RIGHT VENTRICULAR STRAIN BY SPECKLE TRACKING ECHOCARDIOGRAPHY IN PATIENTS WITH END-STAGE CHRONIC KIDNEY DISEASE UNDERGOING RENAL TRANSPLANTATION

Pham Vu Thu Ha*, Tran Duc Hung*, Nguyen Thi Thu Ha*

ABSTRACT

Objective: To evaluate right ventricular strain by speckle tracking echocardiography in patients with end-stage chronic kidney disease before and 1 month after kidney transplantation. **Subjects and methods:** The study included 63 patients diagnosed with end-stage chronic kidney disease. All patients received kidney transplantation at Military Hospital 103 from October 2023 to April 2025. They were followed up for 1 month after kidney transplantation. Right ventricular strain was evaluated before and 1 month after successful kidney transplantation. All informed consents were obtained from participants, and the research was approved by the Ethics Council of Military Hospital 103, Military Medical Academy. **Results:** RV4CLS (-17.56 ± 4.82 vs -21.14 ± 3.90, p < 0.01) and RVFWLS (-20.59 ± 6.10 vs -24.81 ± 4.58, p< 0,01) 1 month after kidney transplantation improved significantly compared with pre-transplantation. The rate of right ventricular dysfunction group decreased significantly 1 month after transplantation (40.5 vs 13.5 %, p < 0.01). RV4CSL and RVFWSL after transplantation in the pre-transplant pre-emptive treatment group were statistically higher than in the hemodialysis group. RV4CSL had a moderate positive correlation with the time of dialysis before kidney transplantation. RV4CSL had a moderate positive correlation with hemoglobin level before kidney transplantation. **Conclusion:** RV4CSL and RVFWSL 1 month after kidney transplantation improved significantly compared with pre-transplantation. The rate of the right ventricular dysfunction group also decreased significantly. RV strain was also associated moderately with the type of pretransplant renal replacement therapy, the duration of dialysis, and the hemoglobin level.

Keywords: *right ventricular strain, kidney transplantation, speckle tracking echocardiography.*

I. INTRODUCTION

End-stage renal disease (ESRD) is a global health burden, in which cardiovascular complications are the most common cause of death. Factors such as hypertension, anemia, volume overload, metabolic disorders, valvular heart disease, coronary artery disease, diastolic dysfunction, and finally systolic dysfunction [1]. In particular, the right ventricular function plays an important role in the treatment and prognosis of patients. Assessment of right ventricular function by classic echocardiography such as TAPSE, RVFAC on 2D echo, or S' on the tissue Doppler, has many limitations due to dependence on measurement angle and only partially reflects right ventricular movement. Recently, speckle-tracking echocardiography has helped assess right ventricular strain (RV strain) with high sensitivity to detect early dysfunction. Many studies have shown that RV strain has independent prognostic value for cardiovascular events in patients with chronic kidney disease. Nowadays, kidney transplantation is the optimal treatment for ESRD. Many studies have shown that right ventricular function and RV strain tend to improve after kidney transplantation. Therefore, assessing RV strain before and

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after kidney transplantation is important in monitoring, predicting prognosis and managing cardiovascular risk in this group of patients. Therefore, we conducted this study with the aim of examining the changes in right ventricular strain by speckel tracking echocardiography in patients with end-staged renal disease before and after kidney transplantation.

II. OBJECTIVES AND METHODS

2.1. Study population: Including 63 patients diagnosed with end-stage chronic kidney disease and kidney transplantation at Military Hospital 103 from October 2023 to April 2025, followed up 1 month after kidney transplantation.

* *Inclusion criteria:* Patients diagnosed with end-stage chronic kidney disease according to the guidelines of the International Society of Nephrology KDIGO 2024.

* *Exclusion criteria:* Pericardial disease, atrial fibrillation, acute coronary syndrome, primary pulmonary hypertension, valvular heart disease (moderate or more stenosis or regurgitation), pulmonary embolism, congenital heart disease, chronic obstructive pulmonary disease, chronic cor pulmonale; patients who do not cooperate or do not agree to participate in the study.

2.2 Methods

2.2.1. Study design: prospective, longitudinal follow-up

2.2.2. Equipment: All echocardiographic studies were performed by EPIC 7G (Philips Medical system, USA) using an S5-1 transducer.

