Prospective Study of Central Venous Pressure Trends during Major Neurosurgical Procedures in an Elective Operation Theatre Setting of a Tertiary Care Centre

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ABSTRACT

BACKGROUND
There are extensive variations in central venous pressure during intraoperative period of a major neurosurgical patients. Monitoring of central venous pressure is vital for guiding the administration of fluids, blood and blood products. Central venous pressure (CVP) also measures the intracranial pressure indirectly. Increased intracranial pressure thereby reduces the cerebral blood flow, leading to cerebral ischemia.

METHODS
This is a prospective study where 25 major neurosurgical cases posted for elective major neurosurgery were selected. Right subclavian vein was selected for cannulation, by blind technique in all these cases. CVP was recorded every 15 minutes. Central venous catheter was connected to a pressure transducer linked to a multichannel monitor; zeroing was done and the CVP reading obtained.

RESULTS
Central venous pressure reading was done serially and showed the trends in haemodynamics in various stages of surgery. Initial intraoperative periods showed lower values due to intravenous (I / V) induction of anaesthesia, use of mannitol and diuretics. Later on, the trends changed to higher side subsequent to administration of fluids and blood as required.

CONCLUSIONS
Monitoring of CVP is an important component of haemodynamic monitoring along with non-invasive blood pressure (NIBP), intra-arterial blood pressure (IABP), and urine output. Central venous pressure can be used to aspirate an air embolism occurring during the intraoperative period after employing Durant’s position.

KEYWORDS
CVP, NIBP , USS – Ultra Sound Scan, IVC – Inferior Vena Cava, IVCCI – Inferior Vena Cave Collapsibility Index, PEEP – Positive End Expiratory Pressure, C / L – Central Line, IABP.

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BACKGROUND

The central venous pressure is the pressure measured in the central vein close to the heart. It indicates mean right atrial pressure and is frequently used as an estimate of right ventricular preload. The CVP doesn't measure blood volume directly. CVP depends on the pressure of venous blood in the great vessels; vena cava. The central venous pressure is determined not only by intravascular volume and venous return, but also by venous tone and intrathoracic pressure plus right heart function and myocardial compliance. Normally increased venous return results in augmented cardiac output, without significant changes in CVP. But poor right ventricular function or an obstructed pulmonary circulation leads to increased CVP.

Similarly, hypovolaemia patient may have initial normal CVP reading due to vasoconstriction. Loss of blood volume or widespread vasodilation leads to decreased venous return and decrease in right atrial pressure and CVP. The mean right atrial pressure measured by CVP closely resembles the mean left atrial pressure. In normal patients CVP in assumed to be a reflection of left ventricular preload. But in patients with cardiopulmonary disease the right ventricle and left ventricle may function independently. In these cases left ventricular preload is estimated by measuring pulmonary capillary wedge pressure using pulmonary artery catheter. The pulmonary artery catheter with the help of computer can calculate cardiac output and further guide patient management. The first recorded placement of a central venous cannula in a human happened in 1929 by Werner Forssmann who cannulated himself by passing a catheter from his own left cephalic vein into his right atrium. Seldinger first described the guide wire directed technique for central venous insertion in 1956. A normal CVP reading is usually between 8 – 12 mm of Hg. These values can be altered depending on patient's volume status or venous compliance.[1,2,3]

New evidence suggests that there is no absolute direct correlation between central venous pressure and blood volume present in circulation. Most significantly the concept of fluid responsiveness emerged and showed an important impact on patient outcome. The central venous pressure was found to be poor predictor of fluid responsiveness. Accurate measurement of CVP was challenged. A proper education regarding central venous pressure may be provided to junior specialists.[4,5,6] Central venous pressure can be used to assess circulatory status of a patient. Central venous pressure monitoring is used almost universally to guide fluid resuscitation. The surviving sepsis guidelines suggest targeting a central venous pressure values between 8 – 12 mm Hg during fluid resuscitation.[7,8] For proper measurement of central venous pressure, it is important to appropriately set the reference level of the pressure measuring devices at the level of right atrium. In supine patient this point is best estimated by using the intersection of the 4th intercostal space with midaxillary line.

