PULMONARY VENOUS FLOW PATTERNS IN CHILDREN WITH CHRONIC RENAL FAILURE

Kronik böbrek yetmezlikli çocuklarda pulmoner venöz akım paternleri

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Abstract

Purpose : *It is aimed to investigate the relationship between the function of right atrium, tricuspid flow velocity, and pulmonary venous flow patterns in cases with chronic renal failure.*

Material and methods: *Pulmonary venous flow patterns and right atrial function and tricuspid valve flow patterns were studied in nine patients on maintenance hemodialysis (HD), in 11 chronic renal failure (CRF) patients and in 14 healthy subjects with Doppler and two- dimensional echocardiography.*

Results : *For right atrial parameters; right atrial systolic diameter (RA sd) and right atrial diastolic diameter (RA dd) in HD patients were significantly increased when compared with both CRF patients and controls. Right atrial diastolic area (RA da) and right atrial systolic areas (RA sa) in HD patients were markedly higher than than of control subjects. In CRF patients, there was a positive correlation between peak forward velocity time integral during ventricular systole (PVs VTI) and tricuspid decelaration time(tr dt) and an inverse correlation between PVs VTI and mean pressure. In CRF patients, a significant positive correlation was observed between peak forward velocity during ventricular diastole (PVd) and right atrial ejection fraction (RA EF), right atrial fractional shortening (RA FS), peak reserve flow velocity during atrial contraction(PVa) and peak forward velocity during ventricular systole. There was a positive correlation between PVa and PVs in CRF patients. In HD patients, a significant positive correlation was observed between PVs and PVd. There was a positive correlation with PVd VTI and mean pressure in HD patients.*

Conclusion : *These results indicate that pulmonary venous flow patterns are related to tricuspid valve flow patterns and right atrial functions in HD and CRF patients. In HD patients, the right atrial functions were markedly higher than that of CRF patients.*

Key Words: *Blood flow velocity, Chronic renal failure, Heart atrium, Hemodialysis, Pulmonary veins, Tricuspid valve*

Özet

Amaç : *Bu çalışma KBY'de pulmoner venoz akım paternleri ile sağ atrium fonksiyonu ve triküspid akım velositesi arasındaki ilişkileri tesbit etmek için yapıldı.*

Materyal metod: *Bu çalışmada, dokuz hemodiyaliz (HD) hastası, 11 kronik böbrek yetersizlikli (KBY) hasta ve 14 sağlıklı çocukta pulmoner venöz akım paterni, sağ atrial fonksiyon ve triküspit kapak akım paterni iki boyutlu ekokardiyografi ve doppler ekokardiyografi ile ölçüldü.*

Bulgular : *HD hastalarında sağ atrial parametreler olan sağ atrium sistolik (RA sd) ve diastolik çapı (RA dd) hem KBY hem de kontrol grubuna göre, sağ atrium sistol (RA sa) ve diastol alanı (RA da) kontrol grubuna göre anlamlı derecede artmıştı. KBY'li hastalarda, sistolde peak akımın velosite time integrali (PVs VTI) ile triküspit kapak deselerasyon zamanı (tr dt) arasında istatistiksel olarak anlamlı pozitif ilişki ve ortalama basınç (mean) arasında istatistiksel olarak anlamlı negatif ilişki vardı. Diastolde peak akım velositesi (PVd) ile sağ atrial ejeksiyon fraksiyonu (RA EF), RA FS, atrial kasılma sırasındaki peak forward akım velositesi (PVa) ve sistolde peak akım velositesi arasında istatistiksel olarak anlamlı pozitif ilişki vardı. Ayrıca PVa ile PVs arasında istatistiksel olarak anlamlı pozitif ilişki vardı. HD hastalarında, PVs ile PVd arasında anlamlı pozitif bir ilişki gözlendi. PVd VTI ile sağ atrial ortalama basıncı arasında istatistiksel olarak anlamlı bir pozitif ilişki vardı.*

Sonuç : *Bu sonuçlar HD ve KBY'li hastalarda pulmoner venöz akım paterninin triküspit kapak akım paterni ve sağ atrium fonksiyonları ile ilişkili olduğunu ve HD hastalarında sağ atrium fonksiyonlarının KBY'li hastalardan belirgin derecede yüksek olduğunu göstermektedir.*

Anahtar Kelimeler: *Hemodiyaliz, Kan akım velositesi, Pulmoner ven, Triküspit kapağı*

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Congestive heart disease is a common complication in chronic renal failure. The cardiac performance in uremia is clinically characterized by and inadequate left ventricular hypertrophy and reduced diastolic compliance(1,2). Right atrial and right ventricular function can be affected in end-stage renal disease. Many factors such as anemia, chronic volume overload, arterial hypertension, arterio-venous shunting of blood, episodic extracorporal circulation, and increased cardiac work load which are chronically disturbed in renal failure may contribute to the complex cardiac findings(1,2).

