.15	0.99
118	78	112	72	44	38	21	22	1.16	1.48
130	80	106	74	30	30	21	21	0.5	0.6
108	92	92	78	30	31	16	28	0.48	1.96
118	70	108	58	40	38	17	20	1.26	1.26
110	80	102	82	42	40	18	18	0.55	1.03
122	70	120	70	36	36	19	19	0.83	1.29
128	80	120	78	32	30	17	19	0.29	0.57
108	72	92	72	30	32	17	17	0.95	1.85
128	80	120	78	30	32	20	22	0.85	0.96
125	72	90	70	32	30	22	20	1.26	1.28
128	80	120	78	35	33	19	19	0.59	1.04
128	72	110	70	33	30	17	17	1.45	1.36
130	80	128	82	32	33	16	18	1.15	1.28
118	78	112	72	30	32	17	17	1.24	1.03
144	80	140	78	33	30	15	16	0.98	1.2
114	72	110	72	36	35	16	17	0.82	1.2
148	90	90	48	30	30	17	17	0.52	0.69
128	83	120	65	40	30	17	18	1.09	1.05
150	90	140	80	38	39	18	19	1.25	1.01
146	84	138	80	30	30	18	18	0.8	1.01
130	75	112	72	32	30	15	17	0.7	0.99
125	70	112	58	32	30	19	19	0.7	1.1
138	72	137	83	33	33	16	16	0.51	0.62
110	70	112	70	32	30	17	17	1.15	1.28
132	75	122	73	34	30	16	17	0.29	0.57
122	70	130	72	32	30			1.09	1.04

IJV FLOW	RIGHT								
(cm2)	DOPPLER VELOCITY		(cm/s)	FLOW (right)	(ml/min)		CROSS SECTION AREA ®		(cm2)
T2	T0	T1	T2	T0	T1	T2	T0	T1	T2
0.21	16.48	14.65	10.18	771	861	128	0.4	0.8	0.69
0.98	20.14	21.56	36.04	1317	1345	2119	0.58	0.96	0.29
1.47	26.86	40.31	12.2	950	2466	1076	1.39	1.34	0.48
0.29	31.34	30.01	15.75	2162	1782	274	0.41	0.78	0.68
0.88	24.92	9.34	13.59	1734	829	717	0.45	0.96	0.74
0.3	18	10	10	540	360	180	0.5	0.2	0.2
1.05	29.91	16.54	14.71	861	1945	926	0.15	0.58	0.85
1.24	14.22	9.14	15.05	1075	690	1119	0.78	1.41	0.72
0.68	28.72	14.23	13.27	947	879	541	0.62	0.51	0.09
0.27	27.7	12.95	12.44	1379	1002	201.5	0.35	0.68	0.15
0.1	18.62	22.45	14.29	323	767	85	0.18	0.53	0.41
1.03	25.17	17.02	18.75	1434	1889	1158	0.24	0.34	0.29
0.72	18.31	21.61	12.26	933	1244	529	0.9	0.94	0.62
1.03	11.68	13.2	10.9	883	1013	673	0.82	1.5	0.34
0.98	19.2	21.56	20.68	679	1395	1211	0.58	1	0.8
1.23	15.24	9.71	10.91	1325	792	805	1.46	1.54	1.02
0.8	25.9	9.53	13.56	1787	731	650	0.46	0.95	0.76
1.05	11.68	13.2	14.8	868	815	932	0.71	1.42	0.3
1	20.14	20.22	18.18	1184	1455	1090	0.56	0.9	0.28
0.37	25.2	13.7	12.4	1230	936	275	0.45	0.69	0.2
0.32	19.4	12.2	12.5	605	505	240	0.5	0.2	0.2
0.9	20.14	20	36.14	1317	1260	1915	0.6	0.88	0.39
0.3	31.34	30.01	14.99	2350	1818	270	0.4	0.68	0.59
0.62	18.51	20.51	11.26	888.48	1242	419	0.89	0.99	0.66
0.51	16.58	14.55	13.18	696	864	403	0.44	0.7	0.59
0.57	26.7	13.95	13.44	1121	920	459.6	0.45	0.6	0.25
0.33	18	11	10	540	409	198	0.5	0.3	0.2
0.8	25.9	9.53	13.56	1787	731	650	0.46	0.95	0.76
0.1	18.62	22.45	14.29	323	767	85	0.18	0.53	0.41
0.98	20.14	21.56	36.04	1317	1345	2119	0.58	0.96	0.29

LEFT							ONSD RT		ONSD LT		SURGICALL ASSESMENT	
DOPPLER VELOCITY		(cm/s)	FLOW (left)	(ml/min)			cm		cm			
T0	T1	T2	T0	T1	T2	T1	T2	T1	T2	1	2	3
17.4	9.76	8.23	417	468	340	4.39	4.26	4.75	4.84		L	
10.56	10.06	12.9	367	579	224	4.42	4.68	5.3	5.12		L	
16.32	18.64	20.32	1361	1337	585	4.4	3.98	4.53	4.9		L	
43.76	23.39	14.89	1076	1094	607	3.98	3.87	3.98	3.86	L		
24.24	11.47	8.97	654	660	398	4.46	5.06	3.49	5.06			L
10	14	12	300	168	144	5	6	5	5.9			L
11.65	12.79	7.29	104	445	371	4.97	4.98	4.3	4.38		L	
16.01	10.11	8.9	749	855	384	4.01	4.21	4.7	4.38		L	
15.1	10.57	22.79	561	323	123	4.7	4.8	3.46	5.35			L
13.53	9.13	9.1	284	372	81	4.1	4.56	4.43	4.52		L	
39.52	20.5	8.18	426	651	201	4.25	4.9	4.82	4.54			L
18.81	8.62	8.87	270	201	154	4.46	4.17	4.48	4.45		L	
7.01	10.9	13.1	378	614	487	4.5	4.6	4.4	4.5		L	
22.6	18.28	8.29	1111	1638	269	4.5	4.5	4.3	5.1		L	
10.56	10.6	12.9	367	636	619	4.1	4.2	4.1	4.3		L	
11.17	7.68	9.8	978	708	599	3.9	4.1	4	4.1		L	
24.2	11.47	9.9	667	653	451	4.8	4.9	5	5.1			L
22.19	8.11	11.42	945	690	205	4.1	4	4.2	4.2		L	
11.6	12.72	8.94	398	686	150	4.1	4.2	4.3	4.5		L	
14.5	9.02	9.1	391	373	109	4.5	4.6	4.8	5.2			L
10.2	14.5	12.2	306	174	146	3.9	4.5	4.6	5.1		L	
10.44	10.16	13	375	536	304	4.42	4.65	5.3	5.22		L	
40.76	24	14	978	979	495	3.98	4	3.98	3.86	L		
10.01	10.9	13.1	534	647	518	4.5	4.59	4	4.5		L	
17.4	10.76	8.33	459	451	294	4.39	4.36	4.55	4.84		L	
13.53	10.33	9.1	365	371	136	4.1	4.56	4.43	4.52		L	
10	14	12	300	252	144	4.5	4.6	4.5	4.5			L
24.2	11.47	9.9	667	653	451	4.8	4.9	5	5.1			L
39.52	20.5	8.18	426	651	201	4.25	4.9	4.82	4.54			L
10.56	10.06	12.9	367	579	224	4.42	4.68	5.3	5.12		L	

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