Original Article

Right Atrial Pressure Significance in Renal Function Indices

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Abstract

Background: With attention to association of right atrial pressure to renal venous hypertension, we try to review renal function indices changing due to congenital heart disease as base of right atrial pressure and cyanosis condition.

Methods: Forty five children without preexisting renal disease, diagnosed as pulmonary hypertension due to congenital heart disease with or without cyanosis entered to this study, their renal function indices besides to their right atrial pressure measured by angiographic documents. The effects of right atrial pressure and cyanosis on renal function indices evaluated by appropriate statistical methods.

Results: Right atrial pressure is not a common problem but it is more frequent in cyanotic than acyanotic patients. In addition significant proteinuria occurs in cyanotic patients with high right atrial pressure (above 5 mmHg). There is not any difference between renal function as glomerular filtration rate or creatinine in either groups of cyanotic or acyanotic with a high or normal right atrial pressure.

Conclusion: In cyanotic congenital heart disease patients who have pulmonary hypertension measuring of right atrial pressure seems essential; in high risk group including those with high right atrial pressure and cyanosis, significant proteinuria may happen in up to 30% of cases independent of age or gender.


Keywords: Right Atrial Pressure – Proteinuria – Congenital Heart Disease

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Introduction

There is a clear association between renal and heart failure that can affect patients' survival. However, the exact mechanisms through which heart failure affects renal function is a matter of controversy. It may be due to hypoxia occurring in conditions such as cystic fibrosis, chronic obstructive pulmonary disease (COPD), obesity, sickle cell anemia, apnea, polycythemia or in some physiologic conditions like living in high altitude. Hypoxia with or without heart problems can damage glomeruli and increase permeability which ultimately leads to endothelial swelling and sclerosis. Pulmonary hypertension is a common problem in congenital heart defects and can cause a rise in serum creatinine and in addition may result in hemodynamic problems which leads to increased mortality and morbidity in these patients especially following surgical procedures or injection of radiocontrasts for imaging. In fact works at this field in children has not been done precisely but in a similar study from Ghaffari et al it was shown that significant proteinuria may be seen in remarkable number of children even before age two, although the precise mechanism of proteinuria in heart disease has not been revealed completely. Obesity-related focal segmental glomerulosclerosis (FSGS). One study demonstrated that adult obese patients have increased plasma volume and increased right atrial pressure, which decrease with weight reduction along with parallel decreases in urinary protein losses. Other conditions also associated with increased right atrial pressure and presumed renal venous hypertension such as tricuspid atresia, constrictive pericarditis, and pulmonary hypertension have been associated with proteinuria and nephrotic syndrome. In this study we decide to find the association between right atrium pressure and renal function in children with congenital heart disease and pulmonary hypertension in two groups of cyanosis and acyanosis patients.

Methods

Forty five children over 1 months of age with no preexisting renal disease diagnosed with congenital heart disease and pulmonary hypertension with or without cyanosis were enrolled in this study. The diagnosis has been made by angiographic and echocardiographic studies. Patients who were taking drugs affecting urine protein secretion and those with renal structural problems were excluded. Their second morning urine sample was evaluated for proteinuria by measuring protein to creatinine concentration in urine and these values were compared to normal level as age (Table 1). Their serum creatinine was measured which should be evaluated regarding their age by the following formula: \( \text{Cr (mg/dl)} = 0.18 + \text{age(y)} \times 0.032 \). Their glomerular filtration rate was measured by Schwartz formula: \( \text{GFR (ml/min/1.73m2)} = K \times \text{length (cm)} / \text{Plasma creatinine (mg/dl)} \). K was defined 0.45 for term infant upto 2 years and 0.55 after that for girls and boys under age 12. Data regarding age, sex, anthropometric characteristics, serum creatinine were gathered and questionnaires were filled. Echocardiography was performed and the type of structural defects and parameters about shunt characters, regurgitation and pressures or gradients were recorded. The left and right ventricles and their valvular structures were assessed in detail by using standard left lateral decubitus position by Vingemed system with 2.5 MHz probe (GE holten, Norway) in the apical four chambers view. Diameter of the right atrium (RAD) and left atrium (LAD), were measured at the levels of mitral and tricuspid annulus valve in millimeter (mm) defined as the distance from the lateral wall of the right atrium to the interatrial septum and from the lateral wall of the left atrium to the interatrial septum. The pulmonary valve was structurally assessed in parasternal short axis view. Then the mean and peak pressure gradients over the pulmonary valve were obtained by using color wave Doppler. Valvular pulmonary stenosis was defined as dysplastic or dysmorphic pulmonary valve with a peak systolic pressure gradient of more than 20 mmHg and a mean pressure gradient of more than.
10 mmHg. For comparing of our results we enrolled 20 normal children without existing renal or cardiac disease who had been hospitalized for elective surgery. Their hemoglobin and hematocrit, anthropometric characters, protein excretion and GFR were measured and is shown in table 1.

