Case Report

Non-Invasive Assessment May Have a Key Role in Follow-Up Performance of Modified Cabrol Aortic Root Reconstruction

Julia Grapsa, Declan O'Regan, Antonios Kourliouros, Thanos Athanasiou, Petros Nihoyannopoulos

Departments of Cardiology and Cardiothoracic Surgery, Hammersmith Hospital, Imperial College Trust, London, UK

Key words: **Cabrol, modification, bicuspid aortopathy, stress echocardiography, myocardial perfusion imaging, speckle tracking.**

Surgical repair of ascending aortic disease involving the aortic root most commonly involves the direct anastomosis of the coronary ostia to the composite aortic graft. Occasionally, when direct aortocoronary anastomosis is not safe or technically challenging—such as in cases of extreme aortic dilatation, calcification and reoperations—the Cabrol technique and its modification can provide a safe and effective alternative. As the Cabrol is often reserved as a second line or bailout procedure, there is insufficient evidence to support the optimal imaging assessment and follow up of patients who have undergone this complex aortic reconstruction. We present the case of a patient where emergency replacement of the aortic root took place with a modified Cabrol aortocoronary anastomosis. We discuss the usefulness, findings and limitations of modern non-invasive imaging modalities that can provide a complete functional and anatomical assessment of this surgical technique.

Manuscript received:
January 12, 2011;
Accepted:
July 17, 2011.

Address:
Julia Grapsa

Department of Cardiology
Hammersmith Hospital
Imperial College Trust
London, UK
e-mail: Julia.grapsa@imperial.nhs.uk

The surgical treatment of aneurysms and dissections involving the aortic root most commonly comprises replacement of the aortic root and ascending aorta and re-implantation of coronary artery "buttons" (which contain a cuff of the native aortic wall) onto the composite aortic conduit. Almost thirty years ago, Cabrol and colleagues proposed an alternative technique for re-implantation of the coronary arteries where the coronary ostia are anastomosed to a second graft in an end-to-end fashion; this graft is then attached to the ascending aortic conduit side-to-side.[1] Most clinical studies have demonstrated inferior long-term outcomes of the Cabrol technique compared to the direct "button" reconstruction.[2] However, both the original Cabrol and its published modifications could provide an invaluable alternative when safe aortocoronary anastomosis is hindered, such as in extreme aortic dilatation, heavily calcified aorta, and re-operations.

The optimal methods for the non-invasive functional and anatomical assessment of the results of this procedure have not been clearly defined in the literature, as the Cabrol is rarely performed nowadays and is often reserved as a second-line or bailout procedure. Concurrently, advances in non-invasive monitoring, including 3-dimensional and speckle tracking techniques, stress echocardiography and cardiac magnetic resonance, have not been applied in this rarely performed reconstruction. The aim of this case report is to highlight the evolving role, but also the challenges and limitations, of modern echocardiographic and magnetic resonance imaging modalities in the assessment of the functional performance of a modification of the Cabrol aortic root replacement.

Case presentation

A 57-year-old male patient with severe symptomatic aortic stenosis underwent aortic valve replacement. Intraoperatively, a bicuspid valve was encountered with asymmetrically placed coronary ostia. The valve was successfully replaced but, due to the friability of the aortic wall secondary to bicuspid aortopathy, significant bleeding of the aortotomy occurred that was not adequately controlled with appropriate surgical manoeuvres. The aortotomy was revisited and a tear of the aortic wall was identified that necessitated its replacement. The aortic root and ascending aortic replacement was performed using a modification of the Cabrol procedure. The graft configuration and technical points of this modification have been described previously.[3] In summary, the graft to the right coronary artery was anastomosed directly onto the valved conduit and the graft to the left main stem onto the previous right aortocoronary graft in a T-fashion. An intra-operative transoesophageal echocardiogram confirmed a suitable position of the aortic valve, with no rocking motion or any leak seen and with a peak aortic velocity of 2.4 m/s (peak pressure gradient 23 mmHg, mean pressure gradient 12 mmHg, aortic effective orifice area 1.7 cm^2), blood pressure 100/67 mmHg and heart rate 95 beats per minute immediately after cardiopulmonary bypass. The patient made an uneventful recovery and was discharged home on the eighth postoperative day.

