Value of Semiquantitative Assessment of Right Ventricular Systolic Function with A Modified Subcostal Echocardiographic View

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ABSTRACT

Background: the assessment of right ventricular function (RVF) is an important component of routine echocardiography study. Tricuspid annular plane systolic excursion (TAPSE) is easy and validated method of RVF but in many patients, this method may be difficult to apply due to inadequate apical window. So, we proposed that Subcostal Echocardiographic assessment of Tricuspid annular Kick (SEATAK) could be comparable to TAPSE.

Aims of the study: they were to assess of RVF with a new arising method SEATAK, to determine the sensitivity & specificity of SEATAK and correlation between SEATAK & TAPSE with the degree of RVF.

Patients and Methods: this study included 100 consecutive patients presented to our echocardiography lab with different clinical indications. Right ventricular function was assessed by the following parameters: RV Myocardial Performance Index (RIMP), TAPSE, Peak Systolic velocity of right ventricular basal free wall by TDI (TASV-TDI), SEATAK and Fractional Area Change (FAC) as reference method for RVF assessment.

Results: according to RVF using FAC, the patient were classified into 2groups,group with FAC ≥35% and other with FAC <35%. There was a significant statistical difference between both study groups according to TAPSE (cm), SEATAK (cm), P-Value <0.05. SEATAK was significantly correlated with TAPSE, TASV-TDI, and FAC values. SEATAK cutoff value ≥1.60 cm has the highest combined sensitivity and specificity of 86% &67% respectively for normal RVF (FAC ≥35%). Positive& negative predictive values are 72% &83%, respectively. Area under the curve equals 0.79, P-Value < 0.001.

Conclusion: SEATAK is correlated with TAPSE, TASV-TDI & FAC for evaluation of RVF with cut-off value of SEATAK for prediction of normal RVF is ≥1.60 with sensitivity and specificity of 86% &67% respectively.

Keywords: Subcostal echocardiographic assessment of tricuspid annular kick, right ventricular function, modified Subcostal Echocardiographic view

INTRODUCTION

Echocardiographic assessment of RV systolic function is valuable for a variety of cardiopulmonary conditions including acute cor-pulmonale, post cardiotomy RV dysfunction, acute left ventricular (LV) failure, and acute or chronic RV systolic dysfunction (RVSD). Recent evidence shows RVSD is a prognostic factor in critically ill patients[(1)].

The right ventricle contraction occurs primarily in the longitudinal plane and can be assessed with M-mode echocardiography with alignment of the cursor with the tricuspid annulus in an apical view, TAPSE; initially described by **Kaul *et al*.**[(2)] in 1984, it has demonstrated correlation with RV ejection fraction and has been shown to be accurate, reproducible, and easy to estimate. Moreover, TAPSE has prognostic significance in patients with pulmonary hypertension.

The most recent American Society of Echocardiography[(3)] guidelines for chamber quantification recommend measuring TAPSE as one of the parameters for assessment of RV systolic function. TAPSE <17 mm is suggestive of RVSD[)]. TAPSE evaluation in critically ill patients has gained interest[(4)]. A feasible alternative method had arisen to assess TAPSE from the subcostal view. This novel alternative method is semi quantitative and can be an alternative to TAPSE and is called SEATAK[(4)].

AIMS OF THE WORK

They are to assess RVF with a new arising method SEATAK, to determine the sensitivity & specificity of SEATAK and correlation between SEATAK & TAPSE with the degree of RVF.

PATIENTS AND METHODS

Study design:

This study was a cross-sectional observational study, which included 100 consecutive patients presented to our echocardiography lab with different clinical indications from January 2018 to September 2018.

The study was approved by the Ethics Board of Al-Azhar University and an informed written consent was taken from each participant in the study.

