Endocardial radiofrequency septal ablation for hypertrophic obstructive cardiomyopathy:two case reports

ruohan zhao
Chengdu Third People's Hospital https://orcid.org/0000-0002-5255-1299
Feng Xiong (**xiongfengsyy@gmail.com**)
https://orcid.org/0000-0002-5231-201X
Shuzhen Wang
Chengdu Third People's Hospital
Hanxiong Liu
Chengdu Third People's Hospital
Duan Luo
Chengdu Third People's Hospital

Case report

Keywords: Endocardial radiofrequency ablation of the septal hypertrophy, hypertrophic obstructive cardiomyopathy

Posted Date: January 14th, 2020

DOI: https://doi.org/10.21203/rs.2.20780/v1

Abstract

Endocardial radiofrequency ablation of the septal hypertrophy (ERASH) is an alternative for hypertrophic obstructive cardiomyopathy (HOCM). Radiofrequency ablation could lead to regional myocardial akinesia, so as to relieve the left ventricular outflow tract (LVOT) gradient. We reported that two patients presented Left ventricular asymmetric hypertrophy in transthoracic echocardiography, and were diagnosed with HOCM. One had a gradient up to 210mmHg during the provocation. The other had a gradient of LVOT up to 108mmHg at rest. Both are symptomatic despite of the optimized medication. Due to the restriction of coronary anatomy, the patients lost the opportunity for the alcohol septal ablation (ASA). ERASH is programmed. The target site was determined by intracardial echocardiography and electroanatomic Carto-mapping system. ERASH caused the targeted myocardium hypokinesia precisely, aiming for interdicting mitral valve systolic anterior motion. 1-month follow-up showed a remarkable improvement of clinical state and a predominant reduction of LVOT gradient assessing by transthoracic echocardiography. ERASH comes up with a new solution for the patient who is not candidate for ventricular septal myectomy and ASA. Carto-mapping system and intracardiac echocardiography enable precise lesion placement and preservation of atrioventricular conduction.

Introduction

The incidence of hypertrophic obstructive cardiomyopathy (HOCM) is known to be about 0.2%, while recently a few researches revealed that it could be higher [1]. The hypertrophy of septum and the anterior wall, mitral valve systolic anterior motion constitute the left ventricular outflow tract (LVOT) obstruction. In the circumstance of drug refractory, non-pharmacological should be taken into account. Currently, there are two non-pharmacological treatments: ventricular septal myectomy and alcohol septal ablation (ASA). Although ventricular septal myectomy is the gold standard for the treatment of HOCM [2], the availability of high-quality operation is limited, which could not cope with the relatively high prevalence of HOCM [3]. As the secondary therapy for HOCM, ASA is mini-invasive, but it relies on individual anatomy of septal arteries. So about 1%-15% of the patients could not be the candidates of ASA [4,5]. Both of the former mentioned treatments have the risk of complete atrial-ventricular block, which call for the pacemaker therapy. Endocardial radiofrequency ablation of septal hypertrophy (ERASH) has been applied on HOCM since 2004, by Dr.LAWRENZ [6]. No matter where the hypertrophy is located, the transcatheter approach enables ablation of endocardium, with multiple lesion up to 28mm [7], imitating the effect of ventricular septal myectomy. Although the experience with ERASH so far always encountered with residual gradient, the developments of the symptoms do exist. We reported ERASH applied in two people with HOCM.

Case 1:

A 66-year old man suffered from symptom of HOCM (activity related chest tightness, shortness of breath, NYHA II-III, angina CCS II) with sign of left ventricular hypertrophy on electrocardiogram and elevation of troponin T and BNP. He was admitted to our center without treatment. Transthoracic echocardiography

(TTE) (vivid I, General Electrics and IE33,Philips) revealed an unsymmetrical hypertrophy of left ventricle, with posterior wall/interventricular septum thickness 20mm/12mm, accompanied with systolic mitral valve systolic anterior motion (SAM) (figure 1A), and gradient of LVOT at admission was 60mmHg at rest by continuous-wave doppler (figure 1B). Coronary angiography was performed to rule out the possibility of coronary artery disease, and sought for suitable septal artery, which turned out to fail. After prescribed the dosage of 47.5mg metoprolol, the patient's heart rate was controlled on average of 68bpm. The gradient at rest and the sign of SAM vanished. But the shortness of breath and activity related chest pain still remained. A provoked gradient was suspected. Thus, a pharmacological stress echocardiography and invasive measurement were under consideration.