Postoperative assessment was carried out 8 weeks following hospital discharge and included conventional transthoracic and Doppler echocardiographic examinations, real-time three-dimensional echocardiography, speckle tracking and a four-dimensional magnetic resonance reconstruction of the aorta and the coronary grafts.

Two-dimensional echocardiography confirmed a peak aortic velocity of 2.5 m/s (peak pressure gradient 25 mmHg, mean pressure gradient 14 mmHg, aortic effective orifice area 1.6 cm^2) with blood pressure 138/80 mmHg and heart rate 76 beats per minute. Systolic function was evaluated with real-time three-dimensional echocardiography, which confirmed good biventricular systolic function with left ventricular (LV) end-diastolic volume 98 ml, LV end-systolic volume 39 ml and LV ejection fraction 59% (Figure 1). There was significant regression of LV myocardial mass (124 g). Speckle tracking was also performed for the assessment of the effect of the composite graft and valve on myocardial diastolic function (Figure 2). LV diastolic function was not altered postoperatively, with no significant change in radial and longitudinal strain (global and regional). The assessment of the coronary arteries was performed with a myocardial perfusion study using SonoVue (second-generation ultrasound contrast agent consisting of phospholipid-stabilised microbubbles filled with sulphur hexafluoride), grey-scale harmonic contrast echocardiography and stress imaging with dobutamine, which confirmed normal coronary flow through all coronary arteries (Figure 3). There were no stunned or hiber-

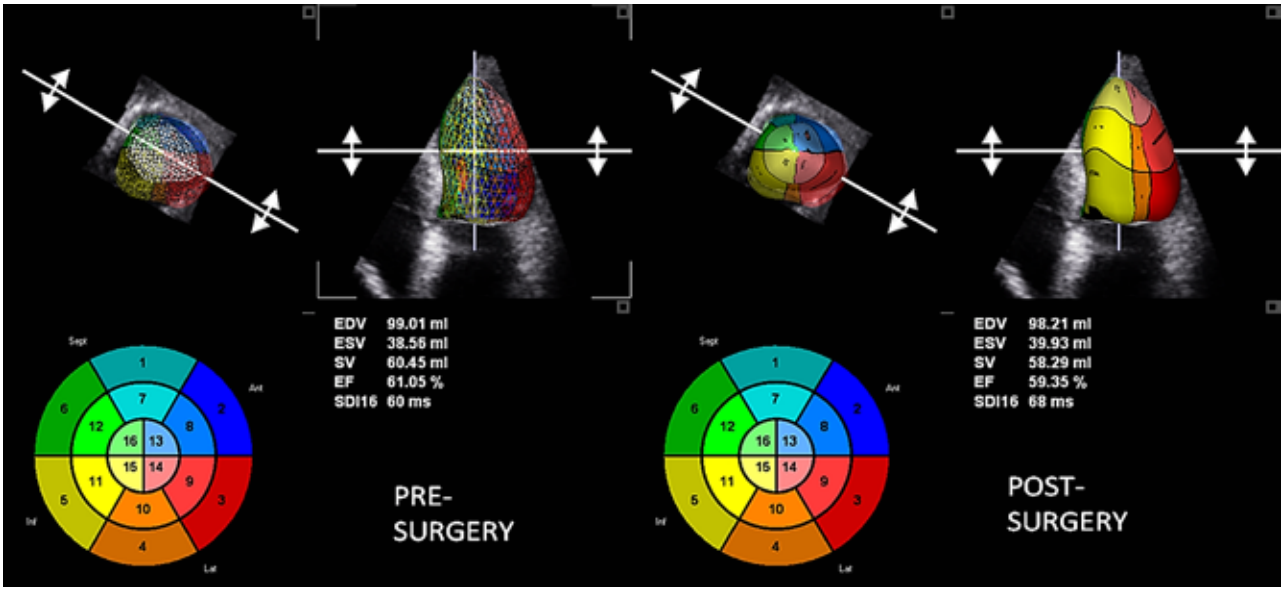

Figure 1. Real time three-dimensional echocardiography immediately pre- and 8 weeks post modified Cabrol.

