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RESEARCH

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# Tissue Doppler vs. conventional parameters for diagnosis of tamponading pericardial effusion: a cross-sectional study in tertiary referral center

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**Abstract**

**Background** Conventional signs of tamponade include right ventricular and atrial collapse and respiratory variation in mitral inflow velocities. Despite being reliable, they are qualitative in nature and are not well correlated with clinical signs of deterioration or improvement. Tamponade is invariably preceded and associated with diastolic dysfunction, and tissue Doppler imaging (TDI) can help in early detection of it, earlier than conventional signs. For this purpose, 36 patients presenting with pericardial effusion have been subjected to echocardiography, including effusion dimensions, presence or absence of routine signs of tamponade and TDI-derived LV and RV E/E′ ratios, as well as clinical signs of tamponade to test the diagnostic accuracy of echocardiographic parameters against them.

**Results** Right atrial and ventricular collapse were the least accurate in the detection of tamponade, while effusion dimension > 14 mm was the most accurate among conventional parameters to point toward tamponade. RV and LV diastolic dysfunction as evidenced by E/E′ ratio showed 100% sensitivity in predicting tamponade, while LV E/E′ ratio showed the highest specificity (100%) in the same context. The higher diagnostic accuracy of LV E/E′ ratio might be also related to the presence of chronic kidney disease patients, with an already jeopardized LV function.

**Conclusions** TDI technology is now available in most of the portable echocardiography machines and can serve as part of point-of-care echocardiography in the early detection of cardiac tamponade and in decision making for pericardiocentesis. Larger studies can help in consolidating the impression driven from our small-scale cross-sectional study.

**Keywords** TDI, Cardiac tamponade, Point of care echocardiograph

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## Background

Pericardial effusion (PEff) is defined by an increase in the physiological amount of fluid within the pericardial space. Tamponade is a critical condition that occurs after sudden and/or excessive accumulation of fluid in the pericardial space that restricts appropriate filling of the cardiac chambers disturbing normal hemodynamics and ultimately causing hypotension and cardiac arrest [1].

The pericardium may be affected by all categories of diseases, including infectious, autoimmune, neoplastic, iatrogenic, traumatic, and metabolic. Hypothyroidism in patients with end-stage renal disease (ESRD) and postoperative pericardial effusion (PPE) is a common finding after cardiac surgery [2–5]. Most effusions are small, asymptomatic, and inconsequential, with reported rates of up to 84% of patients in prospective studies and significantly less in retrospective studies [3]. Echocardiography should be the initial imaging modality used once PEff is suspected [6]. M-mode and two-dimensional echocardiography is the most effective technique, and is the gold standard for the diagnosis of pericardial effusion, because it is sensitive, specific, noninvasive, and available at the bedside [7]. For circumferential pericardial effusions, any pericardial effusion with less than 5 mm of pericardial separation in diastole (corresponding to a fluid volume of 50 to 100 mL) is defined as minimal; 5 to 10 mm of separation as small (corresponding to a fluid volume of 100 to 250 mL); 10 to 20 mm of separation as moderate (corresponding to a fluid volume of 250 to 500 mL); and greater than 20 mm separation as large (corresponding to a fluid volume greater than 500 mL [8]. In most patients, cardiac tamponade should be diagnosed by a clinical examination that shows elevated systemic venous pressure, tachycardia, dyspnea, and paradoxical arterial pulse. The diagnosis is aided by echocardiographic demonstration of moderately large or large circumferential pericardial effusion and in most instances, of right atrial compression, abnormal respiratory variation in right and left ventricular dimensions, and in tricuspid and mitral valve flow velocities. Pulsus paradoxus may be absent with left ventricular dysfunction, atrial septal defect, regional tamponade, and positive pressure breathing [9].

No study, to date, has compared the conventional echocardiographic parameters of cardiac tamponade and tissue Doppler parameters. The aim of this study was to determine the diagnostic accuracy of tissue Doppler parameters namely LV E/E′ and RV E/E′ ratios in determining cardiac tamponade compared to conventional echocardiographic parameters.

## Methods

### Study design and setting

This is a cross sectional analytic study conducted on patients with pericardial effusion admitted in Cairo University Children's Hospital during the period from January 2020 to July 2020.

