External Jugular Venous Pressure versus Central Venous Pressure Measurement as a Clinical Predictor among Critically Ill Mechanically Ventilated Patients

Sheren M. Diab [1], Heba A. Al-Metyazidy [2], Soheir M. Weheida [3], Sabry Mohamed Amin [4] Zainab A. Allam [5]

[1&5]Lecturers of Critical Care and Emergency Nursing, Faculty of Nursing, Tanta University, Egypt
[2]Assistant Prof of Critical Care and Emergency Nursing, Faculty of Nursing, Tanta University, Egypt
[3]Prof of Medical Surgical Nursing, Faculty of Nursing, Alexandria University, Egypt
[4]Prof of Anesthesia, Surgical Intensive Care and Pain Medicine, Faculty of Medicine, Tanta University, Egypt

Abstract

Background: Continuous changes in central venous pressure monitoring among critically ill patients was allied to fluid response. External jugular venous pressure may be a reliable estimation method to central venous pressure and have the advantages of being less invasive. **Setting:** This study was conducted at the anesthesia Intensive Care Unit at Emergency Hospital affiliated to Tanta University Hospitals, Egypt. **The aim of the study** was to estimate external jugular venous pressure versus central venous pressure measurement as a clinical predictor among critically ill mechanically ventilated patients **Method:** A prospective comparative study design was utilized in the current study. A purposive sample of 30 adults mechanically ventilated patients was included in this study. Two tools were utilized to collect data: Tool (I): Mechanically ventilated patient assessment and Tool II: Central venous pressure and External jugular venous pressure assessment. **Results:** It was observed that there was a highly positive and significant correlation between central venous pressure and external jugular venous pressure reading r= 0.813 and p=0,000. **Conclusions:** External jugular venous pressure measurement represented a real value of central venous pressure. A positive statistical correlation between central venous pressure and external jugular venous pressure measurements seems to be a reliable method to differentiate mechanically ventilated patients with high or low central venous pressure monitoring. **Recommendations:** Measurement of external jugular venous pressure should be integrated within the critically ill patient's routine care Measurement. Also Measuring central venous pressure may be replaced with external jugularvenous pressure (EJVP) when indicated. Further studies will be needed to confirm reliability of the EJVP on a larger probability sample.

Keywords: External jugular venous pressure, Central Venous Pressure measurement, Mechanically Ventilated Patients, Clinical predictor.

1. Introduction

A bedside assessment of fluid volume is a crucial part in critically ill mechanically ventilated patient's management. There are several methods used to assess the fluid volume which include invasive and noninvasive methods. Central venous pressure (CVP) is the most commonly used modality for volume assessment. The majority of intensives use CVP as a guidance for fluid management. One of the noninvasive methods for volume assessment includes an external jugular vein pressure (EJVP) **(Van der Mullen et al., 2018 & Aboelnile et al., 2020).**

Jugular venous pressure is the vertical height of oscillating column of blood that reflects the pressure changes in the right atrium in cardiac cycle or an elevated EJVP, has been found to be the most important finding to assess ventricular filling pressures. JVP is described as an estimated JVP ≥10 cm

H2O. If the internal jugular vein is difficult to appreciate, then assessment via the external jugular vein is acceptable **(Jyotsna, 2017 & Thibodeau and Drazner, 2018).**

Also, the records obtained from the jugular vein assessment can be utilized to assess the CVP, which may provide useful information regarding responsiveness of fluid resuscitation, intravascular volume status and cardiovascular assessment with the aim of improving the critically ill patients perfusion and oxygenation of the body's vital organs **(Sathyasuba et al., 2017 & Samoni et al., 2019)**. Central venous catheterization and CVP measurement are essential in critical care unit. Unfortunately, life threatening complications among critically ill patients such as mechanical complications (1.4%-18%). Additionally, infectious and thrombotic complications may occur while using the internal jugular or subclavian veins **(Roberts, 2017 & Björkander et al., 2019)**.

External jugular venous pressure calculation has the benefit of being less invasive, quick, and free of the complications associated with other methods for estimating CVP. However, since EJVP measurements are typically extra thoracic, changes in intrathoracic pressure can go undetected by external jugular venous pressure monitoring. Attempts to compare external jugular venous pressure and CVP in the past have been minimal **(Hur et al., 2018 & Mondal et al., 2020).**

The essential role of nursing intervention for critically ill patient is the comprehensive physical examination. The neck examination which is a component of the head to toe assessment in critically ill patients was done to assess magnitude and waveform of the jugular venous pulse. This measurement is done easily at the bedside without patient embarrassment before invasive hemodynamic monitoring techniques **(Rajendram et al., 2020 & Olson, 2021).** Moreover, concern has been raised that clinicians have become less focused on the bedside evaluation of physical signs as tools for diagnostic testing has advanced. Yet, the bedside evaluation of CVP remains nearly universally feasible, clinically meaningful, immediately available, and readily repeatable **(Meyer, 2019 & Hidaka et al., 2020).**

Significance of the study:

