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# A STUDY OF INFERIOR VENA CAVA AND RIGHT VENTRICLE DIAMETER IN ASSESSMENT OF VOLUME STATUS USING ULTRASONOGRAPHY IN EMERGENCY DEPARTMENT OF A TERITIARY CARE TEACHING HOSPITAL

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**ABSTRACT**

**INTRODUCTION:** Physical examination findings, vital signs, and laboratory results are other parameters used to estimate the intravascular volume status. These parameters are not reliable because they are influenced by various clinical conditions.Some of these parameters may be found normal as the compensatory mechanisms of the body initiate; thus, this may result in delays in the detection of volume loss. **METHODOLOGY:** The study was conducted in 50 patients and 50 controls who visited the Emergency Department. **RESULTS:** Diameter of the IVC in expiration was lesser in the pre-fluid resuscitation with a mean of 1.15 compared to the 1.52 in the post-fluid resuscitation group. dIVCi – diameter of the IVC in inspiration was lesser in the pre-fluid resuscitation with a mean of 0.81 compared to the 1.81 in the post-fluid resuscitation group. **CONCLUSION:** IVC CI – IVC caval index was more in the pre-fluid resuscitation with a mean of 33.42 compared to the 16.74 in the post-fluid resuscitation group. dRV – diameter of the right ventricle was lesser in the pre-fluid resuscitation with a mean of 2.80 compared to the 3.14 in the post-fluid resuscitation group.

**KEYWORDS :** Inferior Vena Cava, Right Ventricle Diameter, Assessment of Volume Status

## INTRODUCTION:

Hypovolemia and hypovolemic shock must be diagnosed and treated promptly in the ED's. In both conditions, it is important to identify intravascular volume status of the patient. In ED's, it is sometimes difficult to detect the intravascular volume status. Pulmonary artery and central venous pressure catheters, which provide physiologic data such as cardiac output and right atrial pressure, are time-consuming, invasive, and carry considerable risks.[1]

Physical examination findings, vital signs, and laboratory results are other parameters used to estimate the intravascular volume status. These parameters are not reliable because they are influenced by various clinical conditions. Some of these parameters may be found normal as the compensatory mechanisms of the body initiate; thus, this may result in delays in the detection of volume loss. For instance, in some patients, a 30% loss of total body liquid would be compensated by the body, and blood pressure may be held at normal levels, whereas this amount of loss is sufficient to initiate multiple-organ failure.[2]

Basal cardiac rate of many patients admitted to the ED is unknown. Although tachycardia is an indicator of acute liquid loss, it is not sufficiently specific and sensitive for a diagnosis or follow-up because it may be influenced by different inner and outer signals.

Serum lactate level is a biochemical parameter used as an indicator of tissue hypo perfusion; however, it is insufficient for the early diagnosis of hemodynamic instability and in the guidance of liquid resuscitation.[3]

Central venous pressure (CVP) is the pressure recorded from the right atrium or superior vena cava. CVP is measured (usually hourly) in almost all patients in ICUs throughout the world, in emergency department patients, well as in patients undergoing major surgery Central venous pressure (CVP) has long been used to guide fluid management; however, data suggest that in critically ill patients, central venous pressure may not correlate with the effective intravascular volume. Furthermore, invasive hemodynamic monitoring has not been shown to benefit patients.[4]

Its use is limited because of the invasive nature of the procedure and possible complications (arterial puncture, venous thrombosis, infection, pneumothorax etc) during or after the process.

Indeed, internationally endorsed clinical guidelines recommend using CVP as the end point of fluid resuscitation. The basis for using CVP to guide fluid management comes from the dogma that CVP reflects intravascular volume; specifically, it is widely believed that patients with a low CVP are volume depleted while patients with a high CVP are volume overloaded.[5] This concept is taught to medical students as well as to residents and fellows across a wide range of medical and surgical disciplines. Indeed an authoritative textbook of cardiovascular physiology states as a key concept that “[the] central venous pressure gives clinically relevant information about circulatory [and volume] status.” The chapter on cardiovascular monitoring in a standard anesthesiology text states that “the most important application of CVP monitoring is to provide an estimate of the adequacy of circulating blood volume”, and “[that] trends in CVP during anesthesia and surgery are also useful in estimating fluid or blood loss and guiding replacement therapy.” Over 25 years ago, the “5–2” rule for guiding fluid therapy was popularized. According to this rule, the change in CVP following a fluid challenge is used to guide subsequent fluid management decisions.[6] This rule is still widely used today. Recently, the idea that the CVP reflects blood volume has been challenged.

## METHODOLOGY:

### SOURCE OF DATA:

The study was conducted in 50 patients and 50 controls who visited the Emergency Department

### STUDY DESIGN:

A prospective cross sectional study.

