ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) **7**, 1–6
https://doi.org/10.1093/ehjcr/ytad471

CASE REPORT
Valvular heart disease

Usefulness of catheter pressure measurement using the Navvus RXi system to determine left ventricular outflow tract obstruction and aortic stenosis severity: a case report

Masaki Yashige *, Kan Zen, Eisuke Kataoka, and Satoaki Matoba

Department of Cardiovascular Medicine, Kyoto Prefectural University of Medicine, Kajii-cho 465, Kawaramachi-Hirokoji, Kamigyo-ku, Kyoto 602-8566, Japan

Received 17 April 2023; revised 2 September 2023; accepted 19 September 2023; online publish-ahead-of-print 21 September 2023

Background Left ventricular outflow tract obstruction (LVOTO) sometimes presents with aortic stenosis (AS). Echocardiography is used to assess the diagnosis and severity of LVOTO or AS. However, LVOTO is one of the conditions that makes AS assessment difficult, and catheter pressure measurement is frequently useful in such cases.

Case summary An 84-year-old female patient presented with New York Heart Association functional Class III dyspnoea. Transthoracic echocardiography revealed LVOTO caused by upper septal hypertrophy, mitral valve systolic anterior motion with moderate mitral regurgitation, and a highly calcified aortic valve, which suggested the possibility of severe AS. The continuous Doppler echocardiography revealed a late-systolic peaking dagger-shaped profile with a peak jet velocity of 5.6 m/s. Cardiac catheterization was performed to determine the contribution of AS or LVOTO to her symptoms. Catheter pressures were measured at the ascending aorta (using a coronary catheter) and the LV (using the Navvus RXi system). The initial mean pressure gradient between the apex of the LV, just below the aortic valve and aorta, was measured at 65 and 25 mmHg, respectively. The mean pressure gradient between the apex and the aorta decreased from 65 to 40 mmHg after a 50 mg disopyramide administration. Oral medication therapy effectively stabilized her symptom after catheterization.

Discussion To the best of our knowledge, this is the first reported case of assessing the severity of LVOTO and AS using the Navvus RXi system. Catheter pressure measurement using the Navvus RXi system is a useful method of determining the severity of LVOTO and AS.

Keywords Aortic stenosis • Left ventricular outflow tract obstruction • Echocardiography • Navvus • Case report

ESC curriculum 4.2 Aortic stenosis • 6.5 Cardiomyopathy

Learning points

- Haemodynamic assessment with not only echocardiography but also invasive catheters would be helpful in patients with aortic stenosis (AS) and concomitant left ventricular outflow tract obstruction (LVOTO).
- Catheter pressure measurement using the Navvus RXi system is a simple and useful method to determine the severity of LVOTO and AS.

* Corresponding author. Tel: +81 075 251 5111, Fax: +81 075 251 7093, Email: shige912@koto.kpu-m.ac.jp
Handling Editor: Christoph Sinning
Peer-reviewers: Edgar Francisco Carrizales Sepulveda; Dejan Milasinovic
Compliance Editor: Hikmet Kadioglu

Introduction

Left ventricular outflow tract obstruction (LVOTO) occasionally presents with aortic stenosis (AS), which is estimated to account for 10% of cases.[1]

