Short Communication

Iran J Pediatr
Oct 2013; Vol 23 (No 5), Pp: 593-596

Correlation between QRS Duration, Pulmonary Insufficiency and Right Ventricle Performance in Totally Corrected Tetralogy of Fallot

Asadolah Tanasan[1], MD; Armen Kocharian[2,3], MD; Keyhan Sayadpour Zanjani*[2,3], MD; Farah K. Payravian[4], MD; Sadat Torabian[5], MD

1. Department of Pediatric, Hamedan University of Medical Sciences, Hamedan, Iran
2. Department of Pediatrics, Tehran University of Medical Sciences, Tehran, Iran
3. Pediatric Cardiology Division, Children's Medical Center, Pediatrics Center of Excellence, Tehran, Iran
4. Department of Pediatrics, Islamic Azad University Kazeroon Branch, Kazeroon, Iran
5. Department of Epidemiology, Hamedan University of Medical Sciences, Hamedan, Iran

Received: *Nov 27, 2012*; Accepted: *Jul 13, 2013;* First Online Available: *Aug 14, 2013*

Abstract

Objective: Despite progresses in surgical correction of Tetralogy of Fallot, pulmonary insufficiency and progressive dysfunction of the right ventricle impress its long-term prognosis. In this study we examined the correlations between QRS duration, pulmonary insufficiency and right ventricular performance index.

Methods: We enrolled 57 repaired Tetralogy of Fallot patients. QRS duration on electrocardiogram, pulmonary regurgitation index (regurgitation time to diastolic time ratio), and right ventricular myocardial performance index were measured.

Findings: There was a strong inverse correlation between QRS duration and pulmonary regurgitation index. However, significant correlation did not exist between QRS duration and right ventricular myocardial performance index. QRS duration ≥160 ms predicted severe pulmonary regurgitation with 100% sensitivity and 87% specificity.

Conclusion: Increased QRS duration can predict severity of pulmonary regurgitation.

Iranian Journal of Pediatrics, Volume 23 (Number 5), October 2013, Pages: 593-596

Key Words: Tetralogy of Fallot; Pulmonary Regurgitation; Pulmonary Insufficiency; Ventricular Performance; ECG; QRS Complex

Introduction

Patients with Tetralogy of Fallot (TOF), the most common cyanotic congenital heart disease, can have a long survival if their anomaly has been totally corrected with good results[1]. Pulmonary regurgitation (PR) and progressive dysfunction of the right ventricle (RV) are the most important threatening factors in the long-term prognosis of these patients[2-5]. Correlation between fatal arrhythmias and increased QRS duration >180 ms has been reviewed[6]. Magnetic resonance imaging (MRI) is considered the best method of investigating PR severity and RV dysfunction in corrected TOF patients. However, studies showed correlation with echocardiographic findings which is cheaper and more available[7-9].

In this study we assessed the correlation between QRS duration on electrocardiogram (ECG), PR and RV performance index (RVMPI) to examine whether severe PR and RV dysfunction can be detected by surface ECG.

*** Corresponding Author;**
Address: Pediatric Cardiology Division, Children's Medical Center, No 62, Dr Gharib St, 14194 Tehran, Iran
E-mail: sayadpour@tums.ac.ir

Subjects and Methods

Children with corrected TOF who visited our outpatient clinic from March 2008 to August 2010 were enrolled in this study. Patients with more than mild tricuspid valve insufficiency, residual ventricular septal defect (VSD) with a size >4 mm, residual pulmonary stenosis (PS) with a gradient >35 mmHg, left ventricle ejection fraction (LVEF) <50%, and other types of TOF including pulmonary atresia/VSD and double outlet right ventricle/VSD/PS were excluded from the study.