2.2.3. Echocardiography

- The study subjects were clinically examined and performed 3D echocardiography immediately before and 1 month after kidney transplantation.

- The time for ultrasound before kidney transplantation was between 2 dialysis sessions for patients on hemodialysis or peritoneal dialysis.

+ We measured the left ventricular (LV) size, LVEF, and also left atrial volume (LAVi) and indexed them based on Body Surface Area (BSA) according to ASE 2015 [2]

+ We evaluated the RV function by TAPSE, FAC, S' velocity, all according to Rudski et al. as explain here: M-mode was employed to assess the TAPSE. The *tricuspid annular systolic velocity* (s′) was measured in the apical 4-chamber view through tissue Doppler imaging. The *RV Fractional Area Change* was calculated by this formula: RVFAC = (RV diastolic area– RV systolic area)/RV diastolic area × 100%. The RV diastolic and systolic areas were acquired from the apical 4-chamber view [3]

+ The RV strain analysis was done on an offline basis. Generally, we traced a region of interest by point-and-click approach on the endocardium at end-diastole in RV from the RV-focused view. The right ventricle was partitioned into 6 standard segments at 3 levels (i.e., the basal, middle, and apical levels), correspondingly generating 6 time-strain curves. RV free wall longitudinal peak systolic strain (RVFWLS) was evaluated in the basal, midventricular, and apical segments of the RV free wall and calculated as the average of the 3 segments. RV global longitudinal peak systolic strain (RV4CSL) is calculated automatically by the machine. Longitudinal peak systolic strain is determined as the percentage of myocardial shortening relative to the original length and is conventionally presented as a negative value. Therefore, the more negative the value of RV strain, the more preserved is the shortening. Abnormal threshold of RV4CSL and RVFWSL is > - 20% [4].

2.2.5. Statistical analysis

Data were processed using medical statistics methods on SPSS 25.0 (IBM SPSS

Statistics, Chicago, IL, USA). Continuous demographic and clinical data were demonstrated as mean and SD, and classified data were demonstrated as frequency and percentage. Chi-square test or Fisher's exact test was used to investigate the independency of the two categorical variables. To check the normality of the data, the Kolmogorov-Smirnov test was performed. Compare independent quantitative variables using t - test (if the variable is normally distributed) or Mann - Whitney test (if the variable is not normally distributed). Compare before and after using paired T test. The significance level in all tests was considered 0.05.

2.2.6 Research ethics: Patients voluntarily participate in the research. The research process does not affect the treatment results and health of the patients. The research has been approved by the Ethics Council of Military Hospital 103, Military Medical Academy.

III. RESULTS

Table 3.1. ***Basic and demographic data of the subjects (n=63)***

<table>
<tr><th colspan="2">Variables</th><th>n = 63</th><th>Rate (%)</th><th>p</th></tr>
<tr><td rowspan="4">Age</td><td>< 40</td><td>34</td><td>53.97</td><td rowspan="3">< 0.05</td></tr>
<tr><td>40 – 60</td><td>27</td><td>42.86</td></tr>
<tr><td>> 60</td><td>2</td><td>3.17</td></tr>
<tr><td>$\bar{X}$ ± SD</td><td colspan="2">39.30 ± 11.81</td><td></td></tr>
<tr><td rowspan="2">Gender</td><td>Male</td><td>42</td><td>66.67</td><td rowspan="2">< 0.05</td></tr>
<tr><td>Female</td><td>21</td><td>33.33</td></tr>
<tr><td rowspan="2">Pre-transplant treatment</td><td>Conservation internal medicine</td><td>12</td><td>19</td><td rowspan="2">< 0.01</td></tr>
<tr><td>Hemodialysis</td><td>51</td><td>81</td></tr>
<tr><td rowspan="2">Duration of dialysis</td><td><= 12 months</td><td>19</td><td>37.25</td><td rowspan="2">< 0.01</td></tr>
<tr><td>> 12 months</td><td>32</td><td>62.75</td></tr>
</table>

This study was performed on 63 kidney transplant recipients including 42 men (66.67%) and 21 women (33.33%), with a mean age of 39.30 ± 11.81 years. In terms of treatment type, 12 patients (19%) were categorized in pre-emptive kidney transplantation, and 51 patients (81%) were treated with hemodialysis. The duration of periodic hemodialysis over 12 months accounts for the majority (62.75%)