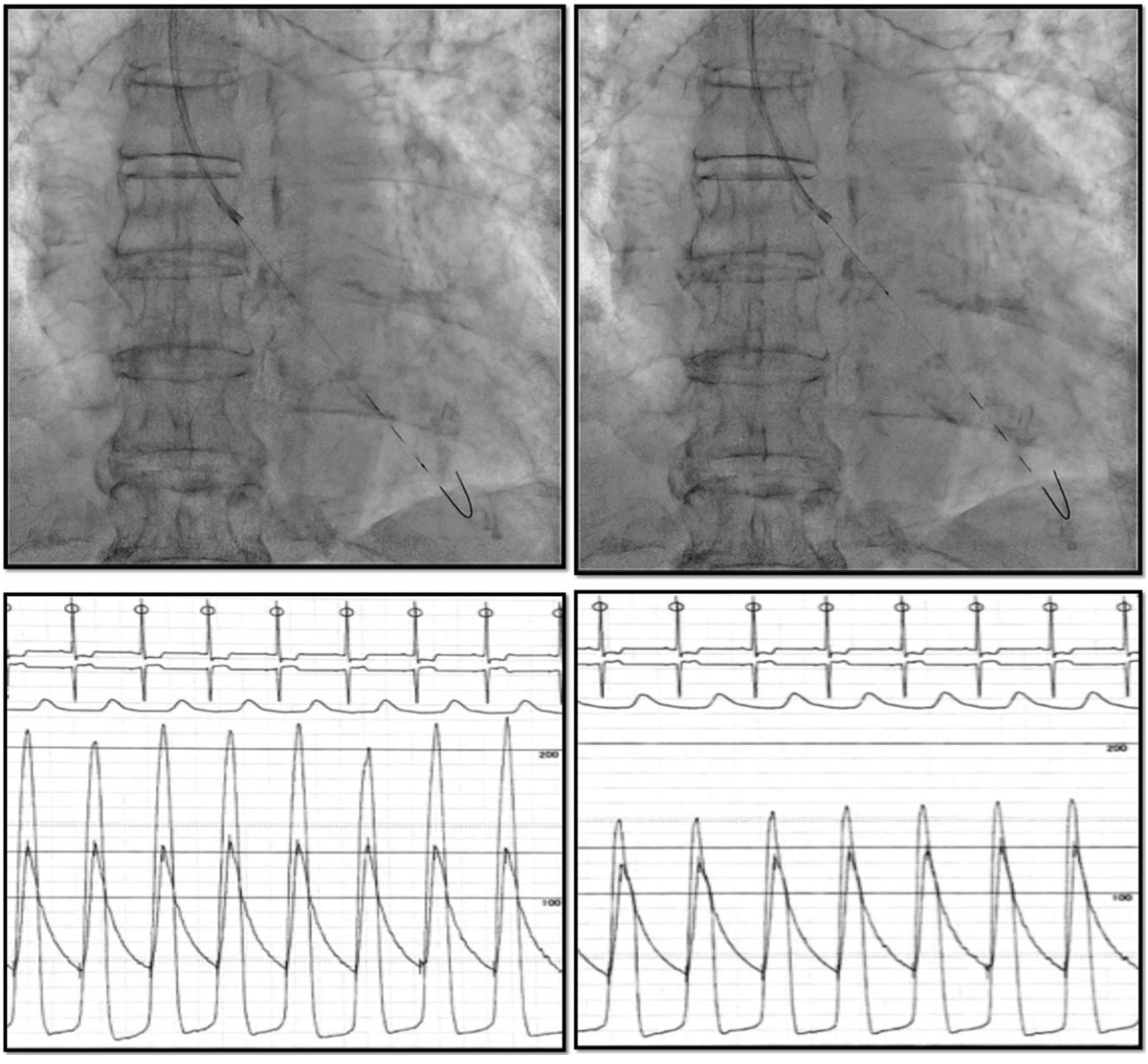
Hypertrophic myocardial septum on LVOT causes an increased subaortic pressure gradient and dyspnoea. Echocardiography is used to assess the diagnosis and severity of LVOTO or AS. However, LVOTO complicates AS assessment by making it challenging to distinguish between the flows across the aortic valve and LVOTO.[2,3] Therefore, selecting the preferred treatment for AS or LVOTO is difficult. Herein, we present a case of LVOTO associated with AS assessed in catheter pressure measurements using the Navvus RXi system (ACIST Medical Systems, Eden Prairie, MN, USA).

Summary figure

Case presentation

An 84-year-old female patient was referred to our institution for heart failure treatment. She presented with New York Heart Association functional Class III dyspnoea on admission. She had a medical history of hypertension and dyslipidaemia. She did not have a family history of Fabry disease. Her medications included dapagliflozin (10 mg/day), spironolactone (12.5 mg/day), and pimobendan (2.5 mg/day). Physical examination revealed a systolic ejection murmur in the sitting position at the right upper sternal border.