Tricuspid flow velocity obtained from pulsed doppler echocardiography is increasingly being used for the indirect evaluation of right ventricular diastolic function. The pulmonary veins conduct blood from the lungs to left atrium. Pulmonary venous flow is pulsative and has been related to the left atrial pressure, mitral valve function and left atrial compliance(3-6). It is not common finding that pulmonary venous flow velocities reflect the functions of right ventricle and right atrium. They have not been used to determine the right ventricular function.

The aim of this study is to determine the relative importance of several proposed factors that could influence pulmonary venous flow velocity in chronic renal failure. It is aimed to investigate the relationships between the function of right atrium, tricuspid flow velocity, and pulmonary venous flow petterns in cases with chronic renal failure(chronic uremic and hemodialysis patients).

PATIENTS AND METHODS

Nine children composed of four male and five female from six to 14 years old (m:12.8) on maintenance dialysis (HD patients) and 11 children composed of six male and five female from five to 16 years old (m: 12.0) with chronic renal failure (CRF patiens) were studied. Control group consists of 14 healthy children ages ranged from six to 15 years old (m: 11.2) six male eight female with functional murmur.

A complete two-dimensional and doppler echocardiographic examination was performed. A Toshiba non-imaging Doppler with a 3 MHz transducer for continuous and pulsed wave Doppler echocardiography was used for the examinations. The length of sample volume was 5 mm. Children were studied resting calmly in supine position. No premedication was used.

Using an apical transducer position, two-dimensional images of the right ventricle and atrium were obtained at a frame rate of either 45 or 55 frames / sec in orthogonal apical two or four chamber views. Tricuspid flow velocity was obtained with pulsed wave technique from an apical transducer position by placing an 3 mm sample volume between the tips of the tricuspid leafleds. Pulmonary vein flow velocity was obtained from an apical or modified apical transducer position using a 5 mm sample volume placed 1 to 2 cm proximal to the right atrium in the right superior pulmonary vein. For the measurement of the right ventricle isovolimetric relaxation time (IVRT), pulmonary and tricuspid flow velocities were recorded together from an apical transducer position using continuous Doppler techniques and a paper speed of 100 mm/sec(7,8).

Echocardiographic data: Right atrial and right ventricle dimension were measured according to the recommendations of the American Society of Echocardiography. Diastolic and systolic right atrial areas and dimensions were identified from the four chamber views. Atrial ejection fraction (EF) for both views were calculated as;

$$EF: \frac{\textit{right atrial volüme (diastolic)} - \textit{right atrial volume (systolic)}}{\textit{right arial volüme (diastolic)}}$$

and were also averaged. Atrial fractional shortening were calculated as;

$$FS: \frac{\textit{right atrial dimension (diastolic)} - \textit{right atrial dimension (systolic)}}{\textit{right arial dimension (diastolic)}}$$

The tricuspid inflow velocity variables measured are shown in figure I. These include IVRT, peak tricuspid velocity in early diastole (E) peak tricuspid flow velocity at atrial contraction (A), tricuspid acceleration time (Tri at), and tricuspid deceleration time (Tri dt). The ratio E/A was calculated in all patients.

The pulmonary venous flow velocity variables measured are shown in figure II. These include peak forward velocity (PVs) and velocity time integral (PVs VTI) during ventricular systole, peak forward velocity (PVd) and velocity time integral (PVd VTI) during ventricular diastole and peak reserve flow velocity (PVa) and velocity time integral (PVa VTI) during atrial contraction.