Table 3.2. ***Summary of echocardiographic findings before and after kidney transplantation (n=63)***

Variables	Before the transplant	1 month after the transplant	p
Dd (mm)	48.76 ± 7.72	42.16 ± 4.89	< 0.01
Ds (mm)	32.02 ± 6.48	26.37 ± 5.22	< 0.01
LVEF (%)	63.17 ± 9.10	66.38 ± 7.15	< 0.01
PAPs (mmHg)	24.92 ± 6.06	22.63 ± 3.98	< 0.01
LAVi (ml/m^2)	29.09 ± 13.12	21.35 ± 7.90	< 0.01
RVD1 (mm)	27.30 ± 4.64	25.44 ± 5.43	> 0.05
RVD2 (mm)	25.99 ± 5.23	24.28 ± 4.65	> 0.05
RVD3 (mm)	48.92 ± 9.13	47.95 ± 9.53	> 0.05
RVWT (mm)	6.12 ± 1.09	5.57 ± 1.41	> 0.05
FAC (%)	49.11 ± 8.28	48.04 ± 6.51	> 0.05
TAPSE (mm)	20.04 ± 4.85	19.73 ± 2.99	> 0.05
s' (cm/s)	11.99 ± 2.17	11.96 ± 2.66	> 0.05

The left ventricular morphology (Dd, Ds) and function (EF) and systolic pulmonary artery pressures (PAPs) as well as LAVi after transplantation were significantly improved compared with those before transplantation. There was no significant difference in the right ventricular morphology (RVD1, RVD2, RVD3, RWT) and function (FAC, TAPSE, s') before and after kidney transplantation.

Table 3.3. ***Changes in the right ventricular strain before and after kidney transplantation (n=63)***

Variables	**Before the transplant (n = 63)** $\bar{X} \pm SD$	**1 month after the transplant (n = 63)** $\bar{X} \pm SD$	**Mean difference (Δ = 1month – baseline)**	**95% CI Δ**	**p**
RV4CSL (%)	-17.56 ± 4.82	-21.14 ± 3.90	- 4.2 ± 4.9	- 2.47 ; - 5.95	< 0.01
RVFWSL (%)	-20.59 ± 6.10	-24.81 ± 4.58	- 3.57 ± 3.62	-2.3; -4.8	< 0.01
RVFWSL <-20% n (%)	40.5	13.5	-	-	< 0.01

RV4CSL and RVFWSL 1 month after kidney transplantation improved significantly compared with pre-transplantation. The rate of right ventricular dysfunction group decreased significantly 1 month after transplantation.

Table 3.4. ***Relationship between post-transplant right ventricular strain and pre-transplant treatment (n=63)***

Variables ($\bar{X} \pm SD$)	**Hemodialysis (n = 51)**	**Conservation internal medicine (n = 12)**	**p**
RV4CSL (%)	-18.41± 4.31	-20.82 ± 3.45	< 0.01
RVFWSL (%)	-21.11 ± 3.82	-24.01 ± 4.03	< 0.01

RV4CSL and RVFWSL after transplantation in the conservation internal medicine group was statistically higher than in the hemodialysis group.

Table 3.5. ***Correlation between right ventricular strain after kidney transplantation and pre-transplant dialysis time (n=63)***

Variables (n = 51)	**r**	**p**
RV4CSL (%)	0.38	< 0.05
RVFWSL (%)	0.12	> 0.05

RV4CSL has a moderate positive correlation with the time of dialysis before kidney transplantation.

Table 3.6. ***Correlation between right ventricular strain after kidney transplantation and hemoglobin level (n=63)***

Variables (n = 51)	**r**	**p**
RV4CSL (%)	0.36	< 0.05
RVFWSL (%)	0.23	> 0.05

RV4CSL has a moderate positive correlation with hemoglobin level before kidney transplantation.