### CASES

- **INCLUSION CRITERIA:**
- Adult patients more than 16 years of age
- Clinical features of hypovolemia
- dry mucosa, reduced skin elasticity, cool extremities
- lengthened capillary refill times
- tachycardia
- reduced urine output
- orthostatichypotension, and fatigue;
- patients in whom hypovolemia is anticipated (such as abnormal uterine bleeding, gastrointestinal bleeding,diarrhea, and vomiting)

- **EXCLUSION CRITERIA:**
- Measurements could not be performed because of technical and anatomical reasons
- obesity
- excessive abdominal gas
- Patients who had
- tricuspid failure
- right-sided heart disease
- portal hypertension
- obstructive lung disease
- Intubated patients

**CONTROLS**

- Consisted of healthy volunteers such as patient relatives and medical personnel.

Logiq Alpha (GE Healthcare, USA, 2008) was used in all ultrasonographical examinations.

**RESULTS:**

**Table 1: Pre and post comparisons of various parameters**

| | Pre | Post | | |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean Difference | P-Value |
| Heart rate | 114.40 ± 12.19 | 100.30 ± 9.98 | 14.10 | <0.001 |
| Systolic Blood pressure | 76.84 ± 8.94 | 101.08 ± 10.37 | 24.24 | <0.001 |
| Diastolic Blood pressure | 56.79 ± 9.04 | 68.17 ± 7.04 | 11.38 | <0.001 |
| DIVCE | 1.15 ± 0.18 | 1.52 ± 0.32 | 0.37 | <0.001 |
| DIVCI | 0.81 ± 0.27 | 1.81 ± 0.30 | 1.00 | <0.001 |
| IVCCI | 33.42 ± 14.98 | 16.74 ± 7.04 | 16.98 | <0.001 |
| DRV | 2.80 ± 0.08 | 3.14 ± 0.16 | 0.33 | <0.001 |

**Table 2: Pre and control comparisons of various parameters**

| | Pre | Control | | |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean Difference | P-Value |
| Age | 38.60 ± 13.33 | 38.84 ± 14.74 | 0.24 | 0.932 |
| Heart rate | 114.40 ± 12.19 | 77.14 ± 8.82 | 37.26 | <0.001 |
| Systolic Blood pressure | 76.84 ± 8.94 | 122.56 ± 7.27 | 45.72 | <0.001 |
| Diastolic Blood pressure | 56.79 ± 9.04 | 78.64 ± 5.17 | 21.85 | <0.001 |
| DIVCE | 1.15 ± 0.18 | 2.07 ± 0.12 | 0.92 | <0.001 |
| DIVCI | 0.81 ± 0.27 | 1.58 ± 0.14 | 0.78 | <0.001 |
| IVCCI | 33.42 ± 14.98 | 24.43 ± 4.28 | 9.10 | <0.001 |
| DRV | 2.80 ± 0.08 | 3.34 ± 0.09 | 0.53 | <0.001 |

**Table 3: Pre, post and control comparisons of various parameters**

| | Pre | | Post | | Control | |
|---|---|---|---|---|---|---|
| | r | P-Value | r | p-Value | r | p-Value |
| DIVCI & SBP | 0.82 | <0.001 | 0.83 | <0.001 | -0.05 | 0.714 |
| DIVCI & DBP | 0.67 | <0.001 | 0.71 | <0.001 | -0.298 | 0.035 |
| DIVCI & HR | -0.32 | 0.026 | 0.44 | 0.001 | -0.035 | 0.809 |
| DIVCE & SBP | 0.86 | <0.001 | 0.78 | <0.001 | -0.09 | 0.521 |
| DIVCE & DBP | 0.66 | <0.001 | 0.71 | <0.001 | -0.22 | 0.134 |
| DIVCE & HR | -0.29 | 0.039 | 0.39 | 0.005 | -0.23 | 0.105 |
| IVCCI & SBP | -0.75 | <0.001 | -0.54 | <0.001 | 0.06 | 0.667 |
| IVCCI & DBP | -0.48 | 0.001 | -0.58 | <0.001 | -0.11 | 0.450 |
| IVCCI & HR | 0.24 | 0.089 | 0.30 | 0.033 | 0.24 | 0.094 |
| DRV & SBP | 0.86 | <0.001 | 0.66 | <0.001 | 0.65 | <0.001 |
| DRV & DBP | 0.68 | <0.001 | 0.58 | <0.001 | 0.33 | 0.017 |
| DRV & HR | -0.19 | 0.169 | -0.27 | 0.054 | 0.11 | 0.445 |

- **dIVCe – diameter of the IVC in expiration** was lesser in the pre-fluid resuscitation with a mean of 1.15 compared to the 1.52 in the post-fluid resuscitation group
- **dIVCi – diameter of the IVC in inspiration** was lesser in the pre-fluid resuscitation with a mean of 0.81 compared to the 1.81 in the post-fluid resuscitation group
- **IVC CI – IVC caval index** was more in the pre-fluid resuscitation with a mean of 33.42 compared to the 16.74 in the post-fluid resuscitation group
- **dRV – diameter of the right ventricle** was lesser in the pre-fluid resuscitation with a mean of 2.80 compared to the 3.14 in the post-fluid resuscitation group

**DISCUSSION:**

In our study we found that mean dIVCe was 1.152 before the fluid resuscitation and was 1.81 after the fluid resuscitation. So the change was 6.5mm for 1000ml of fluid resuscitation

In our study we found that mean dIVCi was 0.806 before the fluid resuscitation and was 1.524 after the fluid resuscitation. So the change was 7.1 mm for 1000ml of fluid resuscitation

On the other hand, Resnick et al[7] compared the dIVC with cardiac rate and the mean arterial pressure in a similar study. In this study, no significant difference was observed in cardiac rate and mean arterial pressure after blood donation. Although a minor decrease was detected in the dIVC, no difference was observed for respiratory CI. It was concluded that the dIVC was not sensitive enough to detect hemorrhage at an early phase. The difference in the results of these 2 studies may originate from the different techniques used in the dIVC measurement.