Statistical analysis :
All values are expressed as mean. Comparison of the control and patient groups was performed by using one way ANOVA . Scheffe test was used for post hoc evaluation. P value <0.05 was considered significant. All analyses were made by the SPSS/PC statistical program (version 8.0 for windows SPSS)

RESULTS

Table I shows right atrial diastolic and systolic areas (RA da and RA sa) and dimensions (RA dd and RA sd), ejection fraction (RA EF) and fractional shortening (RA FS), tricuspid flow velocity variables and pulmonary venous flow velocity variables. In right atrial parameters; right atrial diastolic and systolic diameters, right atrial systolic and diastolic areas in the HD patients were found significantly higher than that of controls($p<0.05$). In HD patients, the right atrial systolic diameter and right atrial systolic areas were significantly increased as compared with CRF patients($p<0.05$). In patients with CRF, there was a positive correlation between PVs VTI and tr dt ($p<0.05$). There was an inverse correlation between PVs VTI and mean pressure in CRF patients ($p<0.05$). A significant positive correlation was observed between PVd and PVs and PVa in CRFpatients ($p<0.05$, $p<0.05$). There was a positive correlation between PVs and PVa in CRF patients($p<0.05$). There was a correlation with PVd and RA EF and RA FS ($p<0.05$, $p<0.05$)(Table II). In HD patients, a significant positive correlation was observed between PVs and PVd ($p<0.05$). There was a positive correlation with PVd VTI and tri mean pressure in HD patients ($p<0.05$)(Table III).

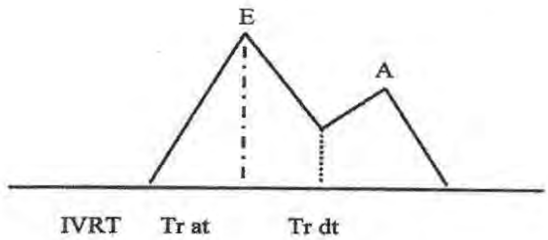

Figure 1. Schema of tricuspid flow velocity. The tricuspid variables measured in this study included peak tricuspid flow velocity in early diastole (E), peak tricuspid flow velocity at atrial contraction (A), tricuspid acceleration time (Tr at), tricuspid deceleration time (Tr dt), and the time interval between aortic valve closure click and the start of tricuspid flow (IVRT).

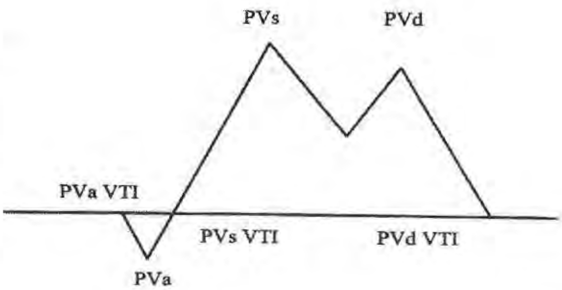

Figure 2. Schema of pulmonary venous flow velocity. Flow above the zero baseline represents forward flow into the left atrium. Flow below into the left atrium. Flow below the zero baseline represents reverse flow associated with atrial contraction. Variables measured included peak pulmonary venous flow velocity during ventricular systole (PVs), peak pulmonary venous velocity during ventricular diastole (PVd), the velocity time integral of pulmonary venous flow during ventricular systole (PVs VTI), the velocity time integral of pulmonary venous flow during ventricular diastole (PVd VTI), the velocity time integral of pulmonary venous flow during at the time of atrial contraction (PVa VTI).

Table I . Right atrial parameters, pulmonary venous velocity variables and tricuspid inflow velocity variables in HD, CRF and control group

	HD group (n=9)	CRF group (n=11)	Control group (n=14)	p
	Mean SD	Mean SD	Mean SD	
PVa cm/sec	0.22 0.05	0.22 0.07	0.16 0.06	>0.05
Pva VTI mm	138.66 31.93	129.81 36.45	128.42 20.84	>0.05
PVs cm/sec	0.46 0.08	0.47 0.10	0.50 0.08	>0.05
PVs VTI mm	256.00 57.68	277.81 72.09	266.57 64.41	>0.05
PVd cm/sec	0.49 0.10	0.53 0.28	0.49 0.12	>0.05
PVd VTI mm	299.55 62.11	241 69.17	240.28 51.52	>0.05
Tr at msec	101.33 34.64	96.36 29.09	97.42 18.27	>0.05
Tr dt msec	126.88 52.41	108.00 33.31	138.00 22.22	>0.05
EV cm/sec	0.69 0.16	0.66 0.15	0.70 0.18	>0.05
AV cm/sec	0.51 0.17	0.52 0.13	0.48 0.16	>0.05
E/A	1.42 0.47	1.29 0.19	1.53 0.43	>0.05
mean mmHg	0.83 0.34	0.82 0.35	0.77 0.38	>0.05
RA EF %	56.66 4.35	59.00 3.66	56.57 6.39	>0.05
RA FS %	28.77 3.11	30.45 2.50	28.85 4.31	>0.05
RA sa cm2	8.62 1.99*	6.85 1.70	6.53 1.58	**< 0.05**
RA da cm2	14.21 4.43*	11.37 2.33	10.74 2.09	**< 0.05**
RA sd mm	26.91 3.72**	23.86 1.80	23.86 3.16	**< 0.05**
RA dd mm	37.62 4.83**	33.20 2.98	32.78 3.26	**< 0.05**