Table 1 - renal functions indices include Glomerular filtration rate (GFR) creatinine (Cr) and significant proteinuria as age matched in cyanosis presence and right atrial pressure measured above 5 mmHg and lower 5 mmHg

<table>
<thead>
<tr>
<th>Right Atrial Pressure (Above 5 mmHg and below 5 mmHg)</th>
<th>Mean GFR (ml/min/1.73m²)</th>
<th>Mean Cr (mg/dl)</th>
<th>Patient (Abnormal proteinuria) Total (in group)-%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 5-cyanotic</td>
<td>140</td>
<td>0.41</td>
<td>1/3 -30%</td>
</tr>
<tr>
<td>Below 5- cyanotic</td>
<td>105</td>
<td>0.4</td>
<td>2/15 -13%</td>
</tr>
<tr>
<td>Above 5- acyanotic (normal for age)</td>
<td>70</td>
<td>0.45</td>
<td>0/1 0 %</td>
</tr>
<tr>
<td>Below 5-acyanotic</td>
<td>103</td>
<td>0.47</td>
<td>3/27-11%</td>
</tr>
</tbody>
</table>

Statistics:
The relationship between parametric numerical variables was evaluated by independents T test for parametric and Man- whitney U test for non parametric data. Categorical variables were compared by χ² test using SPSS software (V.16.1) a less than 0.05 was considered as statistically significant.

Results

Twenty seven acyanotic and 18 cyanotic patients and 20 normal children as control group were enrolled in this study (23 females 22 males). Their mean age in each groups (Cyanotic 38 ± 6.1 months and Acyanotic 34±9.6 months), their serum creatinine and glomerular filtration rate were measured. Three out of 4 Patients who had elevated right atrium pressure were in cyanotic group. Four out of 18 cyanotic patients had high level pressure above 5 mmHg (min 2.5, max12.5) Glomerular filtration rate in this group was more elevated than low atrial pressure without regarding to cyanosis. (Table 1)

Elevated right atrial pressure was observed in 30% of cyanosis and 3% of acyanosis patients. The mean of right atrium pressure in cyanotic was 4.5 mmHg. Right atrium pressure average was lower in acyanotic group (4 mmHg), however this difference was not significant p>0.1. In acyanotic group mean of GFR in patients with abnormal right atrial pressure (>5mmHg) was 140 ml/min/1.73m². Abnormal proteinuria happened in 1/3(30%) of patients with cyanosis along with abnormal right pressure and in 3 of 27(11%) acyanotic with normal right atrial pressure (<5mmHg). High right atrial pressure was seen in cyanosis more common than acyanosis ones. No relation was observed between right atrial pressure(RAP) and cyanosis. There is not any relation between right atrium pressure and hematocrit level. Proteinuria in normal RAP was 0.16 and in high RAP was 0.6. The mean pulmonary arterial pressure in normal was 2.5 mmHg and high right atrial pressure was 5 mmHg. This difference was not significant. Changes of right atrial oxygen saturation and pressure were measured along with protein excretion and their relations were evaluated. There is not any association between oxygen saturation and pressure of right atrium with protein excretion in right atrium pressure up to 12 mmHg maximally in our study. (Figures 1-2) In addition there is not a meaningful relation between mean pulmonary pressure and right atrial pressure independent of presence of cyanosis. (Figure 3)
Fig 2- Right atrial pressure changes compared to serum creatinine level; There is not any relation between right atrial measured at these limitation (2 to 12.5 mmHg) and creatine level.