During clinical observation of critically ill patients who had central venous catheters and need for frequent invasive CVP monitoring we found that the need to have evidences and the consensus on the noninvasive method to measure venous pressure for hemodynamic status and be widely available, simple, can be done at the bedside and becomes a part of daily practice. The use of central venous catheters is linked to a number of complications that are both dangerous to patients and costly to treat. The most common mechanical complications during the insertion of central venous catheters are hematoma, arterial puncture, and pneumothorax, which are reported to occur from 5% to 19% of patients, thrombotic complications in 2% to 26%, and infectious complications in 5% to 26% **(Abdullah et al., 2011).**

Meanwhile, measuring external jugular venous pressure can be used to accurately estimate CVP and has the advantages of being less invasive, quick, and free of any complications (**Hur et al., 2018).** The urgency of putting a central venous catheter, especially in emergency and critical care units with limited staff, is a practical challenge to achieving early directed fluid administration. Even before central venous access is established, the EJV evaluation may allow for fast assessment of CVP. If central venous pressure is low by the EJV evaluation, It may be advised to start intravenous fluid bolus therapy before placing the central venous catheter **(Karki & Bhattarai, 2020)**. As a result, the current research was conducted to determine the external jugular venous pressure as a clinical predictor for central venous pressure assessment in critically ill mechanically ventilated patients.

1.2 The aim of the study was:

To estimate external jugular venous pressure versus central venous pressure measurement as a clinical predictor among critically ill mechanically ventilated patients.

1.3 Research hypothesis

The external jugular venous pressure measurement exhibits matched reading with central venous pressure measurement among critically ill ventilated patients.

2. Subjects and method

2.1 Research design:

A prospective comparative study design was utilized in the current study.

2.2 Study Setting:

This study was conducted at the Anesthesia Intensive Care Unit at Emergency Hospital affiliated to Tanta University Hospitals. Tanta City, Egypt. The hospital has one floor for Anesthesia Intensive Care Unit which consist of 4 wards, each ward contains 6 beds (The capacity of the unit includes 24 beds).

2.3 Subjects:

A purposive sample of 30 adults mechanically ventilated patients who fulfilled the inclusion and exclusion criteria were assigned based on the Epi info program according to the total population admitted per year to the Anesthetic ICU and the sample size calculated as the following:

Z= confidence level 95%, d= Error proportion (0.05), P= population (80%).

Inclusion criteria; included patients of both sex and critically ventilated patients undergoing central venous catheter for hemodynamic monitoring.

Exclusion criteria; included patients with a recent history of neck surgery or trauma, undergoing vasoactive drugs, pulmonary hypertension, significant renal, hepatic, or cardiac diseases, body mass index (BMI)> 30 kg/m^2.

2.4 Tools of the study:

Two tools were utilized to collect data.

Tool I: Mechanically ventilated patient assessment: This tool was developed by the researcher after reviewing the relevant **literature (Qureshi et al., 2017, Santos et al., 2020 & Acho et al., 2020)**. It included 3 parts as following:

Part one: Patient's socio-demographic and clinical data; to assess data related to patient's code age, gender, and diagnosis.

Part two: **Mechanical ventilation parameters**; it was composed of mechanical ventilation mode, tidal volume (Tv), positive end-expiratory pressure (PEEP), peak inspiratory pressure (PIP) **(Acho et al., 2020)**.

Part three: Anthropometric parameters; included patient's weight, BMI, and neck circumferences **(Santos et al., 2020)**.

Tool II: Central venous pressure and External jugular venous pressure assessment: This tool was developed by the researchers after strong reviewing of the relevant literature **(Magder et al., 2018 & Gilbert 2018)**. It was included 3 parts as follows:

Part 1: Central venous catheter assessment; such as catheter type, site, number of the catheter lumens, indication, CVP measuring, and side of measuring CVP **(Zamboni et al., 2020 & Buetti et al., 2020)**.

Part 2: **External jugular venous pressure assessment;** site of EJVP measuring and EJVP measuring concerning sternal angle **(Socransky et al., 2017)**.

2.5 Method

An approval from the ethical committee was taken from the director of the Emergency Hospital, Tanta University Hospitals through official letters from the faculty of nursing explaining the purpose of the study before data collection.

Ethical considerations:

- An informed consent was obtained from every patient and or one of the family members after explanation to the aim of the study and promising them of confidentiality of collected data.
- The patients and or their families were assured that the study was not causing any harm effect for the entire patients.
- The confidentiality and privacy were assured through the coding of all data.

All tools of the study were developed by the researchers after reviewing of the relevant literature.

All tools of the study were tested for content validity by five experts (3) in the field of critical care nursing specialists, (1) anesthesiologists, and (1) medical biostatistics to ensure validity.

All tools of the study were tested for reliability and the Cronbach alpha test was used and found to be 0.884 for the tool I and 0.826 for tool II which represent highly reliable tools.

A pilot study was carried out on 5 critically ill mechanically ventilated patients to test the clarity, possibility, and applicability of the different items of the developed tools. Modifications on tools were done and those patients were excluded from the study sample.

Data collection:

- Each patient who participated in the current study and met the inclusion and exclusion criteria was observed by the researchers.
- Data collection was conducted within the period from the end of **September 2019 t**o the starting of February 2020.

