

Balloon Dilation of Right Ventricular Outflow Tract in a Dog with Tetralogy of Fallot

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ABSTRACT. Balloon dilation was performed on a dog with tetralogy of Fallot. Immediately following balloon dilation, the peak systolic pressure gradient across the pulmonic valve declined from 97 to 63 mmHg. Doppler echocardiography following balloon dilation revealed increased pulmonary blood flow. Clinical symptoms obviously improved and the dog's improved condition was maintained for 4 months. There were no serious complications in performing the procedure. It was concluded that balloon dilation was a safe and effective treatment for a dog case with tetralogy of Fallot. Long-term follow-up studies will be required to identify the exact indications of balloon dilation for tetralogy of Fallot.—**KEY WORDS:** balloon dilation, canine, tetralogy of Fallot.

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For more than 25 years, percutaneous balloon dilation has been used for treatment of various obstructive lesions in human [5] and veterinary medicine [1, 8, 10]. Bright *et al.* [1] reported the first successful application of the balloon dilation for the treatment of pulmonic valve stenosis in a dog. Subsequent reports have confirmed the efficacy and safety of this treatment for pulmonic valve stenosis [8]. However, there were no reports of treating other types of right ventricular outflow obstruction like tetralogy of Fallot by balloon dilation in dogs. In this report, we apply this technique to obstructive right ventricular outflow lesion of tetralogy of Fallot, and discussed the efficacy and indication of balloon technique.

A 6-month-old 6.25 kg female miniature bull terrier was referred to our Animal Clinical Research Foundation for a two-week history of cough. Upon admission, the dog was well-developed. On physical examination, the dog had a Grade 4/6 ejection murmur heard loudest in the aortic area. The heart rate was 120 bpm. Respiratory effort and cyanosis were obvious, especially following exercises or excitement, but even at rest.

Results of a CBC and serum chemistry analysis were normal except for an increased level of PCV (72%) and total protein (8.1 g/dl). Thoracic radiography revealed severe right-sided heart enlargement. P pulmonale (0.5 mV) and ST elevation (0.2 mV) were observed on an ECG. Two-dimensional echocardiography revealed left ventricular hypertrophy, over-riding aorta, ventricular septal defect and enlarged right atrium and ventricle. Continuous Doppler echocardiography revealed an increased maximal velocity above the aortic valve (4.0 m/s).

Cardiac catheterization was performed under isoflurane anesthesia following pre-medication with atropine (0.025 mg/kg) and acetylpromazine (0.1 mg/kg). Results of cardiac catheterization revealed an increased pressure gradient between right ventricle and pulmonary artery, and between left ventricle and aorta (Table 1), both right-to-left shunt and left-to-right shunt across the VSD, over-riding aorta and mitral regurgitation. Right ventricular hypertrophy, infundibular pulmonic stenosis and subaortic stenosis were

noticed on right and left ventricular angiography (Figs. 1, 2). This dog was diagnosed as tetralogy of Fallot with aortic stenosis and mitral regurgitation. We suspected that pulmonary blood flow was diminished and most blood in the right ventricle ejected to the aorta, because. 1) the aorta clearly appeared rather than the pulmonary artery at the right ventricular angiography, and 2) pulmonary flow/systemic flow ratio (Q_p/Q_s) = 0.60 indicated a prominent right-to-left shunt.

To increase the pulmonary blood flow, balloon dilation for infundibular pulmonic stenosis was performed as a preparation for total surgical correction. Following the hemodynamic and angiographic studies, 0.035-inch diameter guide wire was introduced through the surgically isolated right external jugular vein to the pulmonary artery through a previously positioned 5 Fr Swan-Ganz thermodilution catheter. A 5.8 Fr Olbert balloon catheter (Boston Scientific Japan, Tokyo, Japan) with a balloon diameter equal to that of the annulus of the pulmonic valve, was determined by right ventricular angiography. The balloon diameter was 8 mm, and the balloon length was 4 cm. The balloon catheter was introduced over the guide wire and positioned into the stenotic lesion under fluoroscopy. The balloon was rapidly inflated by inflation

Table 1. Intracardiac pressure and blood gas analysis before balloon dilation

	Pressure (Systolic/Diastolic)(mmHg)	O ₂ saturation (%)
RA	4/0	45.9
RV	107/7	49.9
RVOT	99/5	48.7
MPA	10/3	52.5
PAWP	6/-2	—
LV	134/-2	88.8
Ao	70/50	67.5

RA: Right atrium. RV: Right ventricle. RVOT: Right ventricular outflow tract. MPA: Main pulmonary artery. PAWP: Pulmonary artery wedge pressure. LV: Left ventricle. Ao: Aorta.



