Ultrasound of Jugular Veins for Assessment of Acute Dyspnea in Emergency Departments and for the Assessment of Acute Heart Failure

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ABSTRACT: **Background:** When a patient arrives at the emergency department (ED), presenting with symptoms of acute decompensated heart failure (ADHF), it is possible to reach a definitive diagnosis through many different venues, including medical history, physical examination, echocardiography, chest X-ray, and B-type natriuretic peptide (BNP) levels. Point-of-care ultrasound (POCUS) has become a mainstream tool for diagnosis and treatment in the field of emergency medicine, as well as in various other departments in the hospital setting. Currently, the main methods of diagnosis of ADHF using POCUS are pleural B-lines and inferior vena cava (IVC) width and respiratory variation.

Objectives: To examine the potential use and benefits of bedside ultrasound of the jugular veins in the evaluation of dyspneic patients for identification of ADHF.

Methods: A blood BNP level was drawn from each participant at time of recruitment. The area and size of the internal jugular vein (IJV) during inspiration and expiration were examined.

Results: Our results showed that the respiratory area change of the IJVs had a specificity and sensitivity of nearly 70% accuracy rate in indentifying ADHF in our ED.

Conclusions: Ultrasound of the IJV may be a useful tool for the diagnosis of ADHF because it is easy to measure and requires little skill. It is also not affected by patient body habitus.

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KEY WORDS: internal jugular vein (IJV), point-of-care ultrasound (POCUS), dyspnea, heart failure, B-type natriuretic peptide (BNP)

There is an increasing need for a simple clinical tool in the emergency department (ED) setting that can help reach a faster and more reliable diagnosis of acute decompensated heart failure (ADHF). The tool must be easy to operate and be able to be implemented next to the patient's bed [1].

Most of the diagnostic tools that are used today to diagnose ADHF are not ideal because each one has its own unique disadvantages.

- **Echocardiography** [2] is a well-known method for the diagnosis of congestive heart failure, yet it is operator dependent and requires a high level of expertise, which is not always available in the ED.
- **Chest X-ray** may not be available at the patient's bedside. Its sensitivity is questionable, and the findings may be delayed up to several hours.
- **B-type natriuretic peptide (BNP)** levels in the blood can usually be used to exclude ADHF if the levels are below 100 pg/ml and positive high values, especially 300 pg/ml and above [3-5], are indicative of ADHF and its severity. The downside is that measuring BNP levels in the blood is not ideal as a screening test because it is expensive and there is a time factor of blood draw and laboratory work.
- **Physical exam** of the internal jugular veins is done to assess whether there is high pressure in the central venous system, thus inferring the presence of heart failure. The physical examination of IJV is often difficult due to obesity.

In recent years, point-of-care ultrasound (POCUS) [6] has been added to the ED physician's toolbox. In Israel, it is a requirement for every ED to have a standard ultrasound machine. The Israeli Medical Association has made thorough knowledge of POCUS a requirement for achieving specialization in emergency medicine [7].

POCUS is a skill that is easy to learn. One prospective study of military doctors found that the number of ultrasound targets of the aorta, bladder, and pleura, as well as focused assessment with sonography in trauma (FAST) that needed to be performed by a novice physician to achieve a sensitivity of 100% was as low as 10 for the aorta, bladder, and pleura, and 20 cases for FAST [8]. POCUS has become an essential tool in the ED for assessing dyspneic patients [9-15]. Ultrasound guided peripheral and central line access have also become common in the medical arena [16].

Most of the development in endoscopic ultrasound for identifying acute heart failure has been in the area of lung B-lines [17,18] and inferior vena cava (IVC) width and respiratory variation. The IVC measurement is often difficult to obtain due to obesity, bowel gas, and patient discomfort.

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Little research has been conducted on sonographic evaluation of IJV for the assessment of ADHF. The purpose of our study is to demonstrate that an ultrasound scan of the IJV, using a simple bedside method, is a good and reliable tool for assessment of the dyspneic patient with suspected ADHF.

We examined the correlation of change in area of the IJV to BNP levels in patients presenting with dyspnea in the ED. We found a statistically significant correlation between the change in area of IJV during inspiration and expiration and the final diagnosis of ADHF.

PATIENTS AND METHODS

We conducted a prospective observational study between June 2015 and March 2016 at the Padeh Medical Center. In this analytical study the data were collected while the study was in progress.

Our study population was comprised of patients > 18 years of age who arrived at the adult ED with a main complaint of shortness of breath. The patients were recruited after they received an explanation of the study and signed an informed consent form. The patient was placed at an approximate 60º angle and a linear 9 Hz transducer was placed in the supraclavicular area. A cross-sectional area of the IJV was measured and its respiratory change was recorded. Care was taken not to apply pressure to the jugular veins. The time for visualization and measurement of the minimum and maximum of internal jugular vein area took < 5 minutes.

In all participants, a blood sample was drawn at time of recruitment to test BNP levels. All patients received standard of care.

The area, shape, and size of the IJV during inspiration and expiration were examined [Figure 1, Figure 2].

Exclusion criteria included patients who were unable to sign an informed consent and those who required urgent treatment, for example respiratory failure requiring invasive or non-invasive ventilation or ST elevation myocardial infarction.

RESULTS

A total of 59 patients (34 males, 25 females) who met all the criteria were examined in the ED according to the protocol defined in the study.

The average age was 70.7 years. The average age for male patients was 68.1 years and for females the average age was 74.3 years.