The study was carried out in four phases: Assessment, planning, implementation, and evaluation phases.

1-Assessment Phase:

Patient characteristics, anthropometric and mechanical ventilation parameters were assessed using tool I. Also, the central venous catheter was assessed using tool II part one.

II- Planning phase:

This stage was developed centered on the assessment phase, priorities, goals, and expected outcome criteria were taken into consideration when planning patients' care. The expected outcomes include; measuring the CVP and EJVP accurately by the correct way and comparing between CVP and EJVP reading.

III. Implementation Phase:

In this phase, both the CVP and EJVP were monitored during the morning shift for the same 30 studied patients three times a day with 15 minutes interval among the three measurements to allow the patient to return to comfortable state, then the mean of three measurements of both CVP and EJVP were recorded by the researcher and agreed by the treating physician in anesthesia ICU as the following:

1. Central venous pressure monitoring in the mechanically ventilated patient:

This was done by the researcher for the studied subjects in the selected intensive care unit just before measuring EJVP.

A. Preparation of the equipment:

Use aseptic techniques such as hand washing and maximal personal protective barriers were used such as gloves, gown, caps, and masks, antiseptic solution as chlorhexidine gluconate 2% with alcohol, 2 or 3 x 10 ml sterile syringes were used also to check for patency, 2 or 3 x 20 ml syringes filled with normal saline for flush, 2or 3 caps one per lumen and sterile gauzes **(Rahim-Taleghani et al., 2017)**.

B. Patient's preparation:

The critically ill patient was positioned in a supine position and the head turned to the opposite side of CVC before the catheter flushing to prevent mechanical trauma.

C. Flush central venous catheter ports through:

Flush the lumen with 20 ml normal saline and 3 ml of heparin (100 units/ml). Flush the lumen using a push/pause method through a short repetitive push of the syringe plunger to prevent the catheter occlusion, and then lock the lumen immediately to prevent air embolism **(Rahim-Taleghani et al., 2017, Zamboni et al., 2020 & Buetti et al., 2020).**

2. The central venous pressure monitoring technique:

- After flushing the central venous catheter CVC, CVP was monitored at the fourth intercostal space in the mid-axillary line and the patient was in the supine position and detached from PEEP **(Al-Metyazidy and Younis, 2019)**.
- A three-way stopcock was used to attach the manometer to an intravenous line through the extension set to the patient on the other side to remove any air bubbles.
- After that, the three-way stopcock was opened to the fluid bag and the manometer and closed to the patient to fill the manometer column adequately with fluid. Once the manometer has been filled adequately then the 3-way stopcock was turned again to allow opening to the patient and the manometer but closing to the fluid bag. The fluid level within the manometer column was dropped gradually to the level of the CVP, the number of which was read on the manometer score **(Zamboni et al., 2020 & Buetti et al., 2020).**

3. External jugular venous pressure monitoring technique:

This was done by the researcher three times a day with 15 minutes interval for the same 30 study subjects just immediately after CVP measurement, then the mean of EJVP was recorded by the researcher. The EJVP measurement was done according to the following steps:

A. Examination of the external jugular vein

The normal External jugular venous pressure was assessed by checking the external jugular vein in the neck. If the collapsed vein is detected initially, light finger pressure made the distended neck vein. If the distention rapidly clears after relief of pressure, the EJVP is not elevated. However, if external jugular venous distention continues, this does not verify the elevation of correct EJVP reading, since it may reproduce external compression of the vein by delayed blood flow **(Tavoni, 2020).**

B. Measurement of jugular venous pressure

The patient with easily identifiable jugular venous pulsation was enrolled. Each patient was positioned at 45° to the horizontal plane. The neck was rotated slightly to left and the highest visible jugular venous pulsation was detected by inspection with a bright torch. The vein pulsation was established by palpation. Then, the vertical ruler of the EJVP scale was placed at the sternal angle of the patient. After that, the lower end of the horizontal ruler was placed above the highest visible pulsation. Both the scales were checked for leveling. Finally, the reading was read from the centimeter scale of the vertical ruler where the lower end of the horizontal scale was. This reading point to EJVP in cm H_2O **(Zamboni et al., 2020)**.

IV. Evaluation phase:

Evaluation of external jugular venous pressure and central venous pressure values among mechanically ventilated patients were done using tool II. This was done three times a day in the morning shift. Firstly the central venous pressure measuring from the central venous catheter were done by the researcher just before the evaluation of external jugular venous pressure. The mean of three measurements of both external jugular venous pressure and central venous pressure were obtained separately for the same 30 study subjects.

Statistical analysis

The statistical data were prepared, organized, and statistically investigated using a statistical package for social studies (SPSS) version 23. For categorical data, the number and percent were calculated and the differences between subcategories were tested by chi-square χ^2. For numerical data, the range, mean and standard deviation were calculated. The normality of data was tested by using the Kolmogorov-Smirnov test. Both descriptive and inferential statistics involving the Mann-Whitney U test, Kruskal-Wellis H test, and spearman test were used to present results. For each test, a p-value of less than 0.05 was considered statistically significant. Sensitivity and specificity were tested by using the Receiver Operating Characteristic curve (ROC curve) and Area Under the ROC curve (AUC) **(Daniel & Cross, 2018).**

3. Results

Table (1) presents the percentage distribution of the studied patients according to personal characteristics and clinical data. It was noticed that half (50.0%) of the studied patients were within the age group of more than 45 to less than 60 years old and more than half (56.7%) of the studied patients were male. concerning diagnosis, one-third (33,3%) of the studied patients had head trauma and medical diseases at ICU admission whereas less than one-fifth of the studied patients (16,7%, 13.3%, and 3.3%) had respiratory diseases, brain tumor, and brain abscess respectively.