The laboratory findings revealed a brain natriuretic peptide of 185.2 pg/mL (standard range: 0.0–18.4 pg/mL). Electrocardiography (ECG) revealed a normal sinus rhythm and ST-segment depression on the anterior leads, and voltage criteria indicated left ventricular hypertrophy (*Figure 1*). Electrocardiography reading was not of low potential. Transthoracic echocardiography (TTE) revealed a hypertrophic myocardial septum on LVOT and moderate mitral regurgitation with



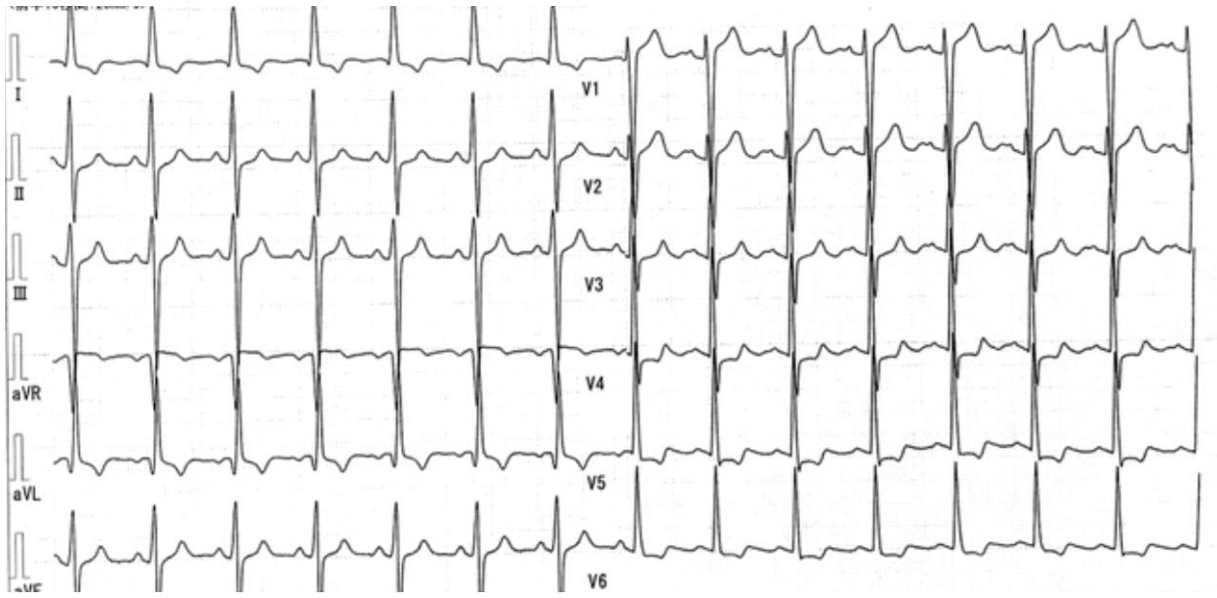


Figure 1 The electrocardiogram of the patient on admission. A normal sinus rhythm and ST-segment depression on the anterior leads, and voltage criteria indicated left ventricular hypertrophy.

systolic anterior motion of the mitral valve (*Figure 2A–C*) and a highly calcified aortic valve, which suggested the possibility of severe AS (*Figure 2D*). The thickness of the basal septum was 17 mm and the posterior wall was 16 mm. The left ventricular (LV) ejection fraction was normal. No granular sparkling was seen on TTE. The aortic valve area measured using direct two-dimensional planimetry was 0.57 cm^2. A late-systolic peaking dagger-shaped profile with a 5.6 m/s of peak jet velocity was revealed in the continuous Doppler echocardiography (*Figure 2E*). However, a precise determination of AS severity was difficult because discriminating the AS from LVOTO velocity was impossible. Cardiac catheterization was performed to determine the contribution of AS or LVOTO to her symptoms. Coronary angiography was performed via the radial artery, and it revealed no coronary artery stenosis (*Figure 3A* and *B*). Then, we attempted to measure the pressure gradient between the aorta and the LV using the Navvus RXi system (ACIST Medical Systems). First, an angiographic diagnostic catheter (Goodtech 5Fr-Judkins Right 4.0, Goodman Medical Ireland Limited, Ireland) was placed in the LV. Next, a 0.014 inch Thruway guidewire (Boston Scientific Corporation, Natick, MA, USA) was inserted in the LV. Then, the 5 Fr JR4.0 catheter was replaced with a 6 Fr JR4 guide catheter, and Navvus RXi was inserted over the 0.014 inch guidewire (*Figure 4A–C*). The initial mean pressure gradient between the apex of the LV and the ascending aorta was 65 mmHg (*Figure 5A*), whereas that between the area just below the aortic valve and the ascending aorta was 25 mmHg (*Figure 5B*). The mean pressure gradient between the apex of the LV and the ascending aorta decreased from 65 to 40 mmHg after a 50 mg dose of disopyramide was administered (*Figure 5C* and *D*).