Stress echocardiography and invasive measurement:

At the beginning of the procedure, a 5Fr MP catheter was introduced into the left ventricle through the right femoral artery. An invasive radial pressure was acquired by invasive blood pressure monitor. The gradient between peak left ventricular pressure and radial pressure remained less than 30mmHg (figure 2A). And then, dobutamine at the velocity of 5ug/kg·min^{-1} was given by micropump to stimulate the gradient. But due to the effect of metoprolol, the heart rate responded less sensitively than the blood pressure. So even when the blood pressure reached 200/80mnHg, the heart rate remained approximately 62bpm. Until then, the gradient remained unchanged. For the grant of safety, dobutamine was terminated. Taking into consideration that the gradient of LVOT in HOCM is closely related with heart rate, the isoprenaline was pumped in at 0.2ug/kg·min^{-1} to activate the β1 receptor. The heart rate quickly reached 87bpm, but the radial blood pressure dropped to 78/39mmHg. The isoprenaline was terminated promptly. The highest gradient measured by TTE was 237mmHg at the heart rate of 87bpm (figure 2B). In the meantime, the SAM turned to be positive, as well as the regurgitation of mitral valve graded to be moderate. The systolic mitral valve attached area was targeted to be the ablation area.

Therapeutic intervention:

A 6Fr pacing catheter was inserted through the right femoral vain into the right ventricle if necessary. The probe of intracardial echocardiography (ICE) (12Fr, SOUNDSTAR, Johnson & Johnson Medical) passed through the opposite femoral vain into the right ventricle to display the LVOT and constructed a three-dimension model of left ventricle. Firstly, a retrograde transaortic way was attempted to place the ablation catheter (8Fr, Biosense Webster) to the targeted area (figure 4). But due to the impossibility to make the catheter stably adhere to the hypertrophic septum, a trans-atrial access was adopted, assisted by a steerable sheath (Agilis, St.Jude). A dose of 4000IU heparin was administered intravenously to maintain the activated clotting time. The ablation catheter was guided by the ICE and fluoroscopy to the constructive LVOT. To prevent injuring the His bundle and the left bundle branch, intracardial potential was detected before ablation by Carto 3 mapping system (Biosense Webster). The ablation generator (Stockert GmbH, Biosense Webster) was applied to deliver 40w for 60s every time. The cooling pump was programmed to release saline 30ml/min during ablation (Thermocool, Biosense Webster). A series of 7 radiofrequency lesions (total time of radiofrequency application, 4.9 minutes; energy range, 40 W;

temperature range, 30-35 °C; contacting pressure, 20-35 g) were delivered in the region of the septal bulge about 1.6cm^2(Figure 3). Finally, the stress echocardiography was repeated, and gradient declined to 83mmHg at the heart rate of 88 bpm (figure 2C)and the blood pressure remained 151/68mmHg at the heart rate of 153bpm. The patient finished the operation with a slight prolongation of QRS to 120ms, with incomplete left bundle branch block, without the complication of cardiac effusion and complete atrioventricular block. The fluoroscopic time was 12 min.