Table (2) reveals the distribution of the studied patients according to mechanical ventilation parameters when enrolled to the study. It was reported that the most common mode of mechanical ventilation among the studied patients (46.7%) was the SIMV mode of mechanical ventilation while the most common mode among them (3.3%) was PRVC. Also, it was found that the total mean scores regarding tidal volume, PEEP and peak inspiratory pressure were 359.03±69.124,6.33±1.398 25.23±4.883 of respectively.

Table (3) shows the mean and standard deviation of the studied patients regarding anthropometric parameters. It was observed that nearly two-thirds (60.0%) of the studied patients were obese with the total mean score and standard deviation at 30.950 ± 4.6690. Additionally, it was found that the total mean scores regarding body weight andneck circumferences were 86.40 ± 11.956 and40.60±8.645 respectively.

Table (4) presents the percent distribution of the studied patients regarding central catheter assessment. It was observed that more than half (53.3%and 56.7%) of the studied patients had the central venous catheter in the subclavianvein at the left side respectively. Regarding the indication of measuring CVP; it was found the most common indication of the central venous catheter (76.7%) among the studied patients was used for hemodynamic monitoring while the least common indication (6.7%) among them was acute kidney injury.

Table (5) shows the distribution of the studied patients according to CVP and EJVP mean rank. It was reported that the mean rank of CVP and EJVP were 46.27and 46.28 respectively. There was no statistically significant difference was observed between CVP and EJVP mean rank p = 0.979 and 0.931.

Table (6) illustrates the distribution of the studied patients according to the sensitivity and specificity of neck circumference when critical cutoff 35.5cm. It was observed that the neck circumference estimation among the studied patients with a critical cutoff value of 35.5 at a negative predicted value had a specificity of 100% and sensitivity of 19.2%while, the critical cutoff value of 35.5 at a positive predicted value had no specificity and 80.0 sensitivity.

Table (7) shows the distribution of the studied patients according to the sensitivity and specificity of CVP and EJVP reading when critical cutoff 12.5. Regarding specificity and sensitivity at cutoff 12.5; it was found that measurement of both CVP and EJVP with higher specificity of 100% and moderate sensitivity (62.5% and57.1%), and negative predictive value were (80% and 60%) respectively. On the other hand, measurements of both CVP and EJVP with no specificity and moderate sensitivity were (37.5% and 42.5%), and positive predictive value was (20% and 40%) respectively.

Table (8) reveals the relationship between socio-demographic and clinical characteristics of the studied patients and the mean rank of both CVP and EJVP reading. It was observed that there was a statistically significant relationship between the EJVP side and the mean rank of both CVP and EJVP reading p <0.05. on the other hand, there were no statistically significant differences between the mean rank of CVP and EJVP readings in relation to age, gender, site, and body mass index where p-value 0.05.

Table (9) presents the relationship between mechanical ventilation parameters and the mean score of both CVP and EJVP reading. A statistically significant relationship was observed between the mean of both CVP and EJVP reading in relation to PEEP. Also, a statistically significant relationship was observed between the mean of EJVP reading and tidal volume P <0.05.

Table (10) shows the correlation between central venous insertion site, EJVP side, body mass index, and neck circumference regarding CVP and EJVP mean scores. It can be seen that there was a positive and significant correlation between CVP and EJVP reading r= 0.813 and p= 0,000.

Table (1): Percentage distribution of the studied patients according to personal characteristics and clinical data.

Personal characteristics and clinical data	The studied patients (n=30) N	%
Age in years		
- 15-	5	16.7
- 25-	8	26.7
- 45-	15	50.0
- More than 45- ≤ 60	2	6.7
Range	**18-67**	
Mean ± SD	**46.90±14.942**	
Gender		
- Male	17	56.7
- Female	13	43.3
ICU admission diagnosis		
- Respiratory diseases	5	16.7
- Head trauma	10	33.3
- Brain tumor	4	13.3
- Brain abscess	1	3.3
- Medical diseases	10	33,3

Table (2): Distribution of the studied patients according to mechanical ventilation parameters immediately when enrolled to the study.

Ventilation parameters	The studied patients (n=30) n	%
Mode of ventilation:		
- SIMV	14	46.7
- ACV	4	13.3
- CPAP	9	30.0
- PC	2	6.7
- PRVC	1	3.3
Tidal volume:		
Range	**250-500**	
Mean±SD	**359.03±69.124**	
PEEP:		
Range	**5-10**	
Mean±SD	**6.33±1.398**	
Peak inspiratory pressure:		
Range	**15-35**	
Mean±SD	**25.23±4.883**	

SIMV: Synchronized Intermittent-Mandatory Ventilation, ACV: Assist-Control Ventilation, CPAP: Continuous Positive Airway Pressure, PC: Pressure control, PRVC: Pressure Regulated Volume Control, PEEP: Positive End Expiratory Pressure.