The data were evaluated using WinPepi V11.28 (Brixton Health, London, UK). Changes in the patient IJV characteristics and blood BNP levels were compared. After statistical interpretation of the data, it was shown that the specificity and sensitivity demonstrated little or no change in the IJV characteristics, which included its shape as well as size and area (0.6948 and 0.6953, respectively, $P < 0.01$).

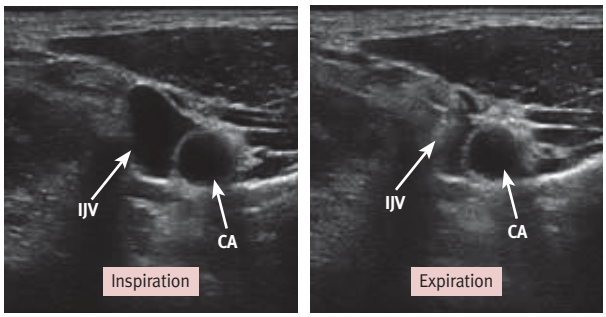
Our results demonstrated that patients with higher BNP levels experienced no significant change of IJV area, and that patients with low BNP blood levels showed a significant change of area, above 50% [Figure 3].

Of 59 patients who were examined and evaluated in the ED, 27 had BNP levels < 100 pg/ml, 7 had BNP levels in the range of 100–300 pg/ml, and 25 had BNP levels > 300 pg/ml. Of the 25 patients with BNP > 300 pg/ml, 21 had no significant change in the area and size of the IJV during inspiration and expiration. Of the 32 patients with BNP levels > 100 pg/ml, 25 had no significant change in the area and size of the IJV during inspiration and expiration. Of the 27 patients with BNP levels < 100 pg/ml, 16 had significant changes in the area and size of the IJV during inspiration and expiration.

DISCUSSION

Our results show that when a cutoff level of BNP > 100 pg/ml was used, both sensitivity and specificity of nearly 70% was achieved in identifying those who were later diagnosed with ADHF.

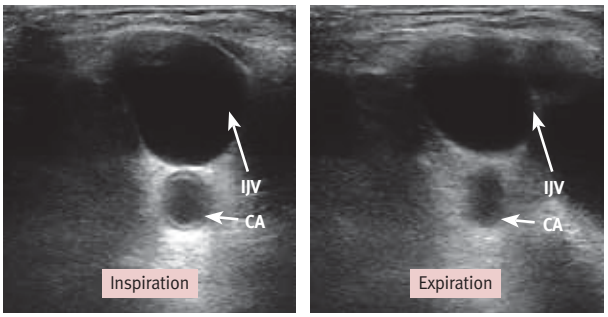
Figure 1. Complete collapse of IJV when measured in a patient with no congestive heart failure



CHF negative – total collapse

CA = carotid artery, CHF = congestive heart failure, IJV = internal jugular vein

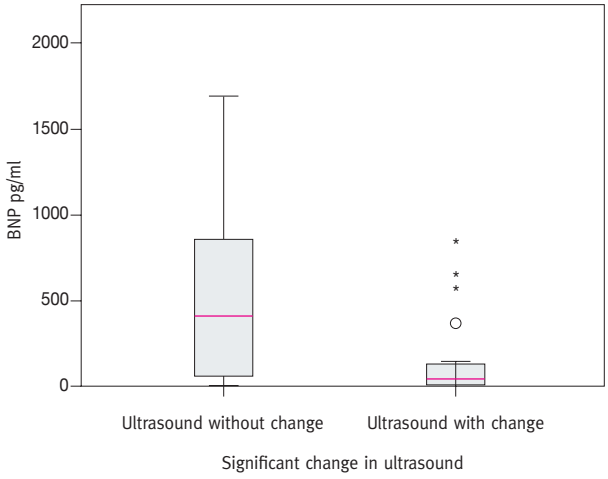
Figure 2. IJV lack of collapse when measured in a patient with congestive heart failure



CHF positive – no change

CA = carotid artery, CHF = congestive heart failure, IJV = internal jugular vein

Figure 3. Presence of a change in ultrasound compared to the BNP levels in patient blood



BNP = B-type natriuretic peptide

When using a higher cutoff of BNP > 300 pg/ml, 84% of patients had no significant change of the area of the IJV.

Performing an ultrasound of IJV is an easy skill to acquire and is not affected by patient body habitus, as opposed to its correlate ultrasound of the inferior vena cava.

Our study results are limited by the fact that the ADHF group was comprised of only those with BNP > 100 pg/ml and dyspnea. This value of 100 pg/ml could be considered a grey area. This uncertainty may explain the significant, although not so high, specificity and sensitivity.

We used a cutoff value of 50% to be a significant change, but to the best of our knowledge, there is no literature supporting this value. We extrapolated this value from literature on IVC values in which the significant range is considered to be 12–40% [19].

When a higher BNP level was used for ADHF a more impressive proportion of patients had no significant respiratory variations, indicating that if a higher level of BNP is used for defining ADHF, along with a larger sample size, more favorable results can be expected.

CONCLUSIONS

Our study shows that ultrasound of the IJV may be a useful tool for the diagnosis of ADHF.

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"The first principle is that you must not fool yourself - and you are the easiest person to fool"

Richard Feynman, (1918–1988), Nobelauriate in physics. American theoretical physicist known for his work in the path integral formulation of quantum mechanics, the theory of quantum electrodynamics, and the physics of the superfluidity of supercooled liquid helium, as well as in particle physics