However, this reference may not be accurate in patients who are not in supine position.[9] Central venous pressure has shown to correlate poorly with cardiac index.[10] Central venous pressure correlates poorly with stroke volume index.

Central venous pressure is also influenced by cardiac output, ortho staxis, arterial dilution and preload. CVP is a functional measure of right atrial and juxta cardiac pressures derived from pericardial and thoracic compartments.[11]

Central venous pressure is a mirror refection of cardio circulatory status. Elevated central venous pressure presents clinically as a pulsation of internal jugular vein, when a patient is inclined at 45^0.

We wanted to study the trends in central venous pressure in major neurosurgical patients during the perioperative- and intraoperative-periods

METHODS

This was a prospective observational study conducted in the super speciality block operation theatre of Government Medical College, Thiruvananthapuram, from July 2013 to November 2014.

Sample Size

Based on the results observed in the existing literature and the correlation co-efficient between central venous pressure and peripheral venous pressure, (peripheral venous pressure is an alternative to central venous pressure in neurosurgical patients) and with 99 % confidence and 90 % power, the sample size ranged from 7 to 21. Totally 25 patients were included as there was adequate infrastructure.

The study was conducted in 25 adult patients undergoing major neurosurgical procedure lasting for more than five hours so that 15 recording of CVP and peripheral venous pressure (PVP) could be done at 15-minute interval after induction of anaesthesia.

Patients were included in the study after taking consent from them. The study was proceeded after getting approval from the institution ethical committee review board. (IEC No. 03 / 27 / 2014 / MCT).

Sample size was calculated using the formula.

$$N = \left(\frac{(Z\alpha\ + Z\beta)x^2}{C\ (r)} + 3\right)$$

Where C (r) = ½ log x $\left(\frac{1+r}{1-r}\right)$

r = correlation co-efficient
$Z\alpha$ = 1.96
$Z\beta$ – 0.8416
For α 0.05 for β 0.20

Inclusion Criteria

Patients aged between 20 - 60 years; patient in whom surgery was done is supine position without extreme positioning; American Society of Anesthesiologists (ASA) PS grade I – and ASA PS grade II patients without cardiac disease.

Exclusion Criteria

Frail patients, patients with septicaemia; patients who are febrile, with arteriovenous (AV) fistulae and peripheral vascular disease; age < 20 years or > 60 years; patients in whom there is contraindication for central line insertion due to bleeding and coagulation discords; ASA III and IV class patients; patients in whom extreme positioning is needed; patients having poor peripheral venous access site.

Technique

After a thorough pre anaesthetic check-up involving history, physical examination including systemic examination, airway examination and laboratory investigations, patients were accepted for anaesthesia. Written informed consent and the consent for study were obtained from each patient. 25 patients were selected consecutively from the neurosurgical patients who would need a neurosurgical procedure lasting for more than 5 hours.

Pre-operative day anaesthetic visit was done. All the procedures, risks, benefits were explained, and the patients were relieved of anxiety. Instructions regarding nil per orally 8 hours prior to surgery, informed consent, arrangement of blood, oral premedication tab pantoprazole 40 mg and tab domperidone 10 mg were given, same drugs were repeated at 6 am the next day.

On the day of surgery all patients received inj glycopyrrolate 0.005 mg / kg wt, inj morphine 0.05 – 0.1 mg / kg wt, after inserting I / V cannulae (18 G) in right upper limb and left lower limb under local anaesthesia. Pre-induction monitors like electrocardiogram (ECG), NIBP, pulse oximeters were attached. Pre oxygenation was done at 6 litres per minute for 3 - 5 minutes. Anaesthesia was induced with inj thiopentone sodium 3 - 5 mg / kg body weight I / V or inj propofol 2 - 3 mg / kg body weight I / V plus inj xylocaine (preservative free) 1.5 mg / kg body weight I / V. Patient was mask ventilated followed by inj succinyl choline 1 to 2 mg / kg body weight I / V. Direct laryngoscopy and endotracheal intubation was done using endotracheal tube size 7.5 mm ID in females and 8.5 mm ID in males connected to Bain's circuit with oxygen inflow. Endotracheal tube (ETT) fixed using dynaplast after confirming ETT position. Anaesthesia was maintained using N_2O + O_2 + isoflurane + inj vecuronium infusion + propofol infusion and patient was connected to circle system. Under sterile precautions, the right subclavian venous cannulation was planned. The area above clavicle and below clavicle up to mammary region was draped. Patient was positioned supine with head down and head turned to left. The right subclavian vein was cannulated using 18G central venous cannula. The three way with venous extension line was placed in line with the central venous catheter, and thereby connected to the transducer which was zeroed at the level of right atrium. CVP can be read in the multichannel monitor.