A 13-lead ECG and complete echocardiography exam were performed in all patients. On ECG, QRS complex duration in lead II was measured from the start of Q wave to end of S wave. PR was evaluated by continuous Doppler echocardiography at parasternal short axis view: PR duration and total time of diastole were measured and their ratio (PR index, PRi) was calculated[7]. We used RV myocardial performance index (RVMPI) to assess RV performance. We measured the time of blood ejection from the pulmonary artery using continuous Doppler at parasternal short axis view (a) and tricuspid valve opening to closure time using tricuspid valve continuous Doppler (b) and calculated RV MPI by the formula "(a-b)/b"[10].

Statistical analysis was performed using SPSS version 11.5 program. A bivariate correlation was performed using Pearson correlation coefficient between QRS duration and both PRi and RVMPI. Statistical significance was inferred at a value level of $P<0.05$.

Findings

Fifty seven patients were enrolled in the study (30 males and 27 females) with the mean age 7.1±5.3 years at the time of study and the mean interval after surgery 2.3±2.1 years. Pearson analysis showed a strong inverse correlation between QRS complex duration and PRi (r=-.536, P<0.001) (Fig. 1). Only 1 patient had a QRS complex duration greater than 180 ms.

There was no statistically significant correlation between QRS complex duration and RVMPI (r=0.242, P=0.084). Only 3 patients had PRi <0.5 indicative of severe PR. One of the 3 was a 7 year-old boy who had a corrective surgery at the age of 1.5 years. His QRS complex duration and RVMPI were 180 ms and 0.6, respectively. Because of progressive RV dysfunction, cardiomegaly and hepatomegaly, homograft was implaned in his RV outflow tract. The other 2 patients with severe PR (PRi<0.5) were 7 and 9 year-old boys with corrective surgery at the ages of 1 and 4 years, respectively. Their QRS complex duration was 160 ms and RVMPI 0.62 and 0.47, respectively. There were 7 other patients in the cohort with QRS

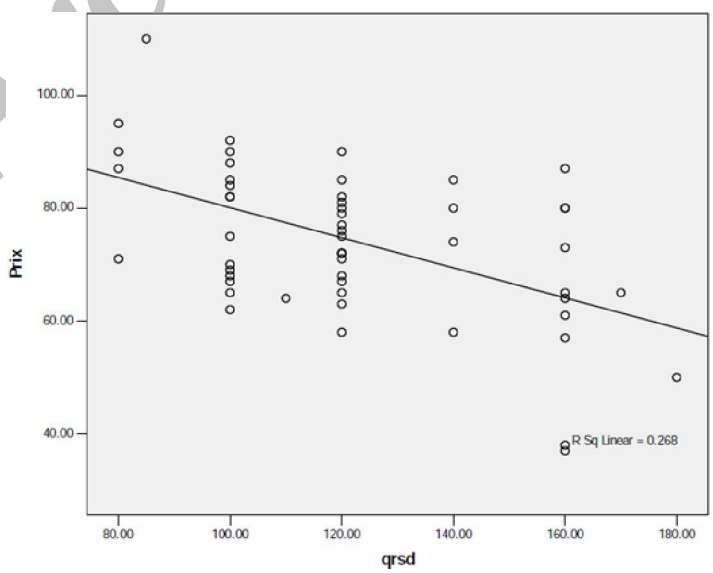

Fig. 1: Correlation between qrsd, QRS duration; Prix, PRi (r=-.536, P<0.001).

duration ≥160 ms but PRi >0.5. Therefore, a QRS duration ≥160 ms can predict severe PR with 100% sensitivity and 87% specificity.

Discussion

TOF is the most common cyanotic heart disease (3.5-9% of congenital heart diseases)[11,12]. PR is a common complication after TOF correction[7]. Severe PR gradually causes RV dysfunction which needs pulmonary valve replacement. Several studies showed that pulmonary valve replacement improves ventricular function and functional class, stabilizes QRS duration, and decreases the rate of ventricular and atrial arrhythmias[13-16] while its mortality is about 2% with few complications[11,17]. Murphy et al reported that among patients with surgically repaired TOF (rTOF), the overall 32-year actuarial survival rate was 86 percent; however, it remains lower than that in the general population[18]. The risk of late sudden death is low[18].