Dapagliflozin, spironolactone, and pimobendane were discontinued based on the findings, and then oral cibenzoline at 150 mg/day and bisoprolol at 2.5 mg/day were subsequently prescribed. A follow-up TTE revealed that the continuous Doppler echocardiography described a 3.1 m/s of peak jet velocity and the patient's symptom was resolved. Careful follow-up with TTE will be planned in future; if TTE reveals an increase in the peak jet velocity in the continuous Doppler echocardiography again, invasive pressure gradient will be measured with a catheter.

Discussion

Herein, we report a case of coexistent LVOTO and AS assessed for severity using the Navvus RXi system. This case demonstrated the usefulness of catheter pressure measurement using the Navvus RXi system to determine LVOTO and AS severity. To the best of our knowledge, this is the first reported case of assessing the LVOTO and AS severity using the Navvus RXi system.

The number of patients with concomitant LVOTO and AS is predicted to increase along with the ageing of the population.[4] Considering the patient's family history and ECG/TTE findings in this case, hypertrophic obstructive cardiomyopathy was the most likely cause of LVOTO. Echocardiography is the first-choice modality to evaluate LVOTO or AS severity because of its cost-effectiveness and non-invasiveness,[5] whereas accurate evaluation of true AS severity is difficult if it coexists with LVOTO, and careful assessment is required to distinguish the flow across the aortic valve from the flow through LVOTO in an echocardiographic examination.[6,7] As in the present case, a mixture of AS Doppler and LVOT Doppler flows makes separation and definition difficult, which is the main component of the pressure gradient. The main cause of symptoms should be determined because treatment interventions differ between LVOTO and severe AS.

Haemodynamics can be measured using not only echocardiography but also invasive catheters in patients with AS and concomitant LVOTO. Two catheters and two arterial access sites are usually required in determining transvalvular pressure gradient by haemodynamic cardiac catheterization. Moreover, previous reports revealed the feasibility of using a single arterial puncture and a 0.014 inch pressure wire for AS evaluation.[8,9] However, several difficulties are encountered while assessing AS using a pressure wire. First, the pressure wire may provoke premature ventricular contractions during manipulation in the LV, thereby hindering the accurate measurement of pressure gradient. Moreover, maintaining accurate positioning within the LV using pressure wires alone is often difficult and the heartbeat may cause the wire to pull out of the LV. The reinsertion of the wire into the LV could be troublesome once it is pulled out from the aorta. Particularly, in cases with LVOTO and concomitant AS, as in the