Follow up:

After the operation, the patient went through the surveillance of electrocardiogram monitor. None of fatal arrythmia was documented. Nor did the patient feel any discomfort. 48 hours after the operation, the patient got discharged. After one month of the ERASH, the patient felt angina disappeared. Electrocardiograph showed left bundle branch block diminished with QRS recovery to 100ms. There was an echo-enhanced region notice at the place of ablation through TTEFigure 5A.The thickness of the myocardium did not change too much. The stress echocardiography presented a gradient at rest of 26mmHg (HR 78bpm) (figure 5B), with SAM negative, without mitral regurgitation, a gradient at provocation of 166mmHg (HR 106 bpm) (figure 5C) and 25mmHg (HR 88bpm) (figure 5D), with SAM positive and mitral regurgitation. The blood pressure fluctuated between 135-158/75-85mmHg.

Case 2:

A 30-year-old woman, presented with shortness of breath for 7 years, exacerbation after activity, was diagnosed with HOCM by echocardiography. The maximum septum was 24mm, and mitral valve moved towards the septum during systole. The gradient of LVOT measured by doppler was 146mmHg. Mitral regurgitation graded to be mild to moderate. After the coronary angiography, proper septal artery was not found. So ERASH was performed as described above through a retrograde transaortic pathway. The target region was the SAM area. The radiofrequency time was 22.4 minutes, energy released was 40 W per 60s, and contacting pressure was 5-15g. Since the region of His bundle was too abundant, coinciding with the region of SAM area, the ablation area was not enlarged. Right after the operation, the gradient fell to 115mmHg. The patient discharged 5 days after the operation. The patient felt relief at rest but the exercise tolerance did not change too much in a one-month follow-up. The TTE showed that the gradient decreased to 70mmHg, still with SAM positive and mild to moderate mitral regurgitation. At the site of RF current application, we noticed an enhanced area about 4mm thick.

Discussion

The gradient of the LVOT at rest ≥ 30 mmHg can be found in 20%~30% hypertrophic cardiomyopathy patient. While for one third of the HOCM patients, gradient can be provoked by either exercise or medication up to 50 mmHg [1]. The severity of LVOT obstruction is influenced by ventricular preload, myocardial contractility and afterload. Exercise can increase the myocardial contractility, afterload and

heart rate, and infusion of isoproterenol can also increase the myocardial contractility and heart rate, which may cut down the preload and induce SAM-septal feedback mechanism. Under that condition, the stroke volume decreases so that the compensation at activity collapse. Just as the case in the first patient, metoprolol could temporarily reduce the gradient by controlling the heart rate and increasing the preload. But once his heart rate exceeded 88 bpm, the patient would lie in danger of shock or even cardiac sudden death. We utilized the radiofrequency to create intramural myocardial lesion in contacting point, as deep as 4 mm, so that the myocardial mobility would be reduced. The provoked SAM-septal feedback mechanism is responsible for the dynamic obstructive HOCM. So even if the septal thickness did not change too much after ERASH, the relief of symptom and reduction of gradient are probably related with the precise location of the ablation to the endo-myocardial tissue in contacting area.

For those with extremely high gradient patient, taking the second patient for an instance, ERASH show a reduction of 52% gradient at rest. According to the literature, above 50% of the gradient reduction is thought to be significant [8]. But in our case, the second patient's exercise tolerance did not improve. The residual gradient is still too high that affect her daily life. The similar circumstance occurred in Sreeram's research, after a 4-year follow-up, there was 5 out of 32 patients underwent an additional procedure [9]. One patient underwent surgical myectomy. Four patients were performed a second ERASH. As for our second patient, since she is still symptomatic, a further progress should be considered. The first choice is to accept the septal myectomy, dealing with the hypertrophic septum, concomitant papillary muscle abnormalities and mitral leaflet elongation thoroughly [10]. The second choice is the newly arisen percutaneous intramyocardial septal radiofrequency ablation [11]. The third option is to receive a second ERASH. But the patient's His bundle distributed abundantly at the SAM area, so the continuation of ablation may place the patient at the risk of complete atrioventricular block.

