NOTE *Internal Medicine*

Pentalogy of Fallot in a Korean Sapsaree Dog

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ABSTRACT. A 5-month-old female Korean Sapsaree dog was presented with severe ascites, cyanosis, respiratory difficulty and exercise intolerance. Diagnostic imaging studies revealed a dextropositioned and over-riding aorta, pulmonary valvular stenosis, ventricular and atrial septal defects, and right ventricular hypertrophy. Based on these findings, the dog was diagnosed as a case of tetralogy of Fallot with atrial septal defect (pentalogy of Fallot). The dog was medically managed by use of diuretics and vasodilators and an occasional phlebotomy.

KEY WORDS: congenital heart disease, Korean Sapsaree, pentalogy of Fallot.

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Tetralogy of Fallot (TOF) is a rare complex congenital cardiac defect characterised by a ventricular septal defect (VSD) with an overriding aorta, pulmonic stenosis (PS) and right ventricular hypertrophy. In dogs, TOF is rare (0.25/1000 dogs examined) [9]. In cats, TOF has also been rarely reported [4]. However, the actual prevalence may be higher than has been reported previously, because severely affected animals commonly die at a young age before having been thoroughly examined [7].

Pentalogy of Fallot (POF) is a more complex congenital cardiac malformation characterised by TOF with either an atrial septal defect (ASD) or patent foramen ovale [12]. It also occurs in association with right aortic arch abnormalities or coronary arterial abnormalities in humans [3]. Increased resistance to right ventricular outflow tract (RVOT), caused by PS, result in R-L shunting of venous blood (responsible for cyanosis). Moreover RVOT obstruction, caused by PS and accounting for RV pressure overload and subsequent RV (right ventricle) hypertrophy, will contribute to the R-L (right to left) shunting.

Several genetic aetiologies including Jagged-1 [5], NKX2–5 (NK2 transcription factor) [6] and ZFPM2 (zinc finger protein multitype 2) [11] have been identified in human TOF. Autosomal recessive inheritance and a possible genetic aetiology have been observed with TOF in Keeshond dogs [10, 15], as this breed had been intentionally inbred. Further pedigree and clinical studies of family members is warranted to clarify a genetic etiology.

A 5-month-old intact female Sapsaree (9.5 kg, Korean native dog), was presented at the Veterinary Teaching Hospital, Kangwon National University with signs of severe dyspnea, ascites, exercise intolerance and cyanosis. On thoracic auscultation, a grade V/VI holosystolic murmur was heard at the left and right apical region of the heart with a precordial thrill.

On the day of presentation, electrocardiographic studies showed a sinus tachycardia (120 beats per min) with right axis deviation (+120°) of an abnormal QRS-complex with S-waves in leads I, II, III, indicating right ventricular hypertrophy (Fig. 1). No significant abnormalities were observed in routine hematology and blood chemistry except polycythemia (58% of packed cell volume; normal range: 37–55%).

Radiographic studies of the thoracic and abdominal cavities revealed a global shaped cardiac shadow, distended caudal vena cava, undercirculation of the pulmonary vasculature, dorsal displacement of the trachea, an enlarged hepatic shadow, and ascites, suggesting right- sided congestive heart failure. A two-dimensional echocardiographic examination showed a perimembraneous (infracristal) ventricular septal defect (Fig. 2A and 2B), thickening of both ventricular walls and of the interventricular septum wall (Fig. 3C and 3D), over-riding and dextro-positioned aorta (Fig. 6), stenotic right ventricular outflow tract (peak systolic outflow velocity of 5.3 m/sec; calculated pressure gradient 112 mmHg; Fig. 5A and B), and an atrial septal defect

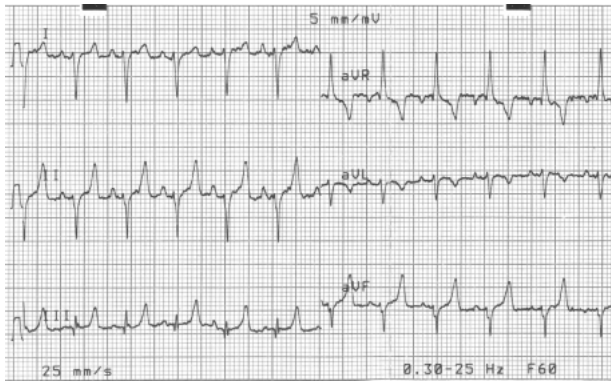

Fig. 1. The 12-lead electrocardiogram recorded from this case. The ECG tracing showed a characteristic right ventricular hypertrophy pattern (presence of S wave in lead I, II, III, and aVF; S wave in V2 and V4 is greater than 0.7 mV; QRS axis is 120°).