### Patient selection

*Inclusion criteria:* Any patient ranging from the first day of life up to 18 years, both genders, with isolated pericardial effusion without structural heart disease, mild, moderate, or severe, tamponading or not, pericardial effusion were included in our study.

*Exclusion criteria:* Pericardial effusion related to major trauma or patients with associated structural or functional heart disease.

All cases were divided according to clinical signs of tamponade (elevated systemic venous pressure, tachycardia, dyspnea, and paradoxical arterial pulse) into [1, 10]: *Group A with signs of Tamponade* and *Group B with no signs of tamponade.*

For both groups, echocardiography was used to diagnose pericardial effusion and was performed to determine the following:

*Effusion size*: defined as maximum perpendicular distance between the epicardium and pericardium during diastole, which may be [11] mild < 10 mml, moderate 10–20 mml, and severe > 20 mm.

*Presence or absence of conventional criteria for cardiac tamponade*: Systolic collapse of the right atrium (RA)—diastolic collapse of the right ventricle (RV), respiratory variation of mitral inflow velocities (more than 25%).

*The Tissue Doppler parameter are as follows:* [12].

RV E/E′: calculated as the ratio of the early diastolic velocity of the tricuspid inflow to the early diastolic tricuspid annular velocity.

LV E/E′: calculated as the ratio of the early diastolic velocity of the mitral inflow to the average of early diastolic mitral annular and basal septal velocities.

### Statistical analysis

Data were coded and entered using Excel and Medcalc. Numerical data were expressed as mean and standard deviation when normally distributed and median, minimum, and maximum when non-normally distributed; categorical data were expressed as percentages.

Comparisons of numerical data were performed using *T*-test, while categorical data were compared using the chi-square test or alternatively using Fisher's exact test if the outcome percentage was equal to zero. The sensitivity and specificity of different echocardiographic parameters against clinical signs of Tamponade were analyzed using Receiver Operating Characteristic analysis (ROC) and illustrated using a ROC curve.

## Results

This study included 36 patients with pericardial effusion, males were 53% of the study cases, and the mean age of the included population is 4 ± 1 (Table 1).

Tamponading effusion was seen in 57% of cases (Table 2).

**Table 1** Demographic data of the study subjects

| Variable | | Measurement |
|---|---|---|
| Age (mean ± SD) | | 4 ± 1 |
| Weight (mean ± SD) | | 14 ± 2 |
| Gender *n* (%) | Male | 19 (53) |
| | Female | 17 (47) |

Echocardiographic parameters (conventional and tissue Doppler) were compared in the 2 patients' groups in Table 3. Among the conventional parameters, variation of mitral inflow velocity was the only parameter to significantly differ between the two groups, it was present in 65% of patients with tamponade, compared to 19% of non-tamponading patients.

In contrast, both RV E/E′ and LV E/E′ ratios derived from tissue Doppler technique were significantly higher (denoting diastolic dysfunction) in group 1 (with tamponade) compared to group 2.

**Table 2** Etiology, signs of tamponade, and echocardiographic parameters in study subjects

| | | |
|---|---|---|
| Etiology *n* (%) | AKI/CKD | 10 (28) |
| | Autoimmune/autoinflammatory disorder | 9 (25) |
| | Acute infection | 14 (39) |
| | Chronic infection | 3 (8) |
| Clinical signs of tamponade *n* (%) | | 20 (56) |
| Effusion dimension in posterior wall in mm (mean ± SD) | | 17 ± 3 |
| Echocardiographic signs of tamponade *n* (%) | Respiratory variation of mitral inflow velocity | 20 (56) |
| | RV diastolic collapse | 18 (50) |
| | RA systolic collapse | 11 (31) |
| RV E/E′ (mean ± SD) | | 8.1 ± 1 |
| LV E/E′ (mean ± SD) | | 8.7 ± 2 |

**Table 3** Comparison of echocardiographic parameters between cases with tamponade (group 1) and cases without (group 2)

| | | Group 1 (tamponading) (*n* = 20) | Group 2 (non-tamponading) (*n* = 16) | *P* value |
|---|---|---|---|---|
| Echocardiographic signs of tamponade *n* (%) | Respiratory variation of mitral inflow velocity | 13 (65) | 3 (19) | < 0.001 |
| | RV diastolic collapse | 11 (55) | 7 (44) | 0.3 |
| | RA systolic collapse | 8 (40) | 7 (44) | 0.6 |
| LV E/E′ | | 10.6 ± 1 | 6.3 ± 0.8 | < 0.0001 |
| RV E/E′ | | 9.5 ± 1 | 6.3 ± 0.8 | < 0.0001 |
| Effusion dimensions | | 19 ± 2 | 14 ± 3.4 | < 0.0001 |