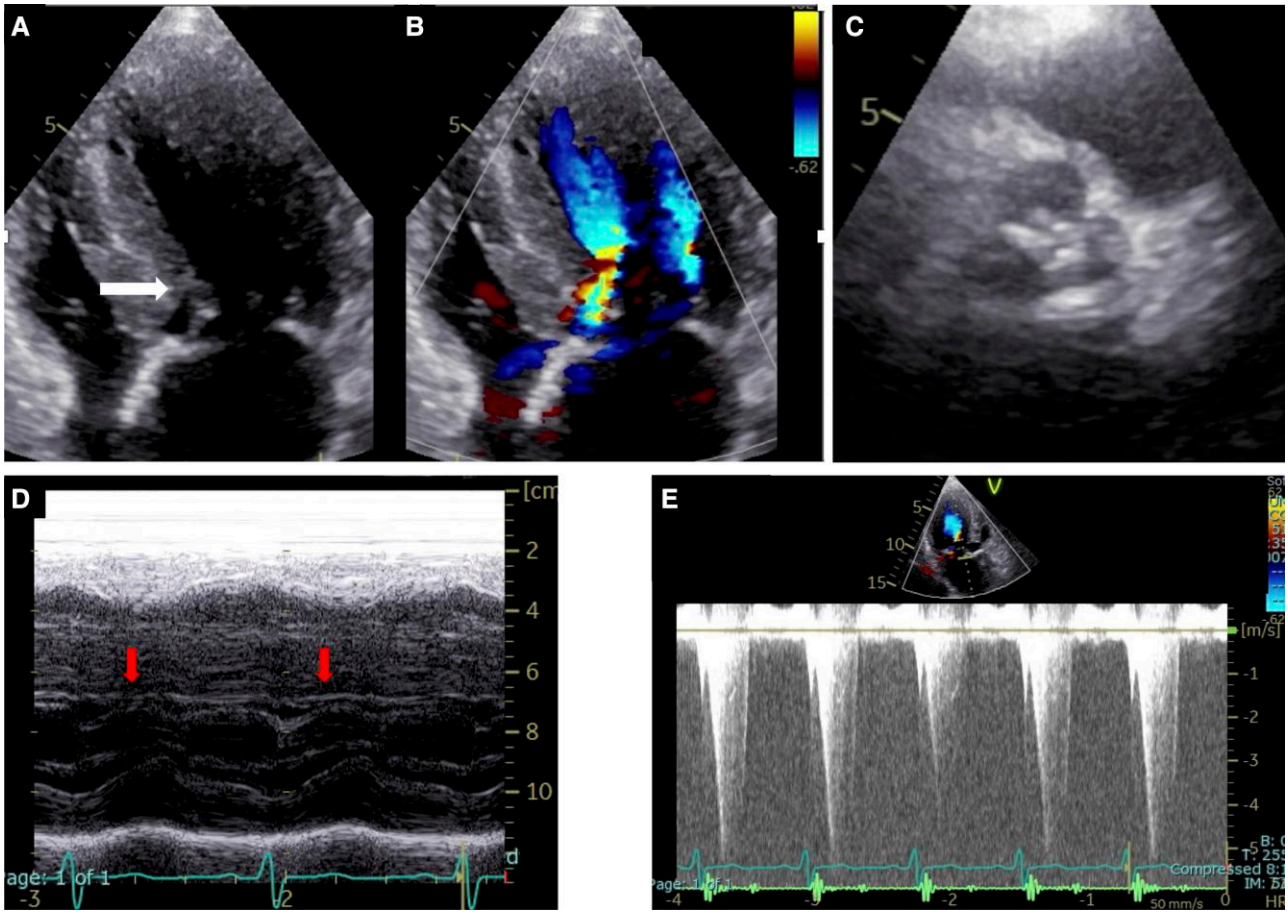


Figure 2 Transthoracic echocardiography findings on admission. (*A*) Transthoracic echocardiography revealed upper septal hypertrophy (arrow). (*B*) Apical long-axis view by colour Doppler echocardiography revealed mosaic flow extending from the left ventricular outflow tract. (*C*) Calcified aortic valve with limited opening. (*D*) M-mode revealed systolic anterior motion (arrows). (*E*) The initial pulse wave Doppler ultrasound of the left ventricular outflow tract.