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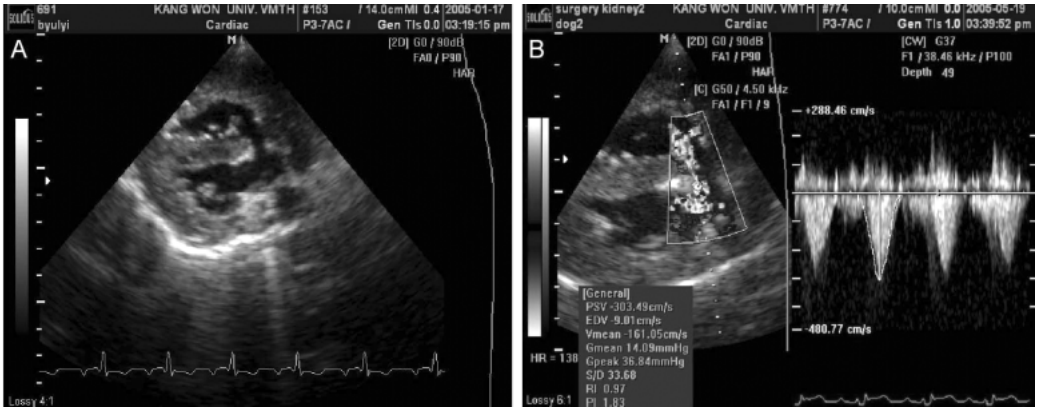

Fig. 2. The 2-dimensional short-axis and colour flow Doppler echocardiogram at the papillary muscle from this case. A large septal defect lied in the left ventricular outflow tract just below the aortic valve (A). Doppler studies revealed the flow direction is right to left at 3.0 m/sec of peak velocity (pressure gradient; 36 mm Hg between two ventricles), and implied the septal defect is large (B).

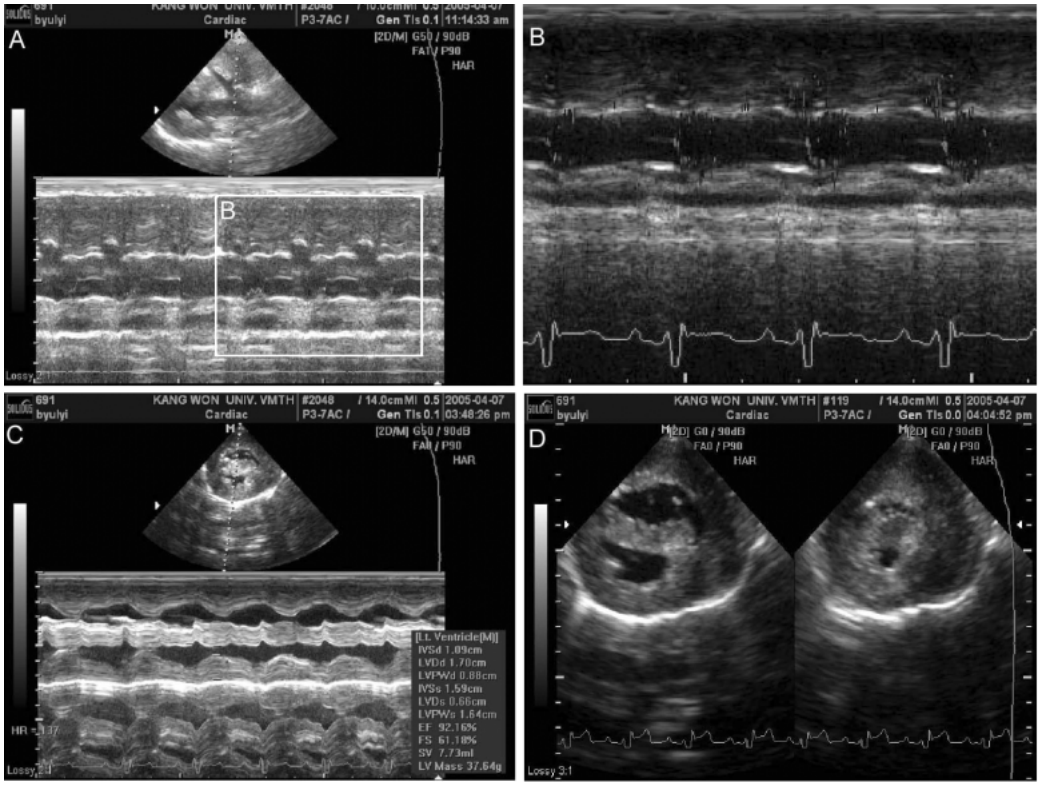

Fig. 3. Echocardiographic images from this case. Notice both severely thickened ventricles (C: M-mode, D: 2-D at diastole and systole) and fluttering of the aortic valve (A: M-mode). M-mode echocardiogram (C) showed thickened interventricular septum, right and left ventricular wall. Both ventricular walls often touched interventricular septum due to ventricular hypertrophy. Two-dimensional short axis echocardiogram at diastole showed the interventricular septum is refracted toward left ventricle because of increased right ventricular diastolic pressure (D). Colour M-mode (B) revealed aortic valve fluttering at systole (note that the fluttering started from R wave to T wave on ECG).