At present, there are two existed traditional therapies which remove the gradient by the reduction of septal thickness. But just as mentioned, both of them have limits. ERASH could be an alternative for HOCM patient who are not candidates for the traditional treatments, since it has several advantages: 1) Given the assistance of steerable sheath, ablation catheter could attach any selected region precisely no matter how the coronary artery varies. 2) ERASH is a mini-invasive way, which could be performed several times in the same patient. Even if the HOCM evolve after the operation, a second ERASH could also be adoptable for the patient. 3) By the surveillance of the potential mapping, the radiofrequency-induced injury to the His bundle could be avoided or predicted. As the maturation of ERASH, the possibility of atrioventricular block may decrease. The lowest incidence of atrioventricular block is documented to be 3% [9]. Besides, late-onset conduction of ERASH is comparatively lower than ASA. 4) ERASH shows safety and feasibility in both adult and children [7, 9, 12–14]. According to a late follow-up of a small sample research [9], ERASH is efficient in most case. 96.9% of the patient had an improvement in both the symptom and the gradient. And there was an 87.5% freedom from reinterventions at 10 years of follow-up. However, ERASH also has the possibility to develop a reentrant ventricular arrythmia due to the scar during the procedure or post-operation[9]. Besides, although ERASH has resulted in improvement in LVOT obstruction and symptoms, the experience with it has been met with high residual gradients, often 30 mm

Hg or more, which have been observed in most but not all reports [15]. The residual gradient may call for a second operation someday.

As the literatures reported, there are two pathways of ablation catheter. One is the retrograde transaortic approach, and the other is the trans-atrial approach. Most of the physician adopted the former one [7, 9, 12, 14]. But in our practice, we found it difficult to attach to the septum stably, so we chose the trans-atrial approach in the first case. This is a relatively less common pathway in the literature [13]. Through the retrograde transaortic pathway, if the target area lays on the superior of the left ventricle, a catheter with large curvature will be beneficial to ablate at precise location with stability, and vice versa. However, the heart beats bring difficulties to the prediction of catheter selection. A catheter selection matters with the economical efficiency of ERASH and the range of the ablation. As for the latter one, under the auxiliary of steerable sheath, it is easier to locate the ablation catheter in place with good stability.

Conclusion

The application of ERASH is a promising therapy in HOCM patient. It comes up with new solution for the patient who is not suitable for ventricular septal myectomy and ASA. However, it remains some drawbacks to improve. The residual gradients are sometimes recorded in the literature, which may require an additional procedure. The post-operational arrythmia should be monitored in case of a new reentrant ventricular tachycardia or fibrillation. ERASH is still a therapy needed to be standardized. Further large-scale studies are needed to clarify the status of ERASH in HOCM treatment.

Abbreviations

HOCM: hypertrophic obstructive cardiomyopathy; LVOT: left ventricular outflow tract; ASA: alcohol septal ablation; ERASH: Endocardial radiofrequency ablation of septal hypertrophy; TTE: transthoracic echocardiography; SAM: systolic mitral valve systolic anterior motion; ICE: intracardial echocardiography.

Declarations

Ethics approval and consent to participate:

Ethics approval and consent to participate was obtained.

Consent for publication

A written informed consent was obtained from the patient.

Availability of data and material

All data generated or analyzed during this study are available from the corresponding author or reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding:

This research was supported by Scientific research fund project of sichuan provincial health department (120538)

Authors' contributions:

Conceptualization: Feng Xiong.

Data curation: Ruohan Zhao.

Formal analysis: Ruohan Zhao, Shuzhen Wang, Feng Xiong.

Intervention: Hanxiong Liu, Duan Luo.

Project administration: Hanxiong Liu, Feng Xiong.

Validation: Ruohan Zhao.

Writing original draft: Ruohan Zhao.

Acknowledgment

Not available.