Table (3): Mean and standard deviation of the studied patients regarding anthropometric parameters on enrollment to the study.

Anthropometric parameters	The studied patients (n=30) n	%
Body mass index		
- Normal weight (18.5–24.9 kg/m2)	1	3.3
- Overweight (25.0–29.9 kg/m2)	11	36.7
- Obese (30.0 kg/m2)	18	60.0
Range	**22-40**	
Mean±SD	**30.950±4.6690**	
Bodyweight		
Range	**66-120**	
Mean±SD	**86.40±11.956**	
Neck circumferences		
Range	**29-59**	
Mean±SD	**40.60±8.645**	

Table (4): Percentage distribution of the studied patients according to central venous catheter assessment.

Central venous catheter characteristics	The studied patients (n=30)	
	n	%
Central venous catheter insertion site:		
- Subclavian	16	53.3
- Internal jugular	14	46.7
Central venous catheter side:		
- Right side	13	43.3
- Left side	17	56.7
Indications for measuring central venous pressure:		
- Hemodynamic monitoring	23	76.7
- Renal failure	2	6.7
- Patient on ventilation	5	16.7

Table (5): Distribution of the studied patients according to central venous pressure and external jugular venous pressure mean rank.

Variables	The studied patients (n=30)	
	Mean rank	**χ^2 P**
Central venous pressure	46.27	0.043 0.979
External jugular venous pressure	46.28	0.143 0.931

* Significant at P <0.05.

Table (6): Distribution of the studied patients according to the sensitivity and specificity of neck circumference when critical cutoff 35.5cm

Critical cutoff 35.5		The studied patients (n=30)		Total
		Specificity (n=4)	Sensitivity (n=26)	
Negative predicted value	n	4	5	9
	% within actual	100.0	19.2	30.0
Positive predicted value	n	0	21	21
	% within actual	0.0	80.8	70.0
Total	n	4	26	30
	% within actual	100.0	100.0	100.0

Table (7): Distribution of the studied patients according to the sensitivity and specificity of central venous pressure and external jugular venous pressure when critical cut off 12.5.

Critical cutoff 12.5		The studied patients (n=30) Central venous pressure reading			External jugular venous pressure reading		
		Specificity (n=14)	Sensitivity (n=16)	Total	Specificity (n=2)	Sensitivity (n=28)	Total
Negative predicted value	n	14	10	24	2	16	18
	% within actual	100.0	62.5	80.0	100.0	57.1	60.0
Positive predicted value	n	0	6	6.0	0	12	12
	% within actual	0.0	37.5	20.0	0.0	42.9	40.0
Total	n	14	14	18	30	28	30
	% within actual	100.0	100.0	100.0	100.0	100.0	100.0

Table (8): Relationship between socio-demographic and clinical characteristics of the studied patients and mean rank of both central venous pressure and external jugular venous pressure reading.

Variables	The studied patients (n=30)	Central venous pressure reading		External jugular venous pressure reading	
	n	Mean rank	P-value	Mean rank	P-value
Age in years:					
- 15-	5	18.00	0.524	15.70	0.898
- 25-	8	17.50		15.56	
- 45-	15	14.50		16.00	
- ≤ 60	2	8.75		11.00	
Gender:					
- Male	17	16.82	0.340	16.59	0.431
- Female	13	13.77		14.08	
Central venous catheter site insertion site			0.705		0.949
- Subclavian	16	14.94		15.41	
- Internal jugular	14	16.14		15.61	
External jugular venous pressure side:			0.005*		0.014*
- Right side	13	20.58		19.92	
- Left side	17	11.63		12.12	
Body mass index:					
- Normal weight (18.5–24.9 kg/m2)	1	14.00	0.855	7.50	0.642
- Overweight (25.0–29.9 kg/m2)	11	14.45		15.77	
- Obese (30.0 kg/m2)	18	16.22		15.78	

* Significant at P <0.05.

Table (9): Relationship between mechanical ventilation parametersand mean score of both central venous pressure and external jugular venous pressure reading.

Mechanical ventilation parameters	The studied patients (n=30)	
	Mean of central venous pressure reading	Mean of external jugular venous pressure reading
	χ^2 p	χ^2 p
- Tidal volume	133.231 0.730	177.238 0.031*
- Peak inspiratory pressure	45.778 0.127	46.369 0.115
- PEEP	158.988 0.006*	147.917 0.028*

PEEP: Positive End Expiratory Pressure * Significant at P <0.05.

Table (10): Correlation between central venous insertion site and external jugular venous pressure side, body mass index, and neck circumference regarding central venous pressure and External jugular venous pressure reading mean scores.