In our study, we performed dIVC measurements from 2 cm caudal to the junction point of the hepatic vein and the vena cava inferior.

Mean diameter for the dIVCi in hypovolemic patients was 8.06 mm (P<.001).

On the other hand, although a correlation existed between blood pressure and pulse in the hypovolemic group, none existed in the control group. These results are partially similar to the results of Resnick et al.

Yanagawa et al[8] used the dIVCe in the early diagnosis of hypovolemic shock using ultrasonography in patients with trauma. In this study, the threshold level of the dIVCe for the diagnosis of hemorrhagic shock was 9 mm. The dIVCe (7.7 mm) measured in the shock group was significantly lower than the level (13.4 mm) measured in the control group.

In our study we found that mean dIVCe (1.152 mm) measured in the shock group was significantly lower than the level (2.07 mm) measured in the control group. Hence our results correspond to Yanagawa et al.

A similar study was performed by Sefidbakht et al[9] in patients with trauma. In this study, dIVCe and dIVCi levels (5.6 and 4 mm) of the shock group were significantly lower than those of the control group (11.9 and 9.6), and the CI was higher. With this study, the dIVC was considered a reliable indicator of shock, although blood pressure is at normal limits because of sympathetic activation.

In our study, dIVCe and dIVCi levels (11.52 and 8.06 mm) of the shock group were significantly lower than those of the control group (20.7 and 15.84 mm)

Akilli et al[10] compared the dIVCe and dIVCi with other shock parameters such as cardiac rate, systolic blood pressure (SBP)/ diastolic blood pressure (DBP), shock index, urine discharge, hemoglobin level, leukocyte count, and excessive base in the patients admitted to the ED with hemorrhagic shock. It was concluded in this study that the dIVC in hemorrhagic shock is more valuable than in conventional shock parameters. Our results were partially similar to the results obtained by them. We didn't evaluate parameters like urine discharge, hemoglobin level, leukocyte count, and excessive base Yanagawa et al[8] evaluated the response to volume replacement in patients experiencing hypovolemic shock due to trauma. Systolic blood pressure, cardiac rate, hemoglobin, and arterial base excess were not significantly different among 2 groups (a transient responder group in which a second episode of shock occurred after leaving the ED and a responder group in which the blood pressure remained stable) that received liquid therapy, but a significant difference was observed in the dIVC. When an insufficient extension occurs in the dIVC with liquid replacement, it is concluded that the hemorrhage continues. These results revealed that the dIVC measurement is more sensitive than other parameters in detecting hypovolemia and following the efficacy of the treatment.

In this study, an increase of 3.1 in the dIVC after liquid therapy was lesser in magnitude compared to the results from our study (dIVCi/dIVCe, 7.18/6.58 mm).

RV preload represents filling before RV contraction. Right ventricular filling may be influenced by factors such as intravascular volume status, ventricular relaxation, and compliance. The compliance of the RV is higher than that of the left ventricle. Right ventricular end-diastolic pressure may be monitored using right cardiac catheterization and measured ultrasonographically with the detection of the dIVC and CI. Normal RV diameter ranges between 18 and 33 mm . Resnick et al[7] evaluated the left ventricular diameter in blood donors but were unable to obtain a significant result.

In our study, the dRV was significantly lower ($P < .001$) in the patient group (2.8044 cm) compared with the control group (3.336 cm).

We observed that with administration of 1000 cc isotonic NaCl to hypovolemic patients, the mean dRV increased to levels (3.1392 cm) close to that of the control group (3.336 cm). These results correspond with Zengin et al who concluded that, the dRV may be used as a useful parameter in evaluating the response to fluid replacement.

The results we obtained in this study reveal that the IVC and RV diameters may be beneficial for the early detection of hypovolemia and in the follow of fluid replacement. The dIVC and dRV are more sensitive than conventional parameters (such as blood pressure and pulse) in diagnosing hypovolemia.

## CONCLUSION:

- Point-of-care ultrasonography is becoming increasingly popular, and IVC values can be obtained immediately in the emergency or critical care setting. Ultrasound was done within 5 minutes in every patient by point of care system at the bedside without having to move the patient for further investigations
- The results we obtained in this study reveal that the IVC and RV diameters are beneficial for the early detection of hypovolemia and in the follow-up of fluid replacement.
- dIVC, IVC caval index and dRV are more sensitive than conventional parameters (such as blood pressure and pulse) in diagnosing hypovolemia.

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