References

1. Marian AJ, Braunwald E. Hypertrophic Cardiomyopathy. *Circulation Research.* 2017;121(7):749-770.
2. McLeod CJ, Ommen SR, Ackerman MJ, et al. Surgical septal myectomy decreases the risk for appropriate implantable cardioverter defibrillator discharge in obstructive hypertrophic cardiomyopathy. *Eur Heart J.* 2007;28(21):2583-2588.
3. Ommen SR, Nishimura RA. Hypertrophic Cardiomyopathy-One Case per Year?: A Clarion Call to Do What Is Right. *JAMA Cardiol.* 2016;1(3):333-334.
4. Faber L, Welge D, Fassbender D, Schmidt HK, Horstkotte D, Seggewiss H. One-year follow-up of percutaneous septal ablation for symptomatic hypertrophic obstructive cardiomyopathy in 312 patients: predictors of hemodynamic and clinical response. *Clin Res Cardiol.* 2007;96(12):864-873.
5. Chan W, Williams L, Kotowycz MA, et al. Angiographic and echocardiographic correlates of suitable septal perforators for alcohol septal ablation in hypertrophic obstructive cardiomyopathy. *Can J Cardiol.* 2014;30(8):912-919.

6. Lawrenz T, Kuhn H. Endocardial radiofrequency ablation of septal hypertrophy. *Zeitschrift für Kardiologie.* 2004;93(6).
7. Lawrenz T, Borchert B, Leuner C, et al. Endocardial Radiofrequency Ablation for Hypertrophic Obstructive Cardiomyopathy. *Journal of the American College of Cardiology.* 2011;57(5):572-576.
8. Keane D, Hynes B, King G, Shiels P, Brown A. Feasibility study of percutaneous transvalvular endomyocardial cryoablation for the treatment of hypertrophic obstructive cardiomyopathy. *The Journal of invasive cardiology.* 2007;19(6):247-251.
9. Sreeram N, Emmel M, de Giovanni JV. Percutaneous Radiofrequency Septal Reduction for Hypertrophic Obstructive Cardiomyopathy in Children. *Journal of the American College of Cardiology.* 2011;58(24):2501-2510.
10. American College of Cardiology Foundation/American Heart Association Task Force on P, American Association for Thoracic S, American Society of E, et al. 2011 ACCF/AHA guideline for the diagnosis and treatment of hypertrophic cardiomyopathy: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Thorac Cardiovasc Surg.* 2011;142(6):e153-e203.
11. Liu L, Li J, Zuo L, et al. Percutaneous Intramyocardial Septal Radiofrequency Ablation for Hypertrophic Obstructive Cardiomyopathy. *J Am Coll Cardiol.* 2018;72(16):1898-1909.
12. Shelke AB, Menon R, Kapadiya A, et al. A novel approach in the use of radiofrequency catheter ablation of septal hypertrophy in hypertrophic obstructive cardiomyopathy. *Indian Heart Journal.* 2016;68(5):618-623.
13. Crossen K, Jones M, Erikson C. Radiofrequency septal reduction in symptomatic hypertrophic obstructive cardiomyopathy. *Heart Rhythm.* 2016;13(9):1885-1890.
14. Cooper RM, Shahzad A, Hasleton J, et al. Radiofrequency ablation of the interventricular septum to treat outflow tract gradients in hypertrophic obstructive cardiomyopathy: a novel use of CARTOSound®technology to guide ablation. *Europace.* 2016;18(1):113-120.
15. Sorajja P, Katsiyiannis WT, Harris KM. Searching for Surgical Alternatives in Hypertrophic Cardiomyopathy. *Journal of the American College of Cardiology.* 2018;72(16):1910-1912.

Figures

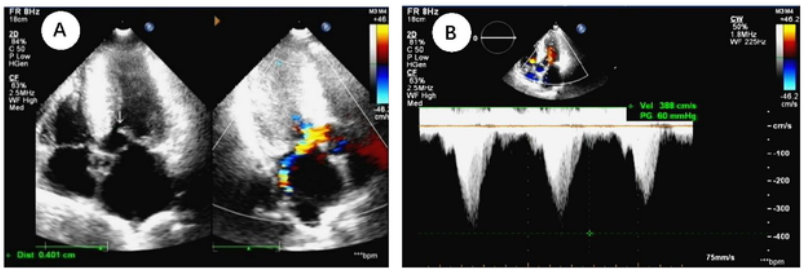

Figure1 A: four-chamber view with SAM positive and mitral regurgitation. B: Gradients in the left ventricular outflow tract (CW-Doppler) at rest before ERASH, 60 mmHg.

