

Does caval aorta index correlate with central venous pressure in intravascular volume assessment in patients undergoing endoscopic transurethral resection of prostate?

ABSTRACT

Background and Objective: Ultrasonography has been suggested as a useful noninvasive tool for intravascular volume assessment in critically ill-patients. Fluid absorption is an inevitable complication of transurethral resection of the prostate (TURP). However, there are few data comparing the caval aortic index with central venous pressure (CVP) measurement for intravascular volume assessment in patients undergoing TURP.

Materials and Methods: This is a prospective observer blinded study carried out on 50 patients who underwent elective TURP. The primary outcome measure of our study was the correlation of the caval aorta (Ao) index with CVP, and the secondary outcome measures were the sensitivity and specificity of the caval Ao index.

Results: There was a positive correlation of inferior vena cava/Ao (IVC/Ao) index to CVP ($R=0.9$ and significant $P=0.001^*$). The sensitivity and specificity of the IVC/Ao index were measured to predict the CVP. A CVP ≤ 7 cm H₂O correlated with IVC/Ao index 0.8 ± 0.3 mean \pm standard deviation (SD) (sensitivity 0.93, specificity 0.66), a CVP of 8-12 cm H₂O correlated with IVC/Ao index 1.5 ± 0.2 mean \pm SD (sensitivity 0.96, specificity 0.42), and a CVP >12 cm H₂O correlated with IVC/Ao index 1.8 ± 0.07 mean \pm SD (sensitivity 0.93, specificity 0.58).

Conclusion: Sonographic caval Ao index is useful for the evaluation of preoperative and intraoperative volume status, especially in major surgeries with marked fluid shift or blood loss and had the advantage of being noninvasive, safe, quick, and easy technique with no complications.

Key words: Cavalaortic index; central venous pressure; intravascular volume status; transurethral resection of prostate

Introduction

Benign prostatic hyperplasia is common worldwide in men over 40 years of age. The open prostatectomy and transurethral resection of the prostate (TURP) have been the surgical options for men with obstructive symptoms. Various irrigating fluids have been used for TURP. The potential complication of such procedure is the systemic absorption of hypotonic irrigating fluid.^[1]

The various clinical manifestations, produced due to the absorption of a large volume of irrigating fluid during TURP leading to alteration in internal milieu are together known as TURP syndrome. Early signs of TURP syndrome are dizziness, headache, nausea, dyspnea, arrhythmias, hypertension, and bradycardia, followed by restlessness and confusion. If not

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treated promptly, a patient becomes cyanotic, hypotensive and ultimately sustains cardiac arrest. Occasionally, it starts with neurological signs.^[2] Despite improvements in the current surgical and anesthetic management, 2.5-20% of patients undergoing TURP show one or more manifestations of TURP syndrome and 0.5-5% die perioperatively.^[3]

There are various techniques for assessing the fluid status such are clinical examination, central venous pressure (CVP) measurement, biochemical markers, bioimpedance, continuous blood volume measurement, or sonographic inferior vena cava (IVC) diameter assessment. However, all of these methods have some limitations when used in clinical practice.^[2-4]

Assessing fluid status through determination and interpretation of CVP is not always accurate.

To measure CVP, a central venous access is essential; it is an invasive procedure, not easily done, time-consuming, difficult to maintain sterile precautions, especially in emergency situation, and has its risks and complications.^[5]

Sonographic evaluation of the IVC/aorta (Ao) index diameter was introduced into clinical practice for evaluation of the body fluid status, and its usefulness was studied and documented. Also, ultrasound (USG) imaging has several advantages; it is simple, noninvasive and can be used for repeated assessment.^[6,7]

The objective of this study is to assess the correlation of caval Ao index with CVP in intravascular volume assessment in patients undergoing endoscopic TURP.

Materials and Methods

This is a prospective observer blinded study conducted during the period from March 2014 to April 2015. Fifty patients who were scheduled for elective TURP under spinal anesthesia were invited to enroll in the study after approval by the Hospital Ethical Committee.

Inclusion criteria

It included American Society of Anesthesiologists (ASA) physical status I, II, or III and age between 50 and 70 years.

Exclusion criteria

ASA physical status of >III, cardiac or pulmonary diseases, renal dysfunction, intra-abdominal mass or ascites and any contraindication to central neuraxial block.

All included participants were asked to take part in the study by the study personnel soon after admission to the

ward, and a written informed consent was obtained from each patient.

In the morning of surgery central venous catheter CAVAFIX Double-lumen catheter (B. Braun) was inserted into the internal jugular vein with tip of catheter above junction of superior vena cava and right atrium as evidenced by X-ray chest and the CVP was recorded by the manometer.