** p < 0.05 compared with control group, ** p < 0.05 compared with CRF and control groups*

DISCUSSION

Pulmonary venous flow patterns and the relationship between pulmonary venous flow patterns and tricuspid flow patterns and right atrial functions have not yet been studied in chronic renal failure. This study aimed to investigate the relations between the function of right atrium, tricuspid flow velocity, pulmonary venous flow patterns in cases with chronic renal failure.

Congestive heart failure in chronic renal failure is caused by dilated cardiomyopathy, a disorder of systolic function, severe left ventricular hypertrophy, which may be associated with excessive systolic function and diastolic compliance.

Table II. The correlation coefficients (r) between the pulmoner venous flow velocity variables and the right atrial function parameters and the tricuspid valve flow patterns in CRF patients

Parameters	PVa	PVaV	PVs	PVsV	PVd	P V d	T R	T R	EV	AV	E/A	mean	RAds	RAdd	RAda	RAsa	RAEF	RAFS
PVa	-	0.01	**0.60***	-0.32	0.76	-0.37	0.19	0.16	0.54	0.27	0.36	0.27	0.12	0.12	0.33	0.33	0.31	0.37
PVa VTI	0.01	-	0.14	0.43	0.03	0.33	0.44	0.19	-0.22	-0.13	-0.15	-0.27	-0.17	0.32	0.22	0.02	-0.01	-0.01
PVs	**0.60***	0.14	-	-0.11	**0.67***	-0.52	0.29	0.31	0.40	0.45	-0.17	0.22	0.12	0.16	0.15	0.34	0.52	0.55
PVs VTI	-0.32	0.43	-011	-	-0.26	0.10	0.46	**0.61***	-0.58	-0.56	0.09	**-0.64***	-0.39	0.24	0.22	0.00	0.05	0.01
PVD	**0.76***	0.03	**0.67***	-0.26	-	-0.09	0.04	-0.19	0.53	0.51	-0.08	0.29	-0.30	0.04	0.15	0.33	**0.60***	**0.65***
PVD VTI	-0.37	0.33	-0.52	0.10	-0.09	-	-0.12	-0.54	-0.38	-0.11	-0.42	-0.15	-0.29	0.13	0.22	0.17	-0.00	-0.00

* *$p<0.05$*

Table III. The correlation coefficients (r) between the pulmoner venous flow velocity variables and the right atrial function parameters and the tricuspid valve flow patterns in HD patients

Parameters	PVa	PVaVTI	PVs	PVsVTI	PVd	PVd VTI	TR AT	TR DT	EV	AV	E/A	mean	RAds	RAdd	RAad	RAas	RAEF	RAFS
PVa	-	0.02	0.04	-0.46	-0.06	-0.60	-0.26	0.29	-0.13	-0.37	0.12	-0.36	-0.37	-0.38	-0.43	-0.08	-0.02	-0.28
PVa VTI	0.02	-	0.49	0.28	-0.15	-0.60	0.47	0.21	-0.18	0.24	-0.54	-0.17	-0.27	-0.27	-0.33	-0.10	-0.03	0.04
PVs	0.04	0.49	-	0.22	**0.66***	-0.08	0.33	0.20	0.21	0.29	-0.30	0.38	0.34	0.41	0.08	0.43	-0.30	-0.41
PVs VTI	-0,46	0.28	0.22	-	0.11	-0.14	0.64	-0.48	-0.29	-0.27	0.13	-0.18	0.46	0.47	0.51	0.41	-0.39	-0.24
PVD	-0.06	-0.15	**0.66***	0.11	-	0.40	0.08	-0.30	0.33	0.27	-0.07	0.49	0.59	0.58	0.26	0.42	-0.46	-0.59
PVD VTI	-0.60	-0.60	-0.08	-0.14	0.40	-	-0.40	-0.19	0.54	0.45	0.14	**0.70***	0.57	0.53	0.49	0.19	-0.19	-0.08