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Patients with poor echocardiographic window, significant arrhythmia, pericardial disease, post valve replacement or who refused to participate to the study were excluded. All patients were subjected to the following: Detailed medical history, Physical examination, Resting ECG and Conventional Echocardiography. Standard 2D TTE examination were performed with " iE33 X Matrix" ultrasound machine using "S5-1" matrix array transducers (Philips Medical Systems, Andover, USA). LV ejection fraction (LVEF) was calculated from apical four- and two chamber views, using the modified Simpson's rule. The following parameters of the Right Ventricular Systolic Function were assessed: TAPSE was measured by M-mode echocardiography with the cursor optimally aligned along the direction of the tricuspid lateral annulus in the apical 4-chamber view. RVFAC was calculated from the apical 4-chamber view using the percentage change in areas of the end-diastolic and end-systolic areas of the RV by outlining endocardial borders at end-diastole and end-systole, and RVFAC (%) is calculated by: (RV end diastolic area – RV end-systolic area) x 100/ RV end-diastolic area

RIMP was measured from the same heartbeat using DTI velocity of the lateral tricuspid annulus, RV- IMP = (IVRT + IVCT)/ ET.

SEATAK was obtained by two-dimensional examination of the subcostal four-chamber view. A counter clockwise rotation was made to create the subcostal short-axis view where these structures are identified (Right atrium and ventricle, tricuspid annulus, and inferior vena cava). Finally, the cursor was aligned in real time with the tricuspid annulus in order to obtain a linear measurement in centimeters from end-diastole to end-systole (tricuspid annular kick) with M-mode echocardiographic imaging[5].

Statistical analysis

Obtained data were recorded in Microsoft excel work sheet and analyzed using SPSS 25.0, categorical data were presented as frequencies and percentages, while continuous data were presented in mean ±SD. Chi square was used to analyze categorical data, independent t-test was used to compare continuous data in the two groups, A Pearson or Spearman correlation was calculated to show the relation between variables. ROC curve was used to perform test accuracy of SEATAK.

This study was approved by the local ethics committee.

RESULTS

This study was conducted on 100 patients. They were divided according to FAC into groups, group with FAC <35% (n=36) and with FAC ≥35% (n=64).

The demographic characteristics are shown in **table 1**.

Table (1): Age and gender in both groups

RV FAC	**< 35%**	**≥ 35%**	**P**
Age (Year), Mean±SD	51.1±12.7	48.0 ±11.7	>0.05
Male (N, %)	30 (83%)	45 (70%)	0.23

There was no statistically significant difference between both groups regarding their age and sex.

- **ECHO criteria:**

As shown in table 2, There were significant statistical difference between both groups according to TAPSE (cm), SEATAK (cm), LVEF%, FAC% (P-Value < 0.05). There was no statistical difference between both groups regarding to mean TAPSE-SEATAK difference (P value>0.05).

Table 2: ECHO criteria in both groups

RV FAC	**< 35**		**≥ 35**		**P-value**
	Mean	SD	Mean	SD	
LVEF (%)	40.1	13.0	55.0	13.1	< **0.001**
TAPSE (cm)	1.91	0.46	2.19	0.41	**0.001**
SEATAK (cm)	1.73	0.52	2.07	0.47	**0.001**
TAPSE-SEATAK	0.2	0.4	0.1	0.3	0.12
TASV-TDI (cm/sec)	11.8	3.0	12.8	3.3	0.18
RIMP	0.6	0.2	0.6	0.2	0.7

Correlation between SEATAK and other ECHO findings

As shown in table 3. There was significant positive correlation between SEATAK, TAPSE, FAC%, TASV-TDI and LVEF (P value <0.05). In figure 6, there is no correlation between SEATAK and RIMP.

Table 3: Correlation between SEATAK and other ECHO findings

vs. SEATAK	**r**	**P-value**
TAPSE	0.823	**<0.0001**
FAC	0. 436	**<0.0001**
TASV-TDI	0.451	**<0.0001**
RIMP	-0.169	0.09
LVEF	0.268	**0.007**

Scattered plot (figure 1) represents the significant strong positive correlation between SEATAK and TAPSI. Correlation Coefficient: 0.82 and p-value P<0.0001.