(Fig. 4). Interestingly, a systolic fluttering of the aortic valve was observed in a long-axis left ventricular outflow view, indicating a jet flow from right ventricle to aorta (Fig. 3A and 3B). Systolic fluttering of the aortic valve is often seen in diseases that create turbulent flow in the left ventricular outflow tract, such as aortic stenosis and hypertrophic cardiomyopathy. In this case however, it may be caused by the shunt flow through the ventricular septal defect.

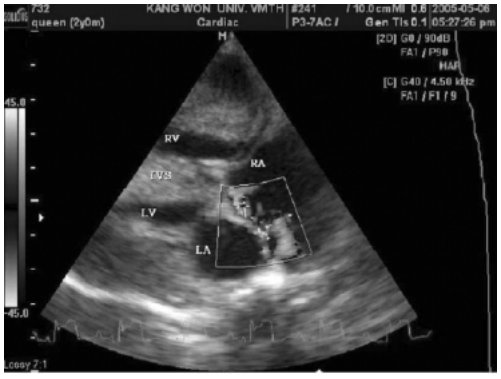

Fig. 4. Colour Doppler echocardiogram showing right-to-left interatrial shunting. Doppler studies revealed that flow direction right to left at 1.2 m/sec of peak velocity (pressure gradient, 5.8 mm Hg).

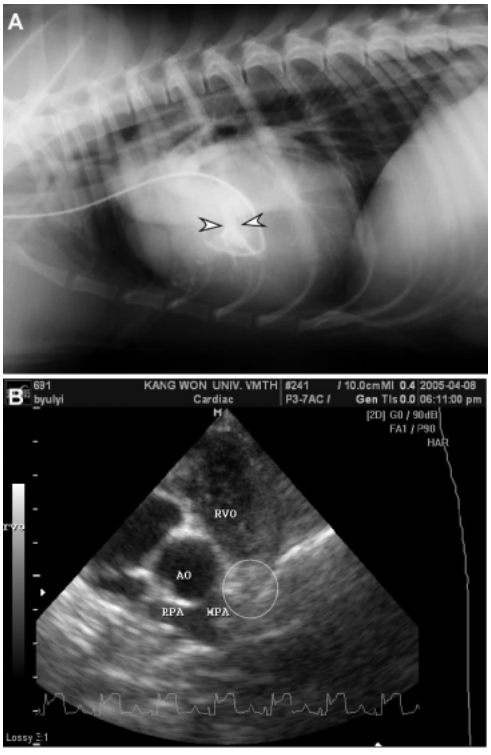

Fig. 5. Pulmonic stenosis of this case in angiography (A; The arrow indicates stenotic right ventricular outflow tract and 2 D echocardiography (B; The circle indicates stenotic right ventricular outflow tract).

Colour and spectral Doppler echocardiography confirmed, R-L shunting flow from the ventricular septum (Fig. 2B). A large septal defect lay in the left ventricular outflow tract just below the aortic valve. Doppler studies at the ventricular septum level revealed the flow direction was right to left at 3.0 m/sec peak velocity (pressure gradient 36 mm Hg between the two ventricles), and implied that the septal

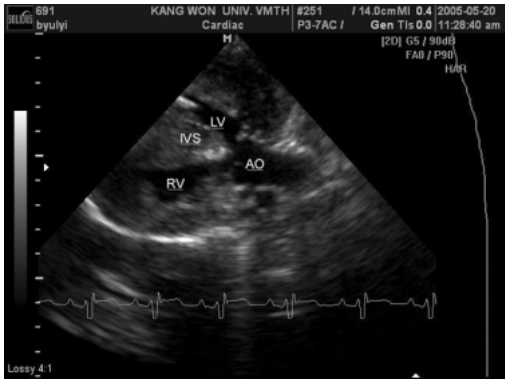

Fig. 6. The 2 D echocardiography showing overriding aorta.

defect was large (Fig. 2B). Furthermore, Doppler studies at the level of the atrial septum revealed right-to-left interatrial shunting with a 1.2 m/sec peak velocity (pressure gradient, 5.8 mm Hg, Fig. 4). A contrast echocardiography study using microbubble reconfirmed R-L shunting in both septa. Based on these findings, the case was diagnosed as tetralogy of Fallot with atrial septal defect.