Caval aortic index

To measure the IVC diameter, a curvilinear probe of 3.5 MHz of the SonoScape USG machine was placed in the subxiphoid region to visualize the confluence of the hepatic veins draining the IVC. The maximum internal anterior-posterior (AP) diameter of the IVC, just caudal to the confluence of the hepatic veins in the longitudinal plane, is measured on the M-mode. The transverse aortic section in the subxiphoid region is noted lying left lateral to the IVC, and the maximum internal AP diameter of the Ao is measured in the longitudinal plane on the M mode. The IVC/Ao is derived by taking the ratio of the two respective diameters measured.

Fluid status was measured by CVP and IVC/Ao index recorded before neuraxial block, after preload, at 5 min after intrathecal block, and immediately after the patients were placed in the lithotomy position. The start of resection was taken as time 0 and measurements were then recorded every 15 min during the first 30 min, then every 30 min, from time 0 until the end of surgery. The two anesthesiologists the one who performed the USG and measured IVC/Ao index, and the other who measured the CVP were blinded to the data obtained by each other.

All patients were preloaded with 10 mL/kg ringer lactate solution and standard monitors for heart rates, systemic blood pressure, electrocardiogram, SpO₂ were attached and CVP were recorded. Central neuraxial block was performed aseptically at L2-3 or L3-4 intervertebral disk space in sitting posture, 0.5% hyperbaric bupivacaine 2-2.5 ml via a 23-gauge LP Quincke Babcock needle was given aiming block level up to T10. Patients were positioned in lithotomy posture and the TURP surgery was started with warm 1.5% glycine irrigation fluid, keeping the irrigation fluid column at a height of 60 cm, measured from the level of pubic symphysis of the patients on the operating table. The duration of the procedure in minutes, volume of prostate gland resected, and the volume of 1.5% glycine used during the procedure were recorded. Intraoperative, serum sodium and potassium levels were measured in patients undergoing surgery beyond 60 min by blood gas analyzer (Osmetach OPT1, CCA-TS) by using venous blood samples. All patients were carefully observed

for the early symptoms of TURP syndrome perioperatively. The procedure was terminated when serum sodium level was <125 mEq/L, serum potassium level was >6.0 mEq/L or early signs of restlessness, bradycardia, yawning, etc., have occurred. Adequate therapeutic measures were taken to prevent further complications.

Fluid input during the study period was determined by the anesthetist based on clinical criteria (arterial pressure, heart rate and observation of the patient). At least three measurements were obtained to determine the baseline.

Complications like shivering, discomfort; nausea and vomiting or allergic reaction were noted and managed accordingly.

The primary outcome measure of our study was the correlation of the caval Ao index and CVP and the secondary outcome measures were the sensitivity and specificity of the caval Ao index.

Statistics

Based on a similar investigation,^[8,9] a sample size of 50 patients was calculated for 90% power, $\alpha = 0.05$, $\beta = 0.1$, and anticipated effect size = 0.40 using sample size software (G*Power Version 3.00.10, Germany). Therefore, we decided to include 50 patients per group to compensate for any losses during the study. Descriptive and analytic statistics were performed on IBM compatible computer by using the windows version of SPSS 11.0.1 (SPSS Inc., Chicago, IL) under windows XP operating system. Data were presented in the form of mean \pm standard deviation (SD). Correlation between CVP and IVC/Ao index using correlation coefficient (Pearson formula).

Results

This study consists of 50 patients of an average age 59.18 ± 5.3 , the mean duration of surgery (min) 70.12 ± 21.9 , intravenous fluid (L) 1.17 ± 0.48 , and irrigation fluid (L) 7.45 ± 1.8 [Table 1].

The mean CVP values were (7.34 ± 1.7 , 8.42 ± 1.2 , 5.4 ± 2.8 , 7.12 ± 2.3 , 8.3 ± 1.9 , 10.5 ± 1.6 , 13.2 ± 2.2 , 12.9 ± 1.7 , 14.5 ± 0.97 , 16.3 ± 1.3) and the mean IVC/Ao index were (1.3 ± 0.14 , 1.4 ± 0.15 , 0.8 ± 0.07 , 1.3 ± 0.11 , 1.4 ± 0.12 , 1.5 ± 0.11 , 1.6 ± 0.03 , 1.6 ± 0.05 , 1.7 ± 0.07 , 1.8 ± 0.04) preoperative, after preload, after anesthesia, after lithotomy, T0 (start of resection), T1 (15 min after resection), T2 (30 min after resection), T3 (60 min after resection), T4 (90 min after resection), and T5 (120 min after resection) respectively and there was a positive correlation of IVC/Ao index to CVP ($R = 0.9$ and significant $P = 0.001^*$) [Table 2].