Intermittent flushing with heparin / saline was done, in central venous catheters. The intra-arterial cannulation was done under sterile precaution. The CVP was recorded immediately after its placement (recorded as at zero minutes) CVP measured at 15 minutes intervals a total of 15 recordings. Post induction monitors for CVP, urine output, intra-arterial blood pressure (BP), noninvasive BP and temperature were also attached.

At the end of the surgery, patient was reversed with inj neostigmine 2.5 mg and inj glycopyrrolate 0.4 mg I / V and extubated awake after return of muscle power, respiration or postoperatively ventilated depending on haemodynamic stability and duration of surgery. At the end of the study, data was collected and analysed.

Statistical Analysis

Descriptive statistical analysis is applied for calculating demographic variables. Arithmetic mean and standard deviation for age distribution, height and weight were calculated. Percentage distribution was calculated for gender, ASA class and distribution of sample according to surgery. The present study was conducted in 25 adult patient undergoing major neurosurgical procedure lasting more than 4 - 5 hours. The CVP was recorded at 15-minute intervals for a total of 15-minute recordings each during the intra operative period.

Arithmetic mean and standard deviation for CVP were calculated at definite intervals of time, thereby the trends in CVP were found, as CVP measurements remained as a continuous variable.

RESULTS

Patients in the study had a mean age of 42.4 ± 10.3 years. 64 % of the patients were females and 36 % were males. ASA PS class of the patients predominated by ASA PSI 56 % and ASA PS II 44 %. Mean height of the patient was 164.2 cm with a standard deviation of 7. Intra-cranial space occupying lesion (ICSOL) tumour excision predominated among surgeries. Mean weight of the patients was 63.2 kg with a standard deviation of 7.1.

Criteria	Criteria Value	Count	Percent
Age	< = 30	5	20.0
	31 – 40	5	20.0
	41 – 50	11	44.0
	51 – 60	4	16.0
Sex	Male	9	36.0
	Female	16	64.0
ASA PS Class	I	14	56.0
	II	11	44.0

Table 1. Percentage Distribution of the Samples According to Age, Sex and ASA PS Class

Mean	164.2
SD	7.0
Median	164
Minimum	152
Maximum	176

Table 2. Descriptive Statistics of Height

First recorded CVP showed a mean value of 10.6 ± 2.7. At 120 minutes, mean CVP was 10.9 ± 2.2. At initial part of surgery CVP values decreased due to inducing agents and administration of diuretics in the form of frusemide and mannitol.

Surgery	Count	Percent
ACOM aneurysm clipping	2	8.0
Arachnoid cyst fenestration	1	4.0
C6-7 foraminotomy	1	4.0
Cerebellar abscess drainage	1	4.0
CP angle tumour excision	2	8.0
Craniotomy & excision cerebellar Tr	2	8.0
Excision glioblastoma	1	4.0
Excision ICSOL	4	16.0
Excision parasagittal meningioma	1	4.0
Excision pituitary adenoma	1	4.0
Frontal meningioma excision	2	8.0
Glioblastoma excision	1	4.0
III ventricle colloid cyst excision	1	4.0
Intraventricular tumour excision	1	4.0
MCA aneurysm clipping	1	4.0
Meningioma excision	1	4.0
Optic nerve decompression	1	4.0
Right parietal meningioma excision	1	4.0

Table 3. Percentage Distribution of the Samples According to Surgery

Mean	63.2
SD	7.1
Median	64
Minimum	52
Maximum	76

Table 4. Descriptive Statistics of Weight

	CVP Mean ± SD
0 M	10.6 ± 2.7
15 M	10.7 ± 2.1
30 M	10.7 ± 2.2
45 M	11.2 ± 2.7
60 M	10.7 ± 2.5
75 M	10.9 ± 2.2
90 M	11 ± 2.2
105 M	11.2 ± 2.4
120 M	10.9 ± 2.2
135 M	11 ± 2
150 M	11.2 ± 2.6
165 M	11.8 ± 2.5
180 M	11.9 ± 2.7
195 M	11.3 ± 2.2
210 M	11 ± 2.2