**$P<0.05$*

The characteristic echocardiographic pattern in end-stage renal disease is a dilated left ventricle with normal systolic function and left ventricular hypertrophy. Anemia, arteriovenous fistula flow rates and increased blood volume are associated with left ventricular dilatation(1,2). Right ventricle and atrium may be dilated in end-stage renal disease, but function is usually normal(9). In our patients, in right ventricular diastolic functions, IVRT in HD patients were found significantly higher than that of control group and Tr dt in control group was found significantly increased as compared with CRF patients. These results revealed that right atrium in chronic hemodialysis patients was markedly dilated and tricuspid flow pattern was usually in normal ranges.

Passage of blood from the lungs to the ventricle affected pulmonary venous flow, left atrial filling and emptying, and transmitral valve flow (5,10-12). Studies of normal patterns of pulmonary venous flow using transthorasic Doppler echocardiography have demonstrated that forward pulmonary venous flow was biphasic, with a systolic and a diastolic peak followed by transient reversal of flow during atrial contraction. Others, however, have suggested that in some patients forward pulmonary venous flow may be triphasic, with the ventricular systolic component divided into early and late phases. These normal flow patterns, however may be markedly altered by abnormalities in cardiac rhythm and function (5,6,11). Our study confirms many of these previous findings. It demonstrates that antegrade pulmonary venous flow patterns are in fact biphasic forward during systole and diastole, which is briefly interrupted by a transient reversal of pulmonary venous flow at the end diastole because of atrial contraction (6,13).

Pulmonary venous flow velocity is the reflection of the pressure gradient between the pulmonary vein and the lef atrium. It is believed to occur as a result of the combination of the relaxation of the left atrium which alters its contraction and the concomitant descent of the atrioventricular groove associated with left ventricular systole(10-12). Pulmonary venous flow velocity previously has been investigated in patients with atrio-ventricular block, atrial fibrillation, and dilated cardiomyopathies. In patients with atrial fibrillation pulmonary vein systolic flow velocity is reduced or absent. In patients with dilated cardiomyopathy, reduced pulmonary venous systolic filling is associated with an immobile mitral annulus or mild to moderate mitral regurgitation(1,5,10,11,14). In restrictive cardiomyopathy the lowest pulmonary vein to the left atrial pressure gradient occurs in systole(8). In patients with chronic rheumatic heart disease, there were correlations between PVd flow patterns and Tr E and mean tricuspid pressure. In this study, in patients with CRF, there was a correlation between with PVs VTI and tr dt (15).

As reported in previous transthoracic and transesophageal studies, pulmonary venous diastolic flow velocity and velocity time integral related with peak mitral flow velocity in early diastole (both variables) were also related to the left atrial diastolic diameter, diastolic volume and left ventricular end diastolic pressure. Patients with increased left ventricular diastolic pressure often have an enlarged atria and an increased atrial pressure (10,11,13). In restrictive cardiomyopathy, the highest pulmonary venous to left atrial pressure gradient occurs in diastole (8). Both restrictive cardiomyopathy and constrictive pericarditis appear to have similar left atrial diastolic compliance. There was correlation with PVd flow velocities and tricuspid mean pressure in patients with chronic rheumatic heart disease (15). In our patients, a significant correlation was found between PVd and RA EF and RA FS and Tr dt in CRF patients. These results revealed that pulmonary venous diastolic flows were also related to right atrial functions.

These results usually suggest that pulmonary venous flow patterns are related to tricuspid valve flow patterns and right atrial functions in patients with chronic renal failure (chronic hemodialysis and uremic patients). The right atrial functions and tricuspid and pulmonary venous flow patterns in chronic hemodialysis patients are markedly higher than those in chronic uremic patients. Pulmonary venous flow measurement is not important for the evaluation of diastolic right ventricular and right atrial function, but pulmonary venous velocities are related to right atrial function in chronic renal failure.

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