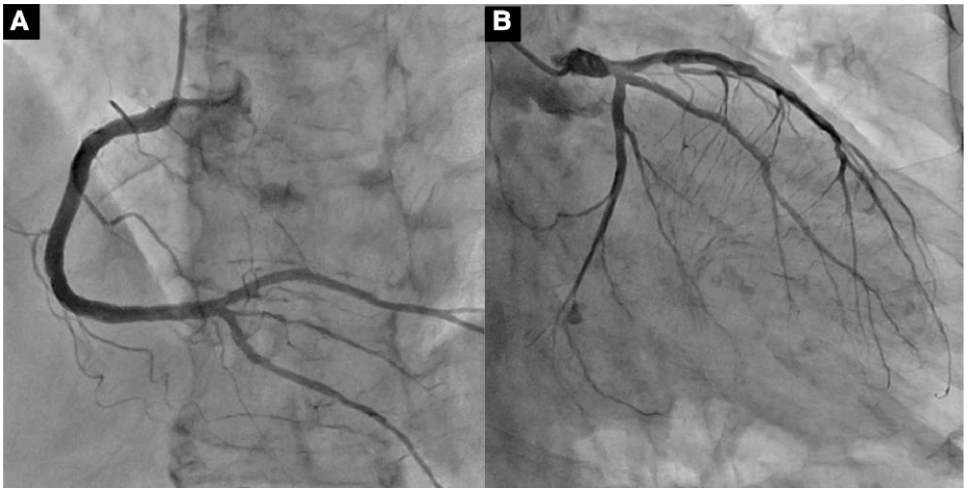


Figure 3 Coronary angiography revealed no significant stenosis in the right coronary artery (*A*) and left coronary artery (*B*).

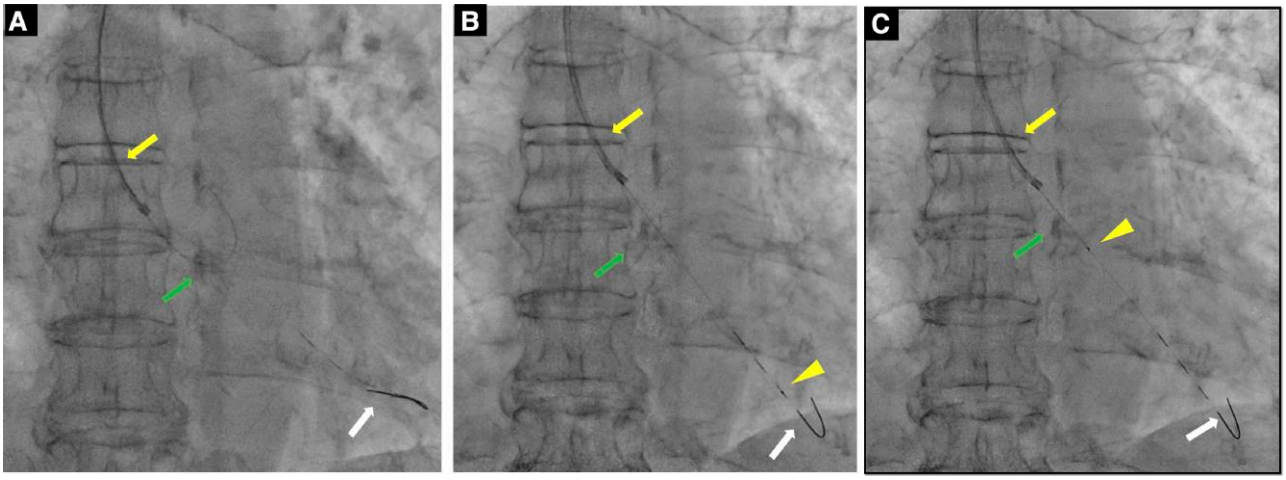


Figure 4 Catheter pressure measurement using the Navvus RXi system. (*A*) A 6 Fr JR4 guide catheter (arrow above) was inserted into the ascending aorta over the 0.014 inch guidewire (arrow in the bottom) through a calcified aortic valve (arrow in the middle). (*B* and *C*) Navvus RXi (ACIST Medical Systems: yellow arrowhead) was inserted over the 0.014 inch guidewire and placed at the apex of the left ventricle (*B*) and just below the aortic valve (*C*).