**Table 4** Receiver Operating Characteristic analysis (ROC) for determination of the sensitivity and specificity of conventional vs. tissue Doppler parameters in diagnosis of tamponading pericardial effusion

| | RVE/E′ | RV diastolic collapse | RA systolic collapse | LV E/E′ | Respiratory variation in mitral inflow velocities | Dimensions |
|---|---|---|---|---|---|---|
| Sensitivity | 100 | 55 | 40 | 100 | 65 | 100 |
| Specificity | 93.75 | 56 | 81.2 | 100 | 56 | 81 |
| Cutoff criterion for numerical parameters | > 7 | - | - | > 8 | - | > 14 mm |

The commonest etiology of effusion seen in cases was acute respiratory infection, accounting for 39% of cases. Kidney disorders and autoimmune disorders were responsible for about 28 and 25% of cases respectively (Table 2).

A receiver operating analysis was performed and detailed in Table 4 and Fig. 1, and it shows that three

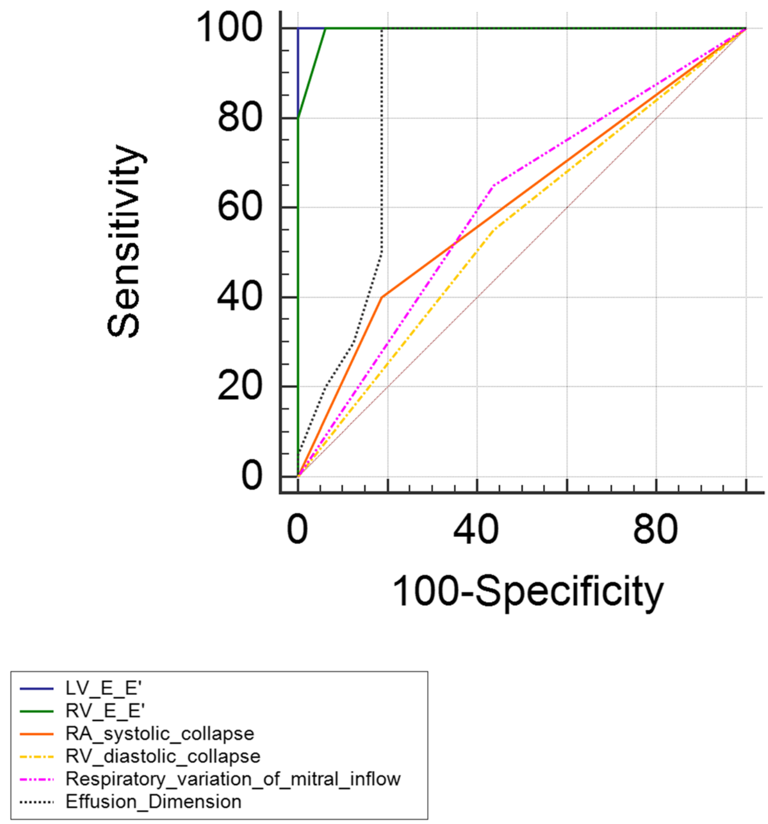


**Fig. 1** Diagnostic accuracy of different Echocardiographic parameters in the detection of cardiac tamponade. Abbreviations: RV E/E′, calculated as the ratio of the early diastolic velocity of the tricuspid inflow to the early diastolic tricuspid annular velocity; LV E/E′, calculated as the ratio of the early diastolic velocity of the mitral inflow to the average of early diastolic mitral annular and basal septal velocities

parameters, namely effusion size, RV E/E′, and LV E/E′, scored the highest sensitivities in the diagnosis of tamponade. However, LV E/E′ > 8 had the highest specificity in diagnosing effusion (100%) (Table 4 and Fig. 1).

## Discussion

Diagnosis of tamponading pericardial effusion, in proper time, is of utmost importance, to prevent any clinical deterioration.

