Preoperative Simulation Using CT Virtual Endoscopy for Minimally Invasive Surgery of Hypertrophic Obstructive Cardiomyopathy

Toshinori Totsugawa, MD, Masatoshi Tsunoda, MD, Nobuyuki Kagiyama, MD, Yuki Otsuki, MD, Hidenori Yoshitaka, MD and Taichi Sakaguchi, MD

Summary

Transaortic septal myectomy is a procedure that involves a learning curve for surgeons because the bulging interventricular septum usually interferes with the visualization of the deep parts of the left ventricular chamber. In this case report, we demonstrate computed tomography virtual endoscopy for preoperative simulation, which enabled us to clearly image the relationship among the bulging septum, the expected myectomy area, and the structures deep in the left ventricle, such as the papillary muscle and abnormal muscular bundles, which are hidden by the hypertrophic septum, thus preventing visualization. This approach could make minimally invasive transaortic septal myectomy safe and easy.

Key words: Right minithoracotomy, Septal myectomy, Computed tomography

Hypertrophic obstructive cardiomyopathy (HOCM) is one type of hypertrophic cardiomyopathy, with a rate of major adverse cardiac events that is significantly higher in HOCM patients than in non-HOCM patients. Transaortic septal myectomy, which was first reported by Morrow, is now an essential therapeutic option for the treatment of HOCM. The recent technical development of minimally invasive surgery allowed this procedure to be performed through a right minithoracotomy. However, minimally invasive transaortic myectomy is technically challenging because the bulging interventricular septum (IVS) interferes with the visualization of the deeper aspects of the left ventricular chamber. In this case report, we demonstrate that preoperative simulation using computed tomography (CT) virtual endoscopy makes this complicated procedure safer and easier