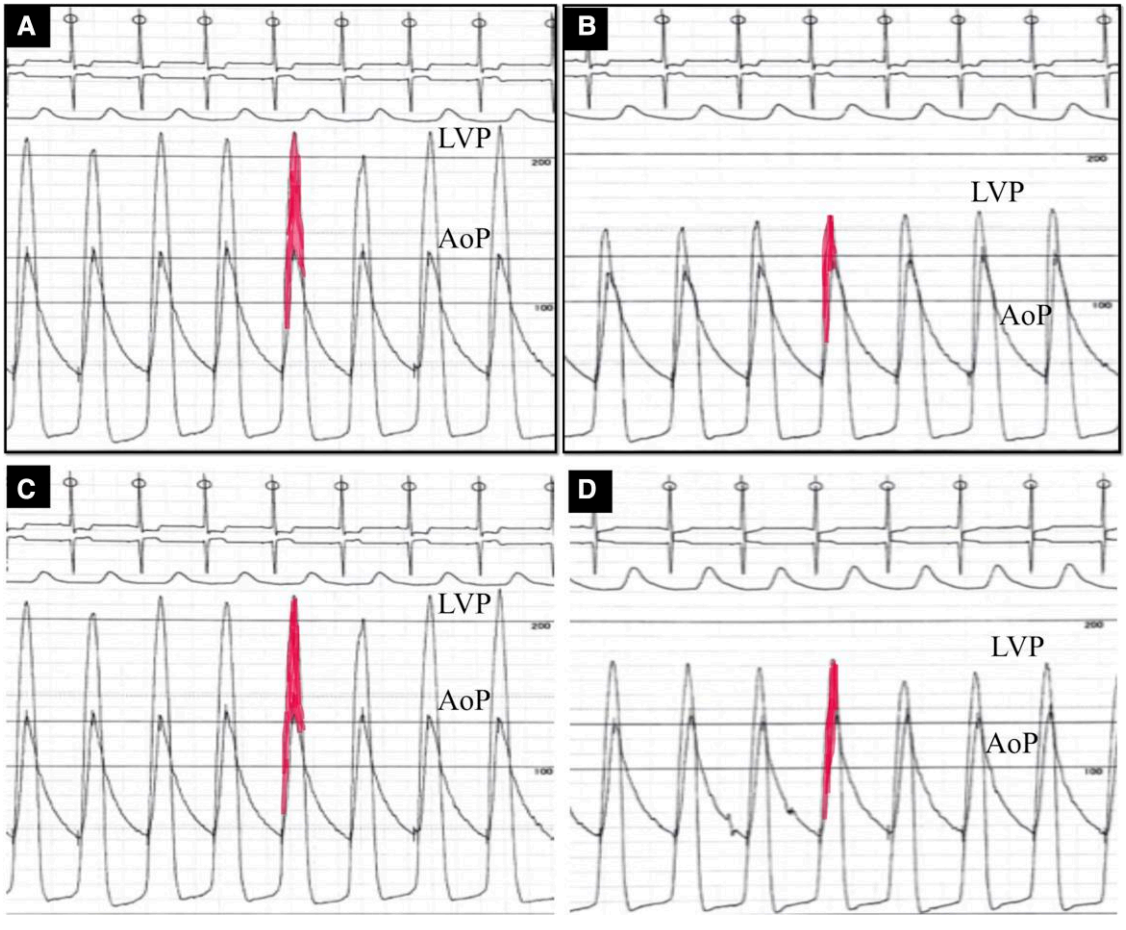


Figure 5 Pressure recording using the Navvus RXi system to determine left ventricular outflow tract obstruction and aortic stenosis severity. The patient's initial mean pressure gradient between the apex of the left ventricle (*A*), just below the aortic valve and aorta (*B*) was measured at 65 and 25 mmHg (coloured area), respectively. The mean pressure gradient between the apex of the left ventricle and the ascending aorta decreased from 65 mmHg (*C*) (coloured area) to 40 mmHg (*D*) (coloured area) after administering disopyramide. AoP, aortic pressure; LVP, left ventricular pressure.

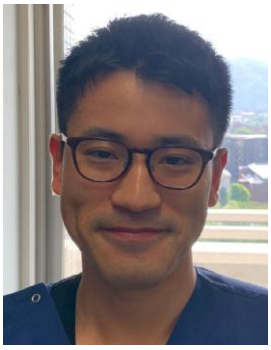
present case, wire reinsertion into a calcified stenotic aortic valve can be difficult.