We tried in this study to determine if relatively new echocardiographic modalities that became readily available in most of the new machines, namely tissue Doppler imaging, can prove itself superior in the detection of cardiac tamponade. For this purpose, we benchmarked conventional and tissue Doppler-derived parameters against clinical evidence of tamponade in a small cohort of patients visiting our facility for different purposes.

Diastolic dysfunction is a recognized feature of cardiac tamponade; the underlying process for the development of tamponade is a marked reduction in diastolic filling, which results when transmural distending pressures become insufficient to overcome increased intrapericardial pressures. Tachycardia is the initial cardiac response to these changes to maintain the cardiac output [13].

Awaiting, compressive features such as right atrial collapse or right ventricular collapse might not give any advantage over clinically overt tamponade, since it means that full-blown tamponade has occurred already. The only standard echocardiographic sign of tamponade that might really point to early diastolic dysfunction is the variation in mitral inflow velocities [14], and hence the statistical significant difference encountered between the two study groups in the prevalence of variable mitral flow velocities, which was noticeably higher in patients with clinical signs of tamponade.

However, variation of mitral flow inflow velocities is largely qualitative and operator dependent.

A study by Simeonidou and colleagues concluded that variation of mitral inflow velocities continued after complete drainage of pericardial effusion and failed to correlate with signs of clinical improvement [15].

Hence, the need arose for more specific and non-operator-dependent echocardiographic signs for the detection of tamponade that are predictors of early diastolic dysfunction occurring in acute pericardial effusion.

Chalikias et al. explored the diagnostic accuracy of peak systolic tricuspid annular velocity in the detection of cardiac tamponade and proved that tissue velocity is a better marker of tamponade, and offers benefit over routine echocardiographic signs [16].

Another case report by Siniorakis and colleagues showed significant respiratory variation of tricuspid annular velocities, as an earlier sign of tamponade [17].

To our knowledge, this study is the first to explore the diagnostic accuracy of RV and LV E/E′ ratios in the detection of tamponade; this research showed definite superiority over conventional signs, both of them had a sensitivity of 100%, while LV diastolic dysfunction was more specific in proving effusion compared to RV, 100% vs. 93%.

This contradicts the general concept that right ventricular filling is more likely to be affected by pericardial lesions [18] and might be also linked to the underlying diagnoses of our effusion patients, notably chronic kidney disorders. The latter might be associated with LV hypertrophy, which increases the likelihood of impaired relaxation and thus can bias our data towards a higher specificity of LV indices over RV.

Coexistence of left ventricular dysfunction with pericardial effusion might delay classic signs of effusion. Elevated left atrial pressures exceed pericardial pressure and delay the appearance of pulsus paradoxus, leading to masking of tamponade. This can add an additional explanation to the findings of our study and shows how tissue Doppler imaging can be useful in early detection of tamponade in the context of impaired myocardial functions [19].

## Conclusions

This study is the first to analyze the role of established RV and LV diastolic dysfunction markers, namely E/E′ ratio, in the detection of clinically significant effusion and comparing their accuracy to routinely approved echocardiographic signs. It clearly shows that tissue Doppler-derived indices are superior in this context. Larger longitudinal studies should be performed before confirming the possibility of bed-side use of these parameters in daily practice.

### Abbreviations

| | |
|---|---|
| CKD | Chronic kidney disease |
| ESRD | End-stage renal disease |
| LV | Left ventricle |
| LV E/E′ ratio | Calculated as the ratio of the early diastolic velocity of the mitral inflow to the average of early diastolic mitral annular and basal septal velocities |
| Peff | Pericardial effusion |
| ROC | Receiver Operating Characteristic analysis |
| RV | Right ventricle |
| RV E/E′ | Calculated as the ratio of the early diastolic velocity of the tricuspid inflow to the early diastolic tricuspid annular velocity |
| TDI | Tissue Doppler imaging |

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### Authors' contributions

AA and AET contributed to the conception of the idea. AA, AET, AB, AMH, AB, and ST contributed equally to the drafting and revision of the manuscript. All authors read and approved the final manuscript.

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### Availability of data and materials

Data cannot be shared to protect the privacy of participants.

## Declarations

### Ethics approval and consent to participate

This study received an approval from the institutional review board of Pediatrics Department, Cairo University. The study involved a chart review of anonymous patients' files with the respective diagnoses mentioned in the manuscript which was deemed not necessary for a consent to participate from patients' caregivers.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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