Figure 1

Figure1 A: four chamber view with SAM positive and mitral regurgitation. B: Gradients in the left ventricular outflow tract (CW Doppler) at rest before ERASH 60 mmHg

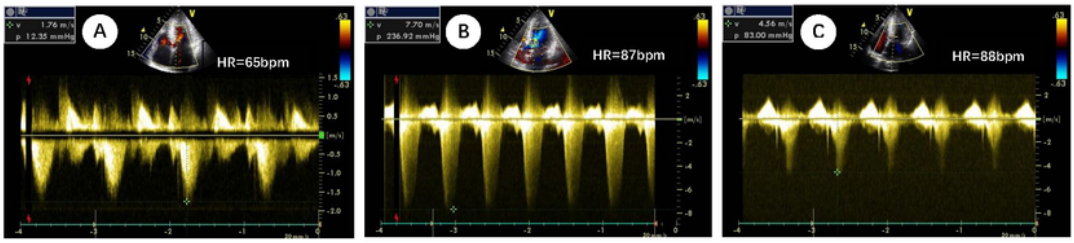

Figure2 A: Left ventricular outflow tract gradient after treatment, 12.35mmHg. B: Gradients in the left ventricular outflow tract (CW-Doppler) at provocation of isoproterenol before ERASH, 60 mmHg, HR 87bpm. C: Gradients in the left ventricular outflow tract (CW-Doppler) at provocation of isoproterenol after ERASH, 83 mmHg, HR 88bpm.

Figure 2

Figure2 A: Left ventricular outflow tract gradient after treatment , 12.35mmHg. Gradients in the left ventricular outflow tract (CW Doppler) at provocation of isoproterenol before ERASH, 60 mmHg , HR 87bpm. Gradients in the left ventricular outflow tract (CW Doppler) at provocation of isoproterenol after ERASH, 83 mmHg , HR

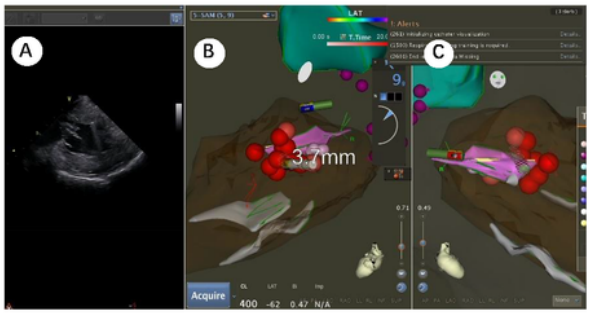

Figure3 A: intracardial echocardiography showed the ablation area. Three-dimensional electroanatomical map of the left ventricular outflow tract (LVOT) endocardial surface created by the electroanatomical CARTO mapping system (CARTO 3 system, Biosense Webster). Pink dots: subaortic septal regions in which branching of the conduction system was detected; Red dots: sites of radiofrequency ablation. The area of ERASH reaching 1.6cm2. B: LAO view. C: RAO view.

Figure 3

Figure3 A: intracardial echocardiography showed the ablation area Three dimensional electroanatomical map of the left ventricular outflow tract (LVOT) endocardial surface created by the electroanatomical CARTO mapping system (CARTO 3 system, Biosense Webster). Pink dots: subaortic septal regions in which branching of the conduction system was detected; Re d dots: sites of radiofrequency ablation. The area of ERASH reaching 1.6cm2. B: L AO view. C: R AO view.