Variables	Mean of central venous pressure reading		Mean of external jugular venous pressure reading	
	r	p	r	p
- **Body mass index**	0.260	0.165	0.026	0.891
- **Neck circumference**	0.181	0.339	0.031	0.871
- **Central venous catheter site**	0.105	0.430	0.154	0.417
- **Central venous pressure reading**	-	-	0.813	0,000**

** high Significant at P =0.000.

4. Discussion

The current study reveals estimation the accuracy of central venous pressure monitoring by external jugular venous pressure. External jugular venous pressure is a closed estimation of central venous pressure in patients undergoing mechanical ventilation. Noninvasive evaluation of the central venous pressure can be executed by way of assessing the external jugular venous pressure. Besides, subjecting clinically stable patients to invasive central venous pressure measurements would be impractical and unethical considering the potential risks of catheter insertion. On the other hand, external jugular venous pressure evaluation can be difficult due to a number of elements inclusive of obesity, anomalous venous anatomy, connective tissue diseases, and venous scarring from catheter insertion **(Mohamed et al., 2011 & Trzebicki et al., 2009).**

Regarding patients' characteristics, the present study revealed that half of the studied patients were within the age group of more than 45 to less than 60 years old and more than half of them were males. This may be translated that males were admitted to intensive care unit due to the nature of stressful work and enormous mischance. This result was contradicted with **Al-Metyazidy & Younis (2019),** who reported that the age group of the majority of the study sample was from 30 to 47 years and the majority of the studied patients were male.

Concerning diagnosis, the contemporary study illustrated that one-third of the studied patients had head trauma and medical diseases during intensive care unit admission whereas less than one-fifth of the studied patients had respiratory diseases, brain tumors, and brain abscess. This may be attributed to the policy of the hospital admission to the Anesthetic Intensive Care Unit at Tanta University Hospitals. This result was supported by **Al-Metyazidy and Younis (2019),** who discovered that around one-fifth of the studied mechanically ventilated patients in Anesthesia Intensive Care Unit at Tanta University Hospitals had been recognized with trauma.

In relation to body mass index and neck circumferences of the studied patients, the present study confirmed that almost two-thirds of the studied patients had body mass index greater than normal. This can also be associated to patients suffering from fluid volume excess as a result of excessive intravenous infusion. This discovering used to be supported by way of **Gur et al. (2011)**, who reported that the majority of the studied sample body mass index was characterized by obesity. On the other hand, this finding was incongruent with **Agung et al. (2019)**, who reported that the majority of the studied sample had normal body mass index.

Regarding central venous catheter characteristics; it was observed that more than half of the studied patients had the central venous catheter in the subclavianvein at the left side. This may be attributed to the patients' assessment and need for tunneled catheter insertion to decrease the catheter-associated bloodstream infection. This finding was inconsistent with **Al-Metyazidy and Younis (2019)**, who stated that the majority of the studied patients had central venous catheter insertion in the internal jugular vein

Also, it used to be observed that the most common indication of central venous catheter among the studied patients was used for hemodynamic monitoring while the least common indication among them was acute kidney injury because the assessment of intravascular volume status plays an important role in determining the diagnosis and direction of therapy in critically ill patients. This finding was congruent with **Agung et al. (2019)**, who noted that the use of central venous pressure monitoring was advantageous in finding out the adequacy of the intravascular volume status among critically ill patients.

Regarding specificity and sensitivity at critical cutoff value 12.5; it was found that the measurement of both central venous pressure and external jugular venous pressure had greater specificity and moderate sensitivity, while negative predictive values were moderate. On the other hand, measurement of both central venous pressure and external jugular venous pressure with no specificity and moderate sensitivity, and positive predictive values were limited. These effects had been contradicted by **Denny et al. (2004)**, who referred to that confirming central venous pressure measurement with limited sensitivity and moderate specificity, positive and negative predictive values were moderate.

Concerning the relation between central venous pressure and external jugular venous pressure in relation to positive end-expiratory pressure; these findings provided evidence that a statistically significant relationship was observed between central venous pressure and external jugular venous pressure reading in relation to positive end-expiratory pressure. Also, a statistically significant relationship was observed between external jugular venous pressure reading and tidal volume. It may be related to changes in juxtacardiac pressure. These results were supported by **Gur et al. (2011)**, who found that the impact of mechanical ventilation had a similar impact on both central venous pressure and external jugular venous pressure. Also, **Shojaee1 et al. (2017)** stated that an increase in positive end-expiratory pressure had a direct relationship with central venous pressure increase. Additionally, **Leonard (2008) and Kim (2016)**, reported that positive end-expiratory pressure-induced change in external jugular venous pressure as an indicator of fluid responsiveness. Moreover, **Hur et al. (2018)** reported that positive end-expiratory pressure -induced increase and decrease in external jugular venous pressure and its associated predictability of the fluid responsiveness.

The finding of the present study suggested that there was a positive and significant correlation between central venous pressure and external jugular venous pressure reading. On the other hand, there was nosignificant correlation between both central venous pressure and external jugular venous pressure values in relation to body mass index, neck circumference, and central venous catheter site. These results were in line with **Abdullah et al. (2011),** who stated that the correlation between external jugular venous pressure and central venous pressure changed in parallel with central venous pressure showing a strong correlation and a clinically acceptable range. Also, **Amelard et al. (2021)** revealed that monitoring the external jugular venous pressure allows equally efficient evaluation of vascular volume as the central venous pressure where the results of the study showed that there were a significant correlation was observed between external jugular vein pressure and central venous pressure. Conversely, these findings were incongruent with **Abdullah et al. (2011)**, stated that the difference found between external jugular venous pressure and central venous pressure is not clinically significant.