Fig 3- Mean pulmonary pressure changes were compared to right atrial pressure. There is not any significant relationship between pulmonary pressure and right atrial pressure.

Discussion

Heart and renal interaction has not been given enough attention yet. An increased incidence of pulmonary hypertension in up to 17% of children with nephrotic syndrome has been shown which is attributed to their hypercoagulability state and pulmonary emboli that may be associated with tricuspid regurgitation. This condition resolves as proteinuria declines to normal level.\textsuperscript{13} Proteinuria less than nephrotic range has been shown in cyanotic patients and long-standing congenital heart disease and pulmonary hypertension which generally occur in adults due to controversial pathogenesis.\textsuperscript{8,14-19} Some studies have reported high right atrial pressure as a risk factor for increased proteinuria in heart disease. It has been attributed to multiple reasons like tricuspid stenosis, constrictive pericarditis and pulmonary hypertension or to fluid overloads which occur in morbid obesity.\textsuperscript{9-11} In the current study we divided patients in to two groups of cyanotic and acyanotic. All patients had pulmonary hypertension. High atrial pressure was more frequent in cyanotic patients than acyanotic ones (16% and 3%, respectively). The mean right atrial pressure in cyanotic patients was higher than acyanotic (5 and 4 mmhg, respectively), this difference was not statistically significant (p > 0.05). Proteinuria was higher in patients who had higher right atrium pressure compared to normal atrial pressure (0.6 and 0.4, respectively). Significant proteinuria was observed in 30% of cyanotic patients with high right atrium pressure and 13% of cyanotic patients with normal atrial pressure. Mean glomerular filtration rate (GFR) in cyanotic patients was not statistically different compared to acyanotic group (104±50 and 101±32: ml/min1.73m\textsuperscript{2}, respectively). Mean GFR in cyanotic patients with high atrial pressure was 140 ml/min1.73m\textsuperscript{2} and in cyanotic patients with normal right atrial pressure was 105 ml/min1.73m\textsuperscript{2} but this difference was not statistically significant. None of the patients had a low GFR as much as chronic kidney disease. Two patients had proteinuria in the range of nephrotic syndrome and both were in infant age group. None had elevated right atrial pressure yet both were cyanotic with pulmonary hypertension. Their pulmonary artery pressure were 78 and 48 mmHg while the mean of pulmonary pressure in patients was 49±23 (25,107) mmHg. So pulmonary hypertension occurs more frequently in Cyanotic groups and significant proteinuria happens more frequently in whom affected with both cyanosis and high atrial pressure, but nephrotic range proteinuria may be observed in infancy in spite of a pulmonary pressure which is not markedly elevated.
Conclusion

Proteinuria in congenital heart disease is a relatively common phenomenon although nephrotic range proteinuria is less common and high right atrial pressure along with cyanosis can be associated with higher incidence of significant proteinuria. In higher atrial pressure there are also larger amounts of protein excretion but it was not meaningful statistically but more thoroughly evaluated in studies with larger populations recommended. Right atrial pressure was not related to pulmonary pressure in our study. GFR was not affected by congenital heart disease in either cyanotic or acyanotic groups neither in high right atrial pressure group nor in normal right atrial pressure ones.

References