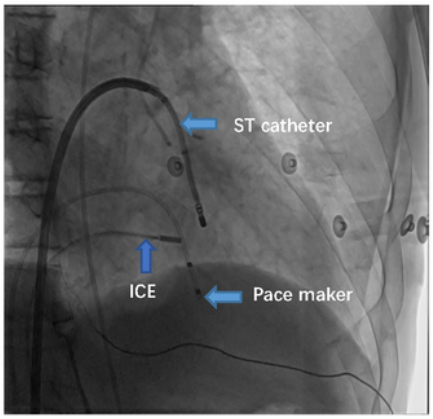

Figure 4 Catheter setting during ablation of the right ventricular septum, RAO.

Figure 4

Catheter setting during ablation of the right ventricular septum, RAO

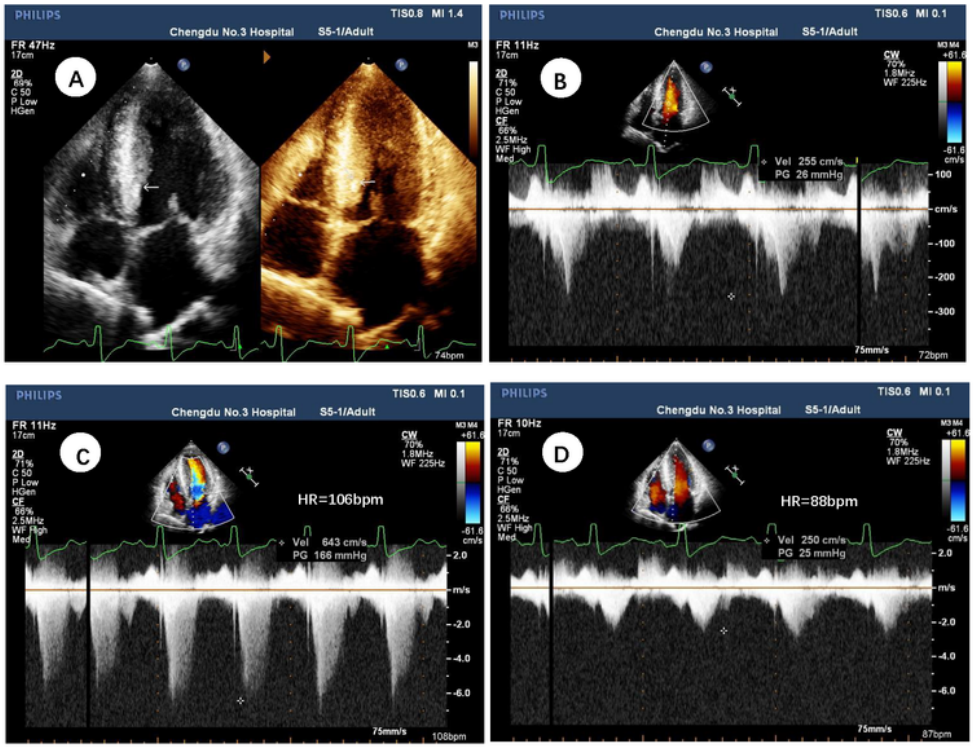

Figure5 A: four-chamber view with echo-enhanced region notice at the place of ablation. B: Gradients in the left ventricular outflow tract (CW-Doppler) at rest of isoproterenol after ERASH, 26mmHg, HR 78bpm. C: Gradients of LVOT at provocation of isoproterenol after ERASH, 166mmHg, HR 106bpm.D: Gradients of LOVT at provocation of isoproterenol after ERASH, 25mmHg, HR 88bpm.

Figure 5

Figure5 A: four chamber view with echo enhanced region notice at the place of ablation . Gradients in the left ventricular outflow tract (CW Doppler) at rest of isoproterenol after ERASH, 26 mmHg , HR 78 bpm. C: Gradients of LVOT at provocation of isoproterenol after ERASH, 166 mmHg , HR 106 bpm. D: Gradients of LOVT at provocation of isoproterenol after ERASH, 25 mmHg , HR C A B H R= 106 bpm H R=88bpm D

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Image080.avi
- Image013.avi