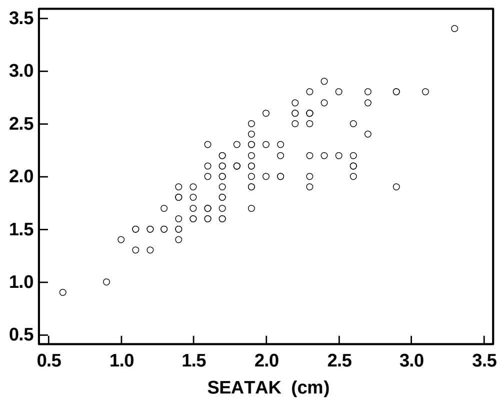

Figure (1): Correlation of SEATAK to TAPSE

Bland-Altman plot below (figure 2) shows mean difference between TAPSE & SEATAK of 0.15cm with upper & lower limits of agreement 0.74 & -0.43 cm respectively.

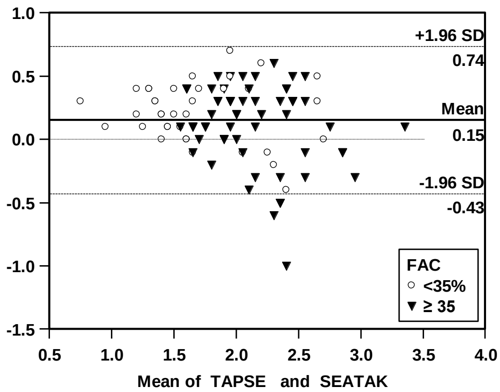

Figure 2: Bland-Altman plot comparing SEATAK to TAPSE

Scattered plot (figure 3) represents the significant strong positive correlation between SEATAK and RV FAC. Correlation Coefficient: 0.44 and P-value <0.0001.

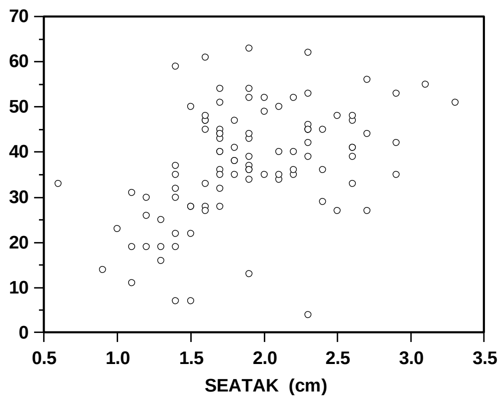

Figure 3: Correlation of SEATAK to FAC

Scattered plot (figure 4) represents the significant weak positive correlation between SEATAK and LVEF. Correlation Coefficient: 0.27 and P-value < 0.007. This significant but weak correlation is obvious in the group with RV dysfunction while non-significant in the other group.

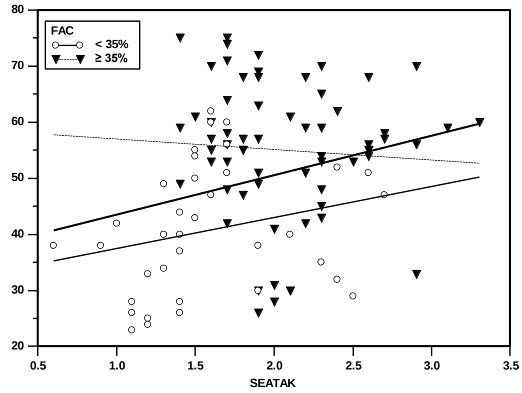

Figure 4: Correlation of SEATAK to LV EF

Scattered plot (figure5) represents the significant weak positive correlation between SEATAK and TASV-TDI. Correlation Coefficient: 0.36 and P-value < 0.001.

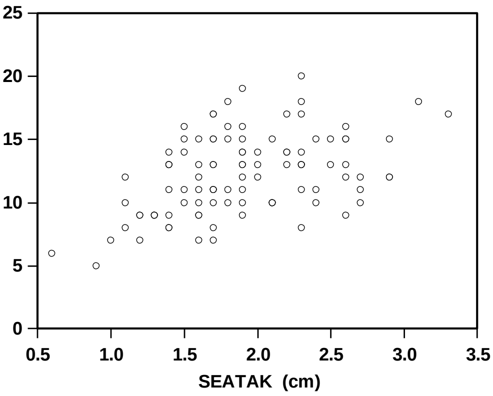

Figure 5: Correlation of SEATAK to TASV-TDI

Scattered plot (figure 6) represents the absent correlation between SEATAK and RIMP. Correlation Coefficient: -0.17 and P-value 0.09.