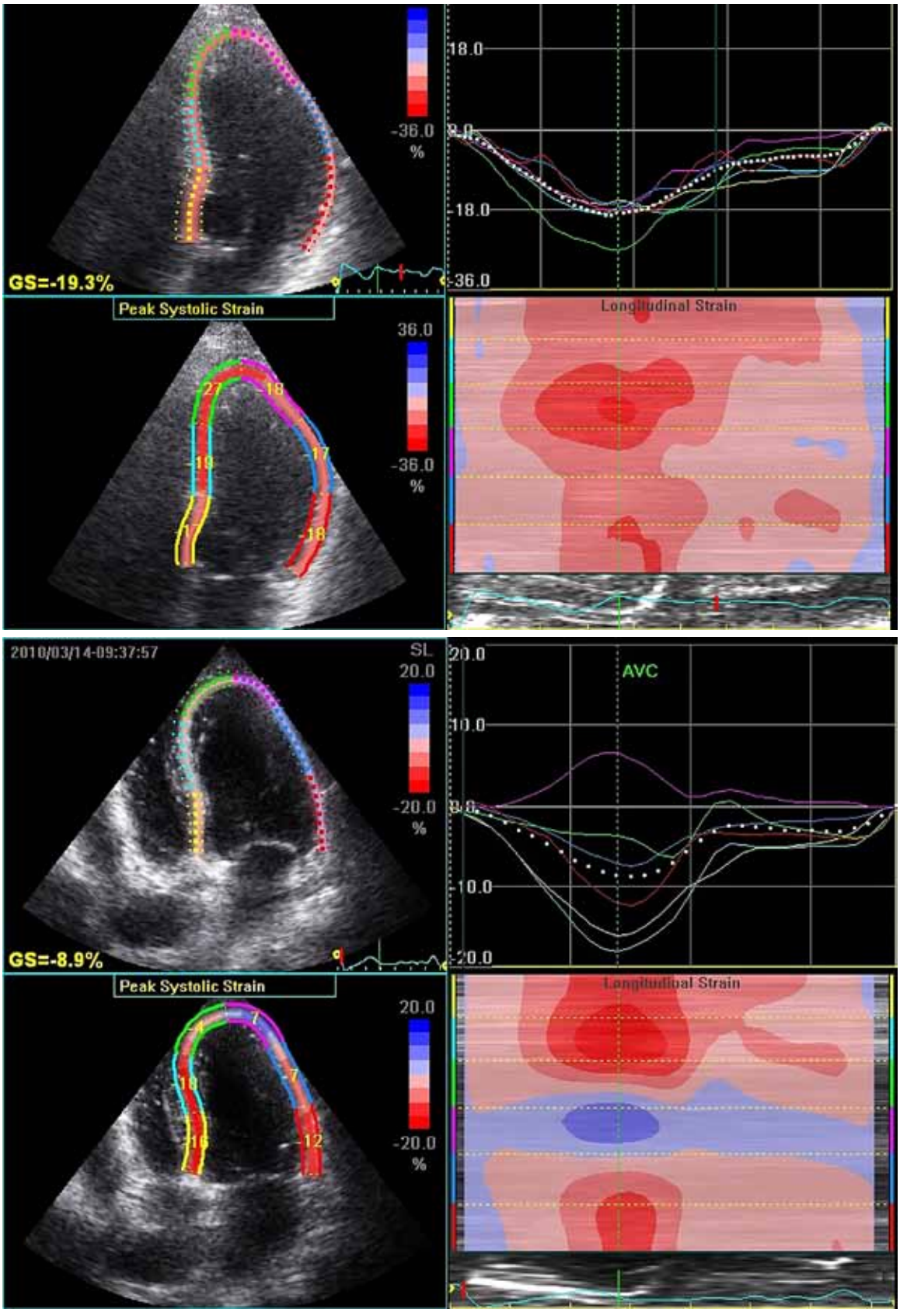

Figure 2. Speckle tracking immediately preoperatively (top) and 8 weeks postoperatively (bottom): radial and longitudinal strain were similar.