IV. DISCUSSION

Our study was performed on 63 kidney transplant patients including 42 men (66.67%) and 21 women (33.33%), with a mean age of 39.30 ± 11.81 years. In terms of types of dialysis, 12 patients (19%) were categorized in pre-emptive treatment, 51 patients (81%) were treated with hemodialysis. The duration of periodic hemodialysis over 12 months accounts for the majority (62.75%). Echocardiographic findings are presented in Table 3.2. The left ventricular morphology and function and PAPs after transplantation were significantly improved compared with those before transplantation. There was no significant difference in the right ventricular morphology. The right ventricular function assessed by 2D echocardiography and TDI (FAC, TAPSE, s') before and after kidney transplantation did not change. However, the results showed that there was a significant improvement in RV4CLS (-17.56 ± 4.82 vs -21.14 ± 3.90, $p < 0.01$) and RVFWLS (-20.59 ± 6.10 vs -24.81 ± 4.58, $p < 0,01$) from baseline to 1 month following the kidney transplant. After kidney transplantation, patients often have reduced volume overload, better blood pressure control, improved anemia, and reduced pulmonary hypertension—factors that contribute to right ventricular dysfunction in patients with end-stage renal disease. So the rate of the right ventricular dysfunction group decreased significantly 1 month after transplantation. This research result is similar to Khani [5]. The results of the study on the shape of RV4CLS and RVFWLS changes, using the fractional polynomial models, showed that the form of the relationship was linear and they improved significantly over time ($p = 0.024$, $p < 0.001$, respectively) [5]. RV strain was independently associated with major adverse cardiovascular events, mostly occurring after the first year following the kidney transplantation [6]. RV dilation and dysfunction are associated with adverse outcomes after renal transplant. Echocardiography, especially STE assessment of RV function, should be a standard part of the pre-kidney transplant cardiovascular risk assessment [7].

The results of RV4CLS and RVFWLS demonstrated that there was a significantly different between the dialyzed and the pre-emptive patients before the transplant ($p < 0.01$). Patients who receive a pre-emptive transplant avoid exposure to dialysis-associated insults altogether—fluid overload, vascular access complications, and uremic toxin build-up. Thus, these patients might show greater or faster improvement in RV strain after transplant, or might even preserve RV strain closer to "normal" pre-transplant, compared to those with long hemodialysis. Khani also found significant improvement in RV strain at 1 and 3 months post-transplant [5].

In the hemodialysis group, dialysis vintage is an important factor reflecting cardiovascular risk, including prolonged fluid overload, repeated hemodynamic changes, uremic toxin exposure, and the presence of AV fistula. Several studies have reported that long dialysis vintage is associated with poor outcomes after kidney transplantation and may be a factor influencing the recovery of right ventricular function after transplantation. We found that RVFWLS had a close positive correlation with dialysis time ($r = 0.38$, $p < 0,05$). But no correlation was found between RV4CLS and pre-transplant dialysis time. According to Haller, longer waiting time on dialysis was not associated with a higher rate of graft loss, but the rate of death was higher in patients on pretransplant dialysis for >1.5 years (hazard ratio, 1.62; 95% confidence interval, 1.43 to 1.83) compared with pretransplant dialysis for <1.5 years [8]. However, Joseph found that the duration of dialysis was not significantly associated with RV dysfunction or RV dilation ($p = 0.76$ and $p = 0.79$, respectively) [7]. However, the degree of improvement may vary among patients, depending on previous dialysis duration, recovery of renal function after transplantation, and associated cardiovascular disease.

Chronic anemia leads to an increase the cardiac output, left ventricular hypertrophy, increased pulmonary arterial pressure, and right ventricular dysfunction. However, anemia improves after kidney transplantation, when kidney function recovers. Post-transplant hemoglobin concentration was correlated positively with RV4CSL ($p < 0.05$). This result was different from the study of Khani et al. In that study, post-transplant right ventricular strain was correlated with hemoglobin level but was not statistically significant ($p = 0.35$) [5].

In conclusion, RV strain is a valuable index in assessing early right ventricular dysfunction and reflects hemodynamic improvement after kidney transplantation. This suggests the role of RV strain as a prognostic tool and long-term follow-up in kidney transplant patients.

V. CONCLUSION

RV myocardial dysfunction in ESDR patients maybe not to detect by conventional methods but can be detected by the newer methods such as speckle tracking echocardiography. RV4CSL and RVFWSL 1 month after kidney transplantation improved significantly compared with pre-transplantation. The rate of the right ventricular dysfunction group also decreased significantly. RV strain is also associated with pre-transplant treatment before kidney transplantation and the duration of heamodialysis.

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