Two interesting echocardiographic findings were the systolic fluttering of the aortic valves and the biventricular hypertrophy. Diastolic aortic fluttering caused by aortic regurgitation is a common echocardiographic feature with aortic valve endocarditis [1, 8]. However, in this case, shunting flow from the right ventricle through the defect in the interventricular septum may cause the aortic valve fluttering at systole. The high velocity of blood flow generated by the hypertrophic left ventricle at systole may also contribute to the aortic valve fluttering.

The increased left ventricle wall thickness of this case may result from pseudohypertrophy of the left ventricle, because insufficient preload can not adequately distend the left ventricular lumen. The abnormally low left ventricular diastolic and systolic lumina may support our assumption.

Secondary right ventricular hypertrophy is a common finding in pulmonic stenosis and pulmonary hypertension. In TOF, the increased right ventricular thickness, evident on echocardiography, and right side cardiac enlargement, evident on radiography, is caused by concentric hypertrophy due to increased afterload, which in turn is caused by right ventricular outflow tract obstruction.

Ascites is a rare clinical signs in TOF, although it has been reported in human [13, 14]. Possibly the abdominal fluid is accumulated by the L-R shunting at the beginning of life. With time, the pulmonary vascular resistance is gradually increased by progressively worsening PS and shunting flow from ASD and VSD, causing the shunt reversal. After the shunt flow is reversed, no further accumulation may not be occurred, since there will be no or little volume overload in the right ventricle. In our case, the dog might have ascites due to initial L-R shunting. After the shunt direction was reversed, no further accumulation has been observed.

Table 1. Echocardiographic dimensions of this case

Date of examination	IVSd[a)] (mm)	LVIDd[a)] (mm)	LVPWd[a)] (mm)	IVSs[a)] (mm)	LVIDs[a)] (mm)	LVPWs[a)] (mm)	EF[a)] (%)	FS[a)] (%)
17/01/05	16.9	14.5	11.7	20	6.6	15.9	88.1	54.5
07/04/05	14.8	14.8	11.3	20	6.3	16.8	90.1	57.4
27/05/05	16.4	19.2	14.5	18	8.4	20.6	88.9	56.2
04/11/05	14.1	22.7	12.1	16	10.0	18.4	87.6	55.9
28/06/06	12.7	21.1	13.1	16.4	12.7	18.7	73.2	39.8
Reference[b)]	7.0 ± 1.2	32.7 ± 3.5	6.2 ± 1.2	10.9 ± 1.7	20.6 ± 3.1	9.2 ± 1.3	20–70	28–48

a) IVSd: interventricular septal thickness at diastole, LVIDd: left ventricular internal dimension at diastole, LVPWd: left ventricular posterior wall thickness at diastole, IVSs: interventricular septal thickness at systole, LVIDs: left ventricular internal dimension at systole, LVPWs: left ventricular posterior wall thickness at systole, EF:% ejection fraction, FS:% fractional shortening.
b) Reference : Bonagura *et al.* (1985).

At the presentation, the dog showed severe respiratory distress and was cyanotic. The dog was initially treated with furosemide (2 mg/kg BID, PO) and enalapril (0.25 mg/kg BID, PO) for 8 weeks to alleviate circulatory failure. However, clinical signs of circulatory failure gradually worsened and dyspnea, hemorrhagic enteritis and prerenal azotemia developed. The PCV was increased to 68%. Therefore, phlebotomy was performed to reduce PCV to 55%. The dog was placed in an oxygen cage with venodilator therapy (nitroglycerin patch, 0.033 mg for every other 12 hr) and 1.5 litre of abdominal fluid was removed by abdominal drainage. After 3-days of intensive care, the condition was stabilised. Maintenance treatment includes a diuretic (furosemide, 4 mg/kg BID, PO), enalapril (0.5 mg/kg BID, PO) and a nitroglycerin patch (0.033 mg for every other 12 hr) with a low salt diet (Hill's h/d) together with exercise restriction.

This is a rare case of tetralogy of Fallot with atrial septal defect in dogs. Ten months after the first visit, the dog was still being successfully managed by medical treatment with occasional phlebectomy. On the M-mode echocardiogram after 10 month's of treatment, the diastolic function of this dog was gradually improved and the thickness of interventricular septum was mildly reduced (Table 1). The 10-month health status of this dog was good with 100 mmHg systolic blood pressure (Doppler method) and 55% PCV, although the dog was still cyanotic and dyspneic at exercise. No further deterioration of clinical signs had been observed.

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