The presence and degree of PR influence exercise tolerance, the incidence of atrial and ventricular arrhythmias, and the risk of sudden cardiac death (SCD)[13,14,19]. Life-threatening ventricular arrhythmias remain the greatest concern for the adult with rTOF. Incidence may be as high as 6%, and until the past decade there were no consistent identifiable risk factors for distinguishing patients at risk[2,18,20,21]. Gatzoulis et al[6] provided the first clues to potential causes for ventricular arrhythmias in rTOF. They reviewed the clinical data of 178 adult survivors with rTOF after a mean follow-up of 21.4 years. Nine patients were found to have sustained ventricular arrhythmias, and four patients had postoperative SCD. They found that QRS duration >180 ms predicted sustained ventricular arrhythmias and SCD with 100% sensitivity, and that QRS duration correlated with RV size. Over the next few years, data supported the idea that the SCD risk in rTOF is a time-related risk factor that accelerates 20 to 25 years after surgical repair.

According to Li et al[8], the ratio of PR time to total diastolic time is correlated with PR fraction in MRI: a value <50% indicates severe PR[7,22]. We used this ratio to assess PR intensity. Although we had only one QRS duration >180 ms and 3 PRi <50%, we showed that PRi inversely correlates with QRS duration. Long QRS duration is a result of RV dilation, which itself can be a result of severe PR[6,22].

We used RVMPI as a factor to assess RV systolic and diastolic functions (normal range <0.3)[7,23,24]. We did not find a significant correlation between QRS duration and RVMPI. This may be due to small number of patients for detecting a weak correlation, late occurrence of RV dysfunction in the presence of severe PR and long QRS duration, and imperfectness of pulsed-Doppler RVMPI to precisely reflect RV function. Yasuoka et al showed that tissue Doppler RVMPI measurement is superior to pulse Doppler method used in our study, to detect RV dysfunction in rTOF patient with PR[25].

Conclusion

Increased QRS duration can predict severity of PR.

Acknowledgment

This paper is part of the dissertation of Dr Tanasan which was supported by Tehran University of Medical Sciences. The authors wish to thank Dr M.A. Navabi for his help in providing the data.

Conflict of Interest: None

References

1. Kirklin JW, Blackstone EH, Jonas RA, et al. Morphologic and surgical determinants of outcome events after repair of tetralogy of Fallot and pulmonary stenosis. A two-institution study. *J Thorac Cardiovasc Surg* 1992;103(4):706-23.
2. Deanfield JE, McKenna WJ, Hallidie-Smith KA. Detection of late arrhythmia and conduction disturbance after correction of tetralogy of Fallot. *Br Heart J* 1980;44(3):248-53.
3. Gatzoulis MA, Balaji S, Webber SA, et al. Risk factors for arrhythmia and sudden cardiac death late after repair of tetralogy of Fallot: a multicentre study. *Lancet* 2000; 356(9234):975-81.