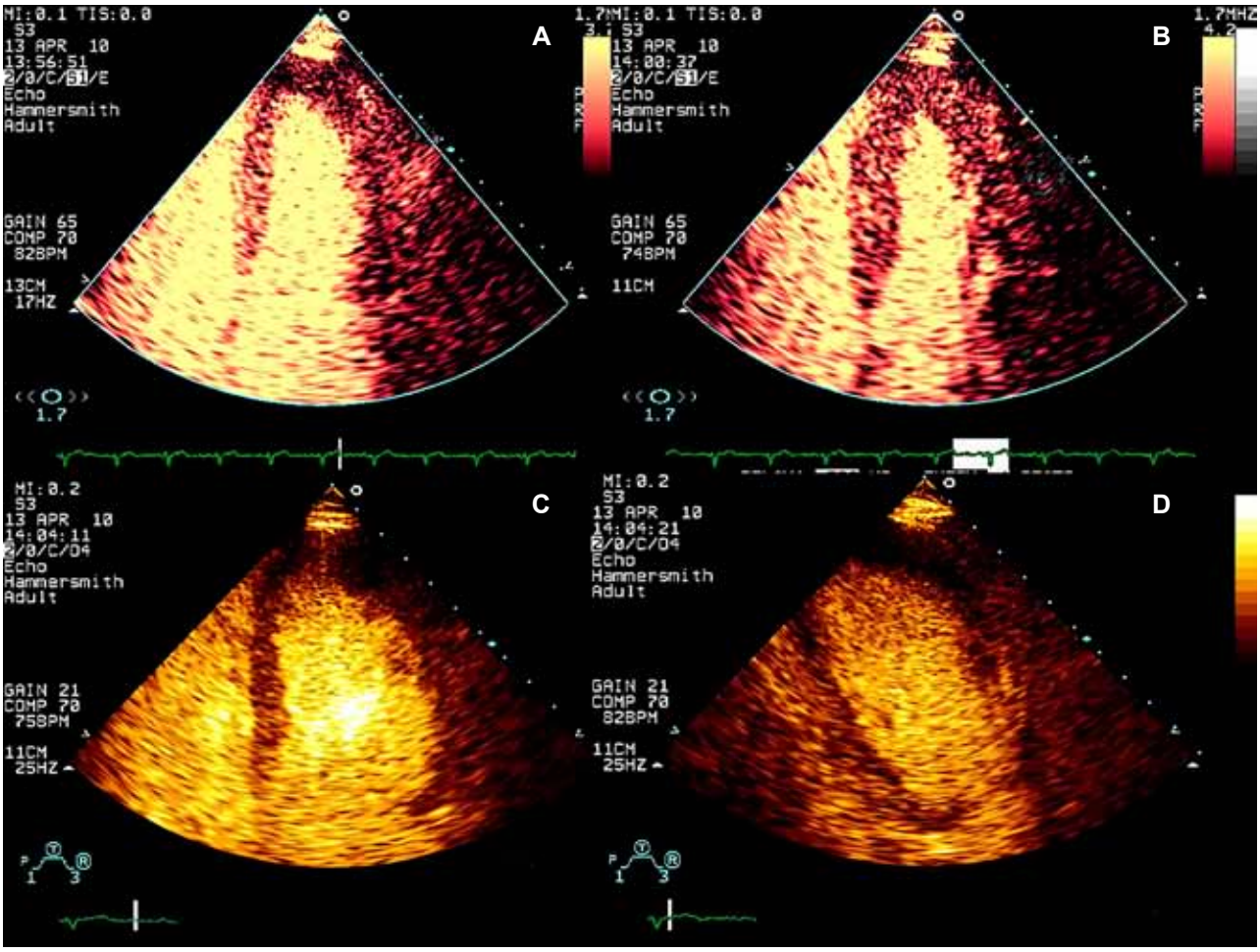

Figure 3. Myocardial perfusion imaging did not demonstrate a perfusion deficit (A, B). Dobutamine stress echocardiography showed good ventricular function at peak stress (C, D).

nating myocardial regions. Stress echocardiography has a high sensitivity and specificity for the diagnosis of significant coronary disease and it allows for reliable definition of the anatomical location and extent of the viable myocardium. Finally, four-dimensional reconstruction magnetic resonance scanning demonstrated the successful grafting in a T-fashion of the previous right aortocoronary graft to the left main stem as well as of the graft to the right coronary artery (Figure 4).