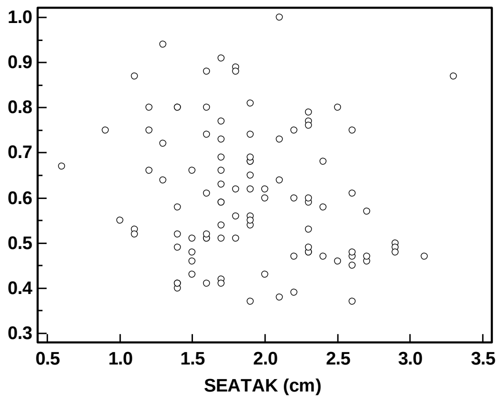

Figure 6: Correlation of SEATAK to RIMP

Test accuracy of SEATAK

Test accuracy of SEATAK for evaluation of RVF is represented in ROC curve, **Figure 7.**

SEATAK cutoff value ≥ 1.60 cm has the highest combined sensitivity and specificity of 86% &67% respectively for normal RVF (FAC ≥35%). Positive & negative predictive values are 72%& 83% respectively. Area under the curve equals 0.79, P-Value < 0.001.

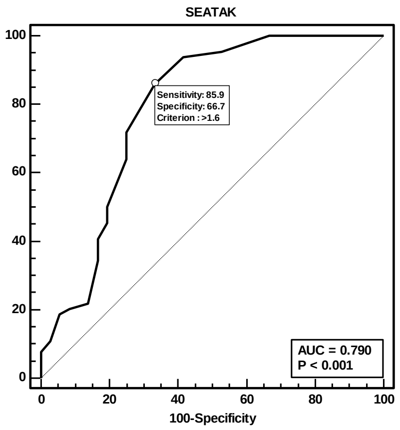

Figure 7: ROC curve for SEATAK test accuracy

DISCUSSION

Assessment of RV systolic function is an important part of patient care in cardiology practice. Cardiac magnetic resonance imaging (CMR) has been established as the gold standard for RV systolic function evaluation[5]. However, transthoracic echocardiography (TTE) is the most frequently used technique for routine examination of RVF. Nevertheless, echocardiographic assessment of RVF is not without challenges ***First***, RV geometry is complex; hence unlike the left ventricle (LV), assessment such as ejection fraction cannot be based on assumption of a symmetrical conical shape [6]. ***Second***, over the years many echocardiographic RV function indices have been used as surrogates of RV function. Some of these indices measure the longitudinal (regional) function of the RV (e.g. tricuspid annular plane systolic excursion or TAPSE) while others measure the global function (e.g. fractional area change or FAC). ***Third***, the quality of images and technical limitations may preclude operators from obtaining certain RV function indices in some clinical sittings such as obese or COPD patients. Recently, **Diaz-Gomez *et al*.**[7] from Mayo Clinic proposed the use of SEATAK as an alternative to TAPSE in evaluation of RVF. They evaluated 45 critically ill patients with different degrees of RV dysfunction.

In our study, we were curious to find out how SEATAK correlates with other echocardiographic indices of RVF in real-world echocardiography practice. To the best of our knowledge, this is the first study too simultaneously assess multiple echocardiographic indices of RVF including SEATAK. FAC, one of the reference standards often used for comparing RV function, has been shown to correlate well with CMR-derived RV ejection fraction. It has been shown in many studies that it has a strong association with patient outcomes [8]. In our study, RVF was considered normal or dysfunctional according to FAC. Hence, included patients were categorized into only 2 groups. The 2 groups were homogenous as there was no statistically significant difference between them as regard age and sex.

This study demonstrated that SEATAK strongly correlated with TAPSE. This is similar to **Diaz-Gomez *et al*.**[7] study in which there was a strong correlation (r = 0.86, P value =0.03) between TAPSE and SEATAK values in different degrees of RVF. In addition, the overall mean TAPSE-SEATAK difference in our study was small (0.15 cm) and the confidence intervals included **0**, meaning the difference was maintained throughout the different values of TAPSE and SEATAK. This difference nearly matched that in the aforementioned study (−0.26 cm). However, SEATAK values were generally higher than TAPSE values in that study as denoted by the negative mean difference. The mean TAPSE-SEATAK difference was not affected by the degree of RVF as evidenced by lack of statistically significant difference between our study groups. This study demonstrated that there was significant moderate & positive correlation between SEATAK and each of FAC& TASV-TDI. Meanwhile, no correlation was found between SEATAK & RIMP.