4. Khairy P, Landzberg MJ, Gatzoulis MA, et al. Value of programmed ventricular stimulation after tetralogy of fallot repair: a multicenter study. *Circulation* 2004;109(16):1994-2000.
5. Silka MJ, Hardy BG, Menashe VD, et al. A population-based prospective evaluation of risk of sudden cardiac death after operation for common congenital heart defects. *J Am Coll Cardiol* 1998; 32(1):245-51.
6. Gatzoulis MA, Till JA, Somerville J, et al. Mechanoelectrical interaction in tetralogy of Fallot. QRS prolongation relates to right ventricular size and predicts malignant ventricular arrhythmias and sudden death. *Circulation* 1995;92(2):231-7.
7. Bouzas B, Kilner PJ, Gatzoulis MA. Pulmonary regurgitation: not a benign lesion. *Eur Heart J* 2005; 26(5):433-9.
8. Li W, Davlouros PA, Kilner PJ, et al. Doppler-echocardiographic assessment of pulmonary regurgitation in adults with repaired tetralogy of Fallot: comparison with cardiovascular magnetic resonance imaging. *Am Heart J* 2004;147(1):165-72.
9. Silversides CK, Veldtman GR, Crossin J, et al. Pressure half-time predicts hemodynamically significant pulmonary regurgitation in adult patients with repaired tetralogy of Fallot. *J Am Soc Echocardiogr* 2003;16(10):1057-62.
10. Tei C, Dujardin KS, Hodge DO, et al. Doppler echocardiographic index for assessment of global right ventricular function. *J Am Soc Echocardiogr* 1996;9(6):838-47.
11. Aarabi MU, Meraji M, Morezaeian H. Echocardiographic ventricular function evaluation in pulmonary valve insufficiency after surgical repair of Fallot tetralogy. *Tehran Univ Med J* 2007; 65(4):32-7. [In Persian]
12. Allen HD, Driscoll DJ, Shaddy RE, et al. Moss and Adam's heart disease in infants, children and adolescents. 7th ed. Philadelphia: Lippincot Williams & Wilkins; 2008.
13. Eyskens B, Reybrouck T, Bogaert J, et al. Homograft insertion for pulmonary regurgitation after repair of tetralogy of Fallot improves cardiorespiratory exercise performance. *Am J Cardiol* 2000;85(2):221-5.
14. Frigiola A, Redington AN, Cullen S, et al. Pulmonary regurgitation is an important determinant of right ventricular contractile dysfunction in patients with surgically repaired tetralogy of Fallot. *Circulation* 2004;110(11 Suppl 1):II153-7.
15. Oechslin EN, Harrison DA, Harris L, et al. Reoperation in adults with repair of tetralogy of Fallot: indications and outcomes. *J Thorac Cardiovasc Surg* 1999;118(2):245-51.
16. Therrien J, Siu SC, Harris L, et al. Impact of pulmonary valve replacement on arrhythmia propensity late after repair of tetralogy of Fallot. *Circulation* 2001;103(20):2489-94.
17. Bove EL, Kavey RE, Byrum CJ, et al. Improved right ventricular function following late pulmonary valve replacement for residual pulmonary insufficiency or stenosis. *J Thorac Cardiovasc Surg* 1985;90(1):50-5.
18. Murphy JG, Gersh BJ, Mair DD, et al. Long-term outcome in patients undergoing surgical repair of tetralogy of Fallot. *N Engl J Med* 1993;329(9):593-9.
19. Gatzoulis MA, Till JA, Redington AN. Depolarization-repolarization inhomogeneity after repair of tetralogy of Fallot. The substrate for malignant ventricular tachycardia? *Circulation* 1997;95(2): 401-4.
20. Garson AJr, Nihill MR, McNamara DG, et al. Status of the adult and adolescent after repair of tetralogy of Fallot. *Circulation* 1979;59(6):1232-40.
21. Rosing DA, Borer JS, Kent KM, et al. Long-term hemodynamic and electrocardiographic assessment following operative repair of tetralogy of Fallot. *Circulation* 1978;58(3 Pt 2):I209-17.
22. Abd El Rahman MY, Abdul-Khaliq H, Vogel M, et al. Relation between right ventricular enlargement, QRS duration, and right ventricular function in patients with tetralogy of Fallot and pulmonary regurgitation after surgical repair. *Heart* 2000; 84(4):416-20.
23. D'Andrea A, Caso P, Sarubbi B, et al. Right ventricular myocardial dysfunction in adult patients late after repair of tetralogy of Fallot. *Int J Cardiol* 2004;94(2-3):213-20.
24. Geva T, Sandweiss BM, Gauvreau K, et al. Factors associated with impaired clinical status in long-term survivors of tetralogy of Fallot repair evaluated by magnetic resonance imaging. *J Am Coll Cardiol* 2004; 43(6):1068-74.
25. Yasuoka K, Harada K, Toyono M, et al. Tei index determined by tissue Doppler imaging in patients with pulmonary regurgitation after repair of tetralogy of Fallot. *Pediatr Cardiol* 2004;25(2):131-6.