5. Conclusion:

Based on the findings of the present study, it can be concluded that:

External jugular venous pressure measurement represented the same value of central venous pressure. A positive statistical correlation between central venous pressure and external jugular venous pressure measurements seems to be a reliable method to differentiate mechanically ventilated patients with high or low central venous pressure monitoring.

6. Recommendations:

In the light of the present study results the following recommendations are suggested:

- Measurement of EJVP should be integrated with the critically ill patient's routine care.
- Routine EJVP examination training should be conducted, and the examination should be used to detect abnormal CVP in critically ill patients.
- Measuring central venous pressure may be replaced with external jugular venous pressure (EJVP) when indicated.
- Further studies will be needed to confirm reliability of the EJVP on a larger probability sample

7. Limitation of the study:

- The central venous pressure was measured with water column manometer not with an electronic transducer.
- The presence of a tracheostomy may limit the ability to accurately examine the jugular pulsation.
- The study was limited to only one specific setting and need for generalization.

8. References

Abdullah, M. H., Soliman Hel, D., & Morad, W. S. (2011): External jugular venous pressure as an alternative to conventional central venous pressure in right lobe donor hepatectomies. Exp Clin Transplant, 9 (6), 393-8.

Aboelnile, D. B., Elseidy, M. I.., Kenawey, Y. A., & Elsherif, I. M. (2020): Prediction of fluid responsiveness in mechanically ventilated patients in surgical intensive care unit by pleth variability index and inferior vena cava diameter. Ain-Shams Journal of Anesthesiology, 12 (1), 1-7.

Acho, M., Lee, A. C., & Lee, B. W. (2020): Ventilators for Nonintensivists. Basic Ventilator Parameters. ATS Scholar, 1 (2), 194-194.

Agung T, Agung S, Aryabiantara W (2019): Correlation between Central Vena Pressure Measurement with Collapsibility Index of Internal Jugular Veins in Critically ill Patients. Journal of Global Pharma Technology. 11 (8):220-23.

Al-Metyazidy H, and Younis G (2019): The Effect of Safety Guidelines during Different Measuring Techniques on Central Venous Pressure Reading in Mechanically Ventilated Patients. International Journal of Novel Research in Healthcare and Nursing. (6) 3: 259-71.

Amelard, R., Robertson, A. D., Patterson, C. A., Heigold, H., Saarikoski, E., & Hughson, R. L. (2021): Optical hemodynamic imaging of jugular venous dynamics during altered central venous pressure. IEEE Transactions on Biomedical Engineering.

Björkander, M., Bentzer, P., Schött, U., Broman, M. E., & Kander, T. (2019): Mechanical complications of central venous catheter insertions: A retrospective multicenter study of incidence and risks. Acta Anaesthes-iologica Scandinavica, 63 (1), 61-68.

Buetti, N., Mimoz, O., Mermel, L., Ruckly, S., Mongardon, N.,

Dupuis, C., ... & Timsit, J. F. (2020): Ultrasound guidance and risk for central venous catheter-related infections in the ICU. A post hoc analysis of individual data of three multi-centric randomized trials. Clinical Infectious Diseases.

Denny D, Andrea M, Monika S, John R, Karen L, Regina M. Taylor-G, John G (2004): Comparison of Clinical Measurement of Jugular Venous Pressure Versus Measured Central Venous Pressure. Chest J.; (126) 4: 747-55.

Daniel, W. W., & Cross, C. L. (2018): Biostatistics: a foundation for analysis in the health sciences. Wiley.

Gilbert M (2018): Central venous pressure and pulmonary artery pressure monitoring. Anaesthesia & Intensive Care Medicine. 1;19 (4):189-93.

Gur R, Nicole c, Andrew A (2011): Ultrasound Accurately Reflects the Jugular Venous Examination but Underestimates Central Venous Pressure. CHEST . 139 (1):95–100.

Hidaka, T., Sumimoto, Y., Dohi, Y., Morimoto, H., Susawa, H., Nitta, K., ... & Higashi, Y. (2020): Non-Invasive Central Venous Pressure Measurement Using Enclosed-Zone Central Venous Pressure (ezCVPTM). Circulation Journal, 84 (7), 1112-1117.

Hur, M., Yoo, S., Choi, J. Y., Park, S. K., Jung, D. E., Kim, W. H., ... & Bahk, J. H. (2018): Positive end-expiratory pressure-induced increase in external jugular venous pressure does not predict fluid responsiveness in laparoscopic prostatectomy. Journal of anesthesia, 32 (3), 316-25.

Jyotsna, M. (2017): JVP-Jugular venous pressure. Indian Journal of Cardiovascular Disease in Women WINCARS, 2 (02), 064-076.

Karki, S., & Bhattarai, M. D. (2020): Correlation of Central with Jugular and Upper-limb Venous Pressure Measurements. Journal of Nepal Health Research Council, 18 (1), 35-40.