Our study is the first to show that SEATAK cut-off value of ≥1.60 cm predicts normal RVF (FAC ≥35%) with sensitivity of 86% and specificity of 67%.

This study showed moderate positive correlation between FAC & TAPSI (r= 0.42, P<0.0001). This in agreement with the research done by **Brown *et al*.**[9] who studied the right and left heart failure in severe H1N1 influenza A infection using multiple echo parameters for right &left side and found that TAPSE and RVFAC, the two main measures of RV systolic function, demonstrated a similarly high rate of RV dysfunction.

Surprisingly, this was in disagreement to the findings of **Lamia *et al.*** [4] who prospectively studied the relationship between the TAPSE and RV & LV function in 86 critically ill patients admitted to medical intensive care unit for acute respiratory failure, circulatory failure, or coma. They found that TAPSE was more strongly related to LV ejection fraction than to indices of RV function in critically ill patients.

In our study, the correlation between SEATAK & LVEF was significant & positive but weak. This is concordant to the findings of **Tamborini *et al.*** [10] who evaluated the feasibility of a routine use of FAC, TAPSE and TASV-TDI in 900 patients of whom 150 were normal subjects and 750 with different pathologies. They found a significant and independent positive correlation was found between the RV parameters and LVEF.

Although the essence of SEATAK, TAPSE & TASV-TDI is evaluation of longitudinal RV function, this study showed that the correlation of

TASV-TDI with the first two parameters was only moderate. Concordant findings were suggested by the research done by **Fichet *et al.*** [(11)] who prospectively studied 48 patients with ARDS on mechanical ventilation. They used TTE to assess feasibility of RV longitudinal systolic function Evaluation with TAPSE & TASV-DTI in comparison to usual 2D indices RVFAC& RVEDA/LVED Aratio. They concluded that the relation between both longitudinal indices was modest ($r^2 = 0.36$, $P < 0.001$)& that TAPSE but not TASV-TDI was found poorly related to RVFAC. They suggested that both indices may not bring identical information to echo study and that TAPSE may be more adapted to ICU use than TASV-TDI.

This study shows no statistical correlation of RIMP with SEATAK, TAPSI or FAC. In addition, no statistically significant difference in RIMP between both FAC groups. This was partially in disagreement with the research done by **William & El-Kilany**[(12)] who assessed of RVF by echocardiography in 100 patients with chronic left sided heart failure (LVEF <40%). In their study, RV systolic dysfunction (defined as presence of these three parameters together FAC <35%, TAPSE <16 mm and TASV-TDI < 10 cm/s) was found in 36% of patients& RIMP was significantly higher values in these patients. However, it is noteworthy that the RIMP value in all patients was 0.63 ± 0.14 and it was found to be abnormal (>0.55) in 67% of patients.

These findings was also supported by the study of **Hyllen *et al.*** [(11)]**,** who assessed RV performance after valve repair for chronic degenerative mitral regurgitation in 40 patients. They showed that longitudinal indices (TAPSE & TASV-TDI) had decreased significantly following surgery with no statistically significant change in global indices (FAC & RIMP). However, mean values of RIMP showed improvement post-surgery.

This discordance between RIMP & other indices of systolic function may be explained by the confounding factor of change in diastolic function integrated in the assessment by RIMP while lacking assessment by other indices.

CONCLUSION

SEATAK is correlated with TAPSE, TASV-TDI & FAC for evaluation of RVF with cut-off value of SEATAK for prediction of normal RVF is ≥1.60 with sensitivity and specificity of 86% & 67% respectively.

Limitations: RV systolic function was judged using another echocardiographic index and the FAC as an alternative to the gold standard CMR. In addition, reproducibility of SEATAK acquisition and measurement was not assessed.

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