The scattered diagram of the various mean IVC/Ao index against its corresponding CVP values [Figure 1] show a positive correlation between the CVP and IVC/Ao index values with correlation coefficient 0.9.

The number of measurements of both CVP and IVC/Ao index is 500 readings (10 readings for each patient of the 50 patients), these readings showed positive correlation between IVC/Ao index and the CVP. Also, these 500 readings were divided into three groups according to the level of CVP. A CVP ≤ 7 cm H₂O correlated with IVC/Ao index of 0.8 ± 0.3 mean \pm SD (sensitivity 0.93, specificity 0.66) with positive predictive value (PPV) = 0.98, a CVP of 8-12 cm H₂O correlated with IVC/Ao index of 1.5 ± 0.2 mean \pm

Table 1: Patient age, duration of surgery, intravenous and irrigation fluid volume

Variables	Range	Mean \pm SD
Patient age (years)	53-67	59.18 \pm 5.3
Duration of surgery (min)	48-112	70.12 \pm 21.9
Intravenous fluid (L)	1.1-1.5	1.17 \pm 0.48
Irrigation fluid (L)	4-10	7.45 \pm 1.8

SD: Standard deviation

Table 2: CVP and IVC/Ao index values

Time	CVP (cm H ₂ O)	IVC/Ao index (mm)
Preoperative	7.34 \pm 1.7	1.3 \pm 0.14
After preload	8.42 \pm 1.2	1.4 \pm 0.15
After anesthesia	5.4 \pm 2.8	0.8 \pm 0.07
After lithotomy	7.12 \pm 2.3	1.3 \pm 0.11
T0 (start of resection)	8.3 \pm 1.9	1.4 \pm 0.12
T1 (15 min after resection)	10.5 \pm 1.6	1.5 \pm 0.11
T2 (30 min after resection)	13.2 \pm 2.2	1.6 \pm 0.03
T3 (60 min after resection)	12.9 \pm 1.7	1.6 \pm 0.05
T4 (90 min after resection)	14.5 \pm 0.97	1.7 \pm 0.07
T5 (120 min after resection)	16.3 \pm 1.3	1.8 \pm 0.04

Correlation of IVC/Ao index to CVP: $R=0.9$; $*P=0.001$

*Statistical significance when $P < 0.05$. IVC/Ao: Inferior vena cava/aorta; CVP: Central venous pressure

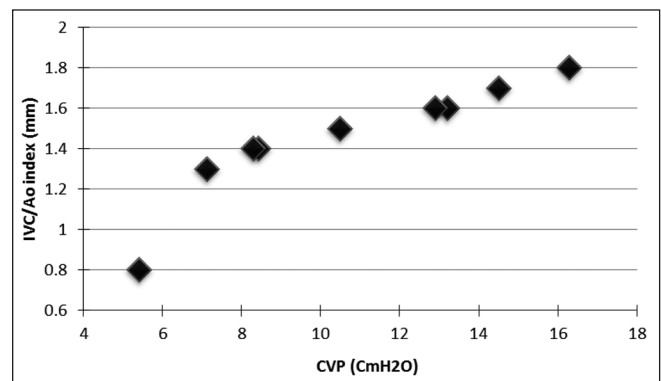


Figure 1: Correlation between inferior vena cava/aorta index and central venous pressure

Table 3: IVC/Ao index sensitivity, specificity, PPV and NPV

Number of readings	CVP	IVC/Ao index	P and r values	Sensitivity, specificity, PPV and NPV values
102	Range: 1-7 cm H ₂ O Mean±SD: 6.5±0.7	Range: 0.4-1.1 mm Mean±SD: 0.8±0.3	r=0.87 P=0.0002*	Sensitivity: 0.93 Specificity: 0.66 PPV: 0.98 NPV: 0.25
221	Range: 8-12 cm H ₂ O Mean±SD: 10.7±1.4	Range: 0.9-1.7 mm Mean±SD: 1.5±0.2	r=0.73 P=0.004*	Sensitivity: 0.96 Specificity: 0.42 PPV: 0.9 NPV: 0.71
177	Range: >12 cm H ₂ O Mean±SD: 14.3±1.2	Range: 1.4-1.9 mm Mean±SD: 1.8±0.07	r=0.65 P=0.04*	Sensitivity: 0.93 Specificity: 0.58 PPV: 0.96 NPV: 0.41

*Statistical significance when $P < 0.05$. PPV: Positive predictive value; NPV: Negative predictive value; IVC/Ao: Inferior vena cava/aorta; SD: Standard deviation

SD (sensitivity 0.96, specificity 0.42) with PPV = 0.9, and a CVP ≥ 12 cm H₂O correlated with IVC/Ao index of 1.8 ± 0.07 mean \pm SD (sensitivity 0.93, specificity 0.58) with PPV = 0.96 [Table 3].