Discussion

With this case presentation, in the era of advanced non-invasive imaging, we would like to emphasise the complimentary role of several modalities that should be validated in the assessment of complex aortic reconstructions, such as the Cabrol procedure and its modifications, especially when there are no currently available guidelines for the optimal follow up in terms of timing, modality and intensity. The following considerations are important for the complete functional and anatomical assessment of the Cabrol.

Firstly, an intraoperative modality such as transoesophageal echocardiography has particular value in the assessment of the operative result, allowing an early diagnosis of technical errors related to valve function and flow of graft to coronary anastomosis. Bi-leaflet mechanical prosthesis assessment can sometimes be challenging because of severe reverberations and acoustic shadowing. Undoubtedly, transoesophageal echocardiography is superior to transthoracic for mechanical prosthesis assessment.[4]

Secondly, the origins of coronary arteries can be identified on transthoracic imaging. During the Cabrol operation, the coronary graft is interposed between the two coronary ostia and then anastomosed to the ascending aortic graft in a perpendicular fash-

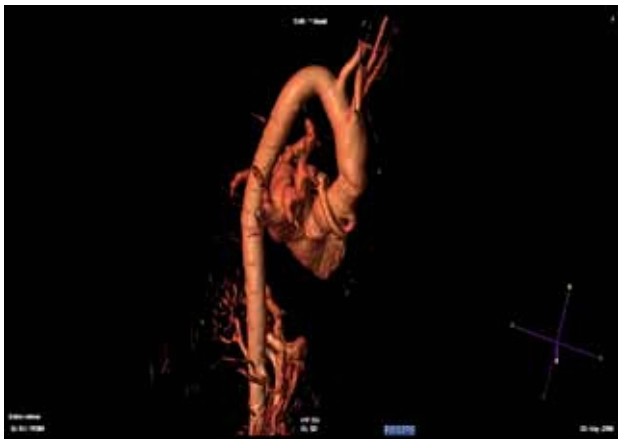

Figure 4. Magnetic resonance image showing the anatomical characteristics of modified Cabrol aortic root replacement and confirming smooth graft to coronary ostia alignment.

ion. Doppler echocardiography can be used to interrogate the flow inside the coronary tube graft, in a manner similar to the investigation of coronary artery flow.[4] With the Nyquist limit set at 50 cm/s, colour Doppler mapping of an unobstructed coronary graft will reveal laminar flow. The colour flow Doppler signal can also be used to facilitate the position of the pulsed Doppler sample volume. Spectral display should confirm the presence of pulsatile flow in the same direction in systole and diastole, with a predominant diastolic wave. However, the increased angle between Doppler and graft may not favour accurate measurement of blood flow velocity. The coronary tube graft dimensions may also be measured, but correct alignment of continuous Doppler with the valve can accurately assess the peak pressure gradient as well as the effective orifice area, which are specific for each manufacturer.

Thirdly, real time three-dimensional echocardiography has a growing role in the evaluation of LV systolic function and it has demonstrated good agreement with cardiac magnetic resonance, with a low measurement bias.[5] It has to be taken into consideration that there might be a slight underestimation of volumes, ejection fraction and mass when compared to magnetic resonance, especially when the LV is dilated. Complementary to the evaluation of systolic function is the assessment of diastolic function as performed with speckle tracking. Our assessments in this case are in agreement with the results of Rost and colleagues, who confirmed regression of LV myocardial mass, unchanged LV ejection fraction and improved LV myocardial strain up to 6 months after aortic valve replacement.[6] Lindqvist and colleagues further emphasised the normalisation of subendocardial function in patients with a normal ejection fraction following valve replacement for aortic stenosis.[7]

Finally, the most important component of the non-invasive assessment following the Cabrol procedure is myocardial perfusion imaging and a postoperative stress echocardiogram with dobutamine. Second-generation ultrasound contrast agents consisting of phospholipid-stabilised microbubbles (SonoVue) have significant stability and resistance to pressure. The possibility of detecting myocardial perfusion defects using SonoVue-enhanced power Doppler and grey-scale harmonic contrast echocardiography have been associated with continuous and intermittent imaging in patients with coronary artery disease.[8,9] The results obtained have been compared with corresponding 99 mTc sestamibi single-photon emission computed tomography images and proved to have significant sensitivity and specificity.[9] The stress echocardiography confirms normal coronary perfusion at peak stress with dobutamine.