The Navvus RXi system is a novel monorail microcatheter with a lesion entry profile of 0.022 inches and an optical pressure sensor located close to the distal tip for the fractional flow reserve measurement.[10] The rapid exchange catheter is compatible with any 0.014 inch guidewire.[11] Pressure measurement using RXi and Navvus microcatheters has several distinctive features. First, only one puncture site is required. Additionally, the one-puncture method reduces the puncture site and punctures the radial artery, which may cause fewer catheterization complications.[12] Second, the system allows multiple pull-backs while maintaining wire access. Pressure measurements can be easily performed without the need to pass the stiffened aortic valve through the wire again even when measuring pressure gradients twice, at rest and under drug stress. Thus, this method caused a steady subaortic pressure gradient recording during cardiac catheterization, even for cases of coexistent LVOTO and AS. Further investigations are warranted to confirm the feasibility of the catheter pressure measurement using the Navvus RXi system to determine LVOTO and AS severity, especially in comparison with other invasive pressure measurement methods such as using pressure wire or two catheters.

Conclusion

Catheter pressure measurement using the Navvus RXi system is a simple and useful method to determine the severity of LVOTO and AS.

Lead author biography



Masaki Yashige is a general cardiologist at Kyoto Prefectural University of Medicine, Kyoto, Japan. His areas of interest include cardiac intervention for structural heart disease.

Acknowledgements

None.

Consent: Written informed consent was obtained from the patient for publication of this case report and any accompanying images.

Conflict of interest: None declared.

Funding: None declared.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

References

1. Bach DS. Subvalvular left ventricular outflow obstruction for patients undergoing aortic valve replacement for aortic stenosis: echocardiographic recognition and identification of patients at risk. *J Am Soc Echocardiogr* 2005;**18**:1155–1162.
2. Hasebe H. Simultaneous intracardiac pressure measurement to detect the origin of pressure gradient in a patient with coexisting aortic stenosis and asymmetrical interventricular septal hypertrophy. *Am J Case Rep* 2018;**19**:1253–1257.
3. Ramamurthi A, Aker EM, Pandian NG. A case of aortic stenosis and hypertrophic cardiomyopathy. *Echocardiography* 2012;**29**:1261–1263.
4. Lindman BR, Clavel MA, Mathieu P, Iung B, Lancellotti P, Otto CM, *et al.* Calcific aortic stenosis. *Nat Rev Dis Primers* 2016;**2**:16006.
5. Baumgartner H, Hung J, Bermejo J, Chambers JB, Edvardsen T, Goldstein S, *et al.* Recommendations on the echocardiographic assessment of aortic valve stenosis: a focused update from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *J Am Soc Echocardiogr* 2017;**30**:372–392.
6. Ozaki K, Sakuma I, Mitsuma K, Suzuki T, Tsuchida K, Takahashi K, *et al.* Effect of cibenzoline and atenolol administration on dynamic left ventricular obstruction due to sigmoid-shaped septum. *Circ J* 2018;**72**:2087–2091.
7. Ayoub C, Brieger D, Chard R, Yiannikas J. Fixed left ventricular outflow tract obstruction mimicking hypertrophic obstructive cardiomyopathy: pitfalls in diagnosis. *Echocardiography* 2016;**33**:1753–1761.
8. Bae JH, Lerman A, Yang E, Rihal C. Feasibility of a pressure wire and single arterial puncture for assessing aortic valve area in patients with aortic stenosis. *J Invasive Cardiol* 2006;**18**:359–362.
9. Harano Y, Kawase Y, Matsuo H. Dynamic improvement of an acute exacerbated subaortic subaortic pressure gradient after intravenous propranolol and cibenzoline, recorded using a pressure wire: a case report. *Eur Heart J Case Rep* 2022;**6**:ytac311.
10. Masdjedi K, Van Mieghem NM, Diletti R, van Deuns R-J, de Jaegere P, Regar E, *et al.* Navvus FFR to reduce CONTRAst, Cost and radiaTion (CONTRACT); insights from a single-centre clinical and economical evaluation with the RXi rapid-exchange FFR device. *Int J Cardiol* 2017;**233**:80–84.
11. Diletti R, van Mieghem NM, Valgimigli M, Karanasos A, Everaert B, Daeman J, *et al.* Rapid exchange ultra-thin microcatheter using fibreoptic sensing technology for measurement of intracoronary fractional flow reserve. *EuroIntervention* 2015;**11**:428–432.
12. Bhat FA, Changal KH, Raina H, Tramboo NA, Rather HA. Transradial versus transfemoral approach for coronary angiography and angioplasty—a prospective, randomized comparison. *BMC Cardiovasc Disord* 2017;**17**:23.