DISCUSSION

Although many modalities of treatment are available for benign enlargement of prostate, TURP is still the standard and is one of the most common surgeries performed in elderly, TURP syndrome symptoms primarily are manifestations of circulatory fluid overload, water intoxication and occasionally toxicity of the solute in the irrigating fluid.^[10] The assessment of intravascular fluid status has an important role in the diagnostic and therapeutic management of intraoperative and postoperative disorders, thus improve outcome. There are various methods of evaluating the intravascular fluid status, but none are optimal and have many limitations. The CVP measures right atrial pressure or right ventricular filling pressure and is an indicator of intravascular fluid status and right heart function. In healthy subjects, changes in CVP are correlated with changes in left ventricular filling pressure. There are multiple factors affecting the CVP value, such as cardiac function, blood volume, vascular tone, high intra-abdominal or intrathoracic pressure and vasopressor therapy.^[11] Central venous catheter placement, an invasive procedure, has a 15% risk for complications.^[12,13] Also, there are many disadvantages such as prolonged hospitalization, an increase in health care costs, decreased quality of life. For these reasons, the use of the noninvasive method for hemodynamic monitoring is needed. The major finding of the current study is the positive correlation between the CVP and IVC/Ao index measurements, as calculated using the Pearson formula; the correlation coefficient was 0.9. There are limited data in the literature regarding the correlation between the CVP measurement and the IVC/Ao index. Many Studies are conducted on the uses of Sonographic IVC diameter assessment in monitoring intravascular fluid status in renal

patients undergoing hemodialysis, nephritic syndrome patients, or patients in ICU.^[8,14,15] The IVC is a high capacitance vessel which distends and collapse according to volume status and its size varies with intrathoracic pressure changes during respiration. In fluid overload, the vein elasticity reaches a threshold above which it becomes minimally distensible, thus maintains a relative constant diameter. Also, IVC size varies greatly between individuals, and it does not correlate well with body mass index or body surface area (BSA).^[14] There is a lack of IVC diameter reference values for pediatric and adult population. The correlation of IVC diameter, body height, and BSA has already been proven with critically ill or emergency patients but accessing BSA is difficult and time consuming. To increase accuracy, IVC diameter was compared with a parameter independent of intravascular fluid status and correlating with BSA. The Ao is noncollapsible and maintains a relatively constant diameter irrespective of the body fluid status. The aortic diameter correlates with BSA, age, and sex of the patient.^[16,17]

Kosiak *et al.*,^[18] showed that IVC/Ao is more specific in the assessment of intravascular fluid status. Thus measuring the IVC/Ao has made the study more simple and patient specific and did not need reference values for each age group. The utility of IVC/Ao for fluid status, the American Journal of Emergency Medicine reported that the IVC/Ao reference value is 1.2 ± 0.17 SD.

For the secondary outcome measures of this study, we divided the caval-aortic index into one of three groups: CVP ≤ 7 cm H₂O; 8-12 cm H₂O; and > 12 cm H₂O. We then examined the appropriate correlation of each caval-aortic index and CVP measurement. There was a positive correlation between IVC/Ao index and the CVP. The sensitivity and specificity of the IVC/Ao index were calculated to predict the CVP, a CVP ≤ 7 cm H₂O correlated with IVC/Ao index of 0.8 ± 0.3 mean \pm SD (sensitivity 0.93, specificity 0.66) with PPV = 0.98, a CVP of 8-12 cm H₂O correlated with IVC/Ao index of 1.5 ± 0.2

mean \pm SD (sensitivity 0.96, specificity 0.42) with PPV = 0.9, and a CVP >12 cm H₂O correlated with IVC/Ao index of 1.8 ± 0.07 mean \pm SD (sensitivity 0.93, specificity 0.58) with PPV = 0.96. These data well corresponded with the results of Sridhar *et al.*^[9]

Conclusion

Sonographic caval Ao index is useful for the evaluation of preoperative and intraoperative volume status, especially in major surgeries with marked fluid shift or blood loss and had the advantage of being noninvasive, safe, quick, and easy technique with no complications.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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