It is important to note that significant limitations in the echocardiographic assessment are high body mass index or respiratory disease, which might be responsible for poor-quality acoustic windows. Furthermore, SonoVue manufacturers have overcome some of the disadvantages that limited its use, and it has been proved to be safe for clinical practice.[10]

The last component of the Cabrol assessment is the confirmation of a smooth alignment of graft to coronary ostia anastomosis, in order to avoid ischaemia and compromised graft patency. Cardiac magnetic resonance remains an imaging modality of high sensitivity and specificity for functional and anatomic assessment post-Cabrol. New techniques, such as the four-dimensional reconstruction of major vessels, delineate the successful position of coronary grafts. Limitations for cardiac magnetic resonance are still claustrophobia, arrhythmias that might cause significant artefacts in the image acquisition, and the presence of a pacemaker.[5] Technically, magnetic resonance still has difficulty in assessing the progress of intraluminal abnormalities of the graft and flow dynamics.

It is important for the non-invasive multi-imaging assessment of the aortic root, valve and biventricular function to be performed quite early, at 6-8 weeks postoperatively. Depending on the patient's symptoms and functional class, a routine echocardiographic assessment should take place in a follow up

examination after 6 months and every year thereafter, to assess valve function and regional wall function. The combination of anticoagulation with warfarin and echocardiographic assessment yearly for the first five years may improve the incidence of adverse events following the Cabrol root replacement and enhance its role in current surgical practice. Although the choice of each modality is related to its availability and expertise, prospective studies are required to validate their role in patients undergoing a Cabrol operation.

References

1. Cabrol C, Pavie A, Gandjbakhch I, et al. Complete replacement of the ascending aorta with reimplantation of the coronary arteries: new surgical approach. J Thorac Cardiovasc Surg. 1981; 81: 309-315.
2. Gelsomino S, Frassani R, Da Col P, et al. A long-term experience with the Cabrol root replacement technique for the management of ascending aortic aneurysms and dissections. Ann Thorac Surg. 2003; 75: 126-131.
3. Kourliouros A, Grapsa J, Nihoyannopoulos P, Athanasiou T. Modification of the Cabrol as a bailout procedure in complicated bicuspid valve aortopathy. Interact Cardiovasc Thorac Surg. 2011; 12: 199-201.
4. Leverich A, Johnston C, Stiles B, Girardi L, Hartman G, Skubas NJ. Cabrol composite graft for aortic root replacement: echocardiographic imaging. Anesth Analg. 2009; 108: 1107-1109.
5. Macron L, Lim P, Bensaid A, Nahum J, et al. Single-beat versus multibeat real-time 3D echocardiography for assessing left ventricular volumes and ejection fraction: a comparison study with cardiac magnetic resonance. Circ Cardiovasc Imaging. 2010; 3: 450-455.
6. Rost C, Korder S, Wasmeier G, et al. Sequential changes in myocardial function after valve replacement for aortic stenosis by speckle tracking echocardiography. Eur J Echocardiogr. 2010; 11: 584-589.
7. Lindqvist P, Bajraktari G, Molle R, et al. Valve replacement for aortic stenosis normalizes subendocardial function in patients with normal ejection fraction. Eur J Echocardiogr. 2010; 11: 608-613.
8. Gaibazzi N, Squeri A, Reverberi C. Flash-phase images to detect coronary artery stenosis: a novel finding during contrast-echocardiography. Eur J Echocardiogr. 2010; 11: E4.
9. Rovai D, Morales MA, Amyot R, L'Abbate A. Clinical experience with SonoVue in myocardial perfusion imaging. Echocardiography. 2000; 17: S17-23.
10. Anantharam B, Chahal N, Chelliah R, Ramzy I, Gani F, Senior R. Safety of contrast in stress echocardiography in stable patients and in patients with suspected acute coronary syndrome but negative 12-hour troponin. Am J Cardiol. 2009; 104: 14-18.