Kim, N., Shim, J. K., Choi, H. G., Kim, M. K., Kim, J. Y., & Kwak, Y. L. (2016): Comparison of positive end-expiratory pressure–induced increase in central venous pressure and passive leg raising to predict fluid responsiveness in patients with atrial fibrillation. BJA: British Journal of Anaesthesia, 116 (3), 350-56.

Leonard, A. D., Allsager, C. M., Parker, J. L., Swami, A., & Thompson, J. P. (2008): Comparison of central venous and external jugular venous pressures during repair of proximal femoral fracture. British journal of anaesthesia, 101 (2), 166-170.

Magder S, Serri K, Verscheure S Chauvin R and Goldberg P (2018). Active expiration and the measurement of central venous pressure. Journal of intensive care medicine.;33 (7):430-35.

Meyer, T. E. (2019): Examination of the jugular venous pulse. UpToDate Online [Internet].

Mohamed H, Hossam S, Wessam M (2011): External Jugular Venous Pressure as an Alternative to Conventional Central Venous Pressure in Right Lobe Donor Hepatectomies./ Experimental and Clinical Transplantation. 9 (6):393-98.

Mondal, H., Mondal, S., Das, D., Alam, N., & Saha, K. (2020): Reliability of a jugular venous pressure scale in cardiovascular clinical examination. Journal of Clinical and Preventive Cardiology, 9 (2), 61.

Olson, K. (Ed.): (2021). Oxford handbook of cardiac nursing. Oxford University Press.

Qureshi N, Hossain T, Hassan I, Akter N, Rahman M, Sultana M, Ashrafuzzaman M, Latif A (2017): Neck Circumference as a Marker of Overweight and Obesity and Cutoff Values for Bangladeshi Adults. Indian J Endocrinol Metab. 21 (6):803-08

Rahim-Taleghani, S., Fatemi, A., Moghaddam, M. A., Shojaee, M., Abushouk, A. I., Forouzanfar, M. M., & Baratloo, A. (2017): Correlation of central venous pressure with venous blood gas analysis parameters; a diagnostic study. Turkish journal of emergency medicine, 17 (1), 7-11.

Rajendram, R., Joseph, A., Davidson, J., Gobindram, A., Singh, P. A., & Patel, A. J. (2020): Critical Care and Anaesthesia. In Cracking the Intercollegiate General Surgery FRCS Viva (pp. 91-164). CRC Press.

Roberts, J. R. (2017): Roberts and Hedges' Clinical Procedures in Emergency Medicine and Acute Care E-Book. Elsevier Health Sciences Elsevier Inc,7th ed, chapter (22), pp. 397-432.

Samoni, S., & Bonilla-Reséndiz, L. I. (2019): Noninvasive Methods of Fluid Status Assessment in Critically Ill Patients. In Critical Care Nephrology, Elsevier ,3rd ed, chapter (135), pp. 821-825.

Santos, L. S., de Jesus, K. M. G., de Araújo Oliveira, M. R. D., Furtado, M. C. M. B., Vermeulen-Serpa, K. M., de Lima Vale, S. H., ... & Leite-Lais, L. (2020): Early parenteral nutrition progression and nutritional parameters in critically ill patients.BRASPEN J; 35 (3): 258-63.

Sathyasuba, M. (2017): Prospective Comparative study of Ultrasound Guided Central Venous Pressure Measurement using Jugular Vein and Inferior Venacava Diameters for Postoperative Patients on Mechanical Ventilation (Doctoral dissertation, Madras Medical College, Chennai).

Shojaee M, Sabzghabaei A, Alimohammadi H, Derakhshanfar H, Amini A and Esmailzadeh B (2017): Effect of positive end-expiratory pressure on central venous pressure in patients under mechanical ventilation. Emergency. 5 (1):1-4.

Socransky, S., Lang, E., Bryce, R., & Betz, M. (2017): Point-of-care ultrasound for jugular venous pressure assessment: Live and online learning compared. Cureus, 9 (6): e1324,available at:. doi: 10.7759/cureus.1324.

Tavoni, V. (2020): Technical note for post processing of jugular venous pulse, central venous pressure and velocity trace. Veins and Lymphatics, 9 (1),1-5.

Thibodeau, J. T., & Drazner, M. H. (2018): The role of the clinical examination in patients with heart failure. JACC: Heart Failure, 6 (7), 543-551.

Trzebicki, J., Flakiewicz, E., Nowa-kowski, P., Kosieradzki, M., Lisik, W., & Chmura, A. (2009): Is external jugular venous pressure a good predictor of volume status in kidney graft recipients? In Transplantation proceedings. 41 (8): 3033-35).

Van der Mullen, J., Wise, R., Vermeulen, G., Moonen, P. J., & Malbrain, M. L. (2018): Assessment of hypovolaemia in the critically ill. Anaesthesiology intensive therapy, 50 (2).

Zamboni, P., Malagoni, A. M., Menegatti, E., Ragazzi, R., Tavoni, V., Tessari, M., & Beggs, C. B. (2020): Central venous pressure estimation from ultrasound assessment of the jugular venous pulse. PloS one, 15 (10), e0240057.