Table 5. Mean Score of CVP at Different Intervals of Time

DISCUSSION

In major neurosurgical procedures the CVP monitoring is used to assess circulatory status and provides guidance to fluid administration, since CVP is a correct reflection of cardio circulatory status. Elevated CVP presently clinically as a pulsation of internal jugular vein (IJV), when a patient is inclined at 45^0. The ease of determination of central venous pressure confers it as clinically attractive, albeit, non-specific indicators of fluid status. IVC collapsibility index[12] (IVCCI) is used adjectively for more accurate assessment of volume status. Insertion of central venous catheter is associated with several complications like haemothorax, pneumothorax and haematoma. CVP cannula insertion needs expertise to avoid complications. Complications can be reduced by ultrasound guided central venous cannulation. Mechanical events during the cardiac cycle are responsible for the sequence of waves seen in a typical central venous pressure trace. The central venous pressure wave form consists of five phasic events, three peaks (a, c, v waves) and two descents.[13,14]

The most prominent wave is the 'a' wave of atrial contraction. Atrial pressure decreases after the 'a' wave as atrium relaxes. This smooth decline in pressure is interrupted by the 'c' wave. The 'c' wave is a transient increase in atrial pressure produced by isovolumetric ventricular contraction, which closes the tricuspid value and displaces it towards the atrium. Atrial pressure continues its decline during ventricular systole, because of continued atrial relaxation and changes in atrial geometry produced by ventricular contraction and ejection. This is the systolic collapse in atrial pressure called 'x' descent. The last atrial pressure peak is the 'v' wave, which is caused by venous filling of atrium during late systole while the tricuspid valve remains closed. Individual CVP wave forms provide unique diagnostic clues about the circulation. Also trends in CVP over time are useful in estimating fluid or blood loss and guiding replacement therapy. Additional useful information may be derived from examining how a fluid bolus simultaneously alter CVP. A study on human cadavers have suggested that the catheter tip should always be located superior to the radiological landmark of carina.[14]

The character of CVP trace depends on many factors, including heart rate, conduction disturbances and tricuspid value function, normal or abnormal intrathoracic pressure changes in right ventricular compliances. One of the most common applications of CVP wave form is the rapid diagnosis of cardiac arrhythmias.[15] Factors that increases CVP are hypervolemia, deep expiration, tension pneumothorax, heart failure, cardiac output, cardiac tamponade, mechanical ventilation, PEEP, pulmonary hypertension and pulmonary embolism. CVP is decreased by hypovolaemia, deep inspiration and distributive shock. False CVP readings are seen in malposition of central venous cannulae, blockade, zeroing error, undiagnosed pathological conditions, positive pressure ventilation, transducer faults and leak in the tubing.

In this study 25 adult patients undergoing major elective neurosurgical procedure were selected. The CVP is recorded after cannulation of right subclavian vein during intraoperative period. First recorded central venous pressure showed mean value of 10.6 ± 2.7 and at 120 min mean CVP value was 10.9 ± 2.2. Initial trends in CVP values were on lower side due to deep anaesthesia via general anaesthesia by using of intravenous induction agents like propofol and thiopentone sodium plus inhalational agents like isoflurane and sevoflurane. Decreased right atrial pressure leads to CVP due to peripheral vasodilation and myocardial depression. There also occurs the action of osmotic diuretic like mannitol 20 % intravenous solution during the initial part of the intraoperative period, leading to intracranial pressure (ICP) and decreased CVP. One patient developed pneumothorax secondary to the central venous cannulation and was subsequently removed from study.

CONCLUSIONS

This study showed that initial CVP value was 10.6 ± 2.7 and at 120 min mean CVP value was 10.9 ± 2.2. Initial trends were on the lower side consequent to induction of anaesthesia and administration of various induction agents, inhalational agents, diuretics and later trends were due to adequate fluid administration and haemodynamic stability.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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