Fig. 1. Left ventricular selective angiography prior to balloon dilation. Subaortic stenosis, mild left to right shunt across the VSD and mitral regurgitation are observed.

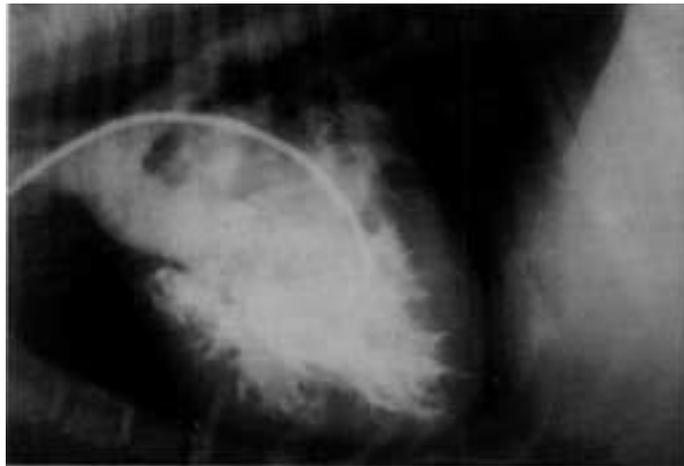


Fig. 2. Right ventricular selective angiography prior to balloon dilation. Aorta is clearly appeared instead of pulmonary artery. Right ventricular hypertrophy and infundibular stenosis are present.

handle of a 1:1 mixture of saline and contrast medium. The balloon was inflated for 3 to 5 seconds, and deflated rapidly. This was repeated three times. Even though ventricular premature beats were observed when the balloon catheter was advanced into the right ventricle, there were no serious complications in performing the procedure.

The results of hemodynamic studies and angiography immediately after balloon dilation revealed relief of pulmonic infundibular stenosis and increased pulmonary blood flow (Fig. 3). The peak systolic pressure gradient across the pulmonic valve declined from 97 to 63 mmHg. Right ventricular angiography revealed more contrast medium flow to the pulmonary artery. Follow-up Doppler echocardiography was performed at 2 days and 1 month after balloon dilation (Table 2). Maximum velocity of the

left ventricular outflow tract declined, and the maximum velocity of right ventricular outflow tract was increased. We understood that this was the consequence of increasing blood flow to the pulmonary vasculature instead of to the systemic vasculature.

Since the dilation, the dog became very active and cyanosis was reduced. Unfortunately, the dog died in an earthquake 4 months after the procedure.

Recent reports in human medicine have documented the safety and effectiveness of balloon dilation to treat tetralogy of Fallot [2–4, 6, 7, 9]. Immediate improvement in aortic oxygen saturation and clinical symptoms were observed after the procedure [4]. Balloon dilation in early life has allowed the growth of the pulmonary arteries and brought about lower mortality following complete surgical correction [3].



Fig. 3. Right ventricular selective angiography after balloon dilation. Main pulmonary artery is more clearly visible than that before the procedure.

Table 2. Changes of Doppler echocardiographic findings

(m/s)	pre-balloon	post-balloon	
		2 days	1 month
Max. velocity of RVOT	0.87	2.0	3.1
Max. velocity of LVOT	4.07	2.7	2.5

Therefore, balloon dilation was considered a valuable palliative alternative to surgical systemic-pulmonary shunt [3].

Balloon dilation requires no thoracotomy or long-term hospitalization [1, 10]. Palliative balloon dilation was performed on this dog first because the clinical and hemodynamic condition were too severe to tolerate long-term anesthesia and open heart surgery. The procedure proved successful in this dog with no complications. Increased pulmonary blood flow was confirmed from the degree of cyanosis and Doppler study, similar to the results observed in human patients. We expected that increased pulmonary blood flow would allow growth of the pulmonary vasculature for complete surgical correction.

Balloon dilation seemed effective for right ventricular outflow obstruction of tetralogy of Fallot for a few month in this dog. Long-term follow-up studies will be required to determine the exact indications of balloon dilation for tetralogy of Fallot. Also, mean survival time should be

compared between dogs treated with balloon dilation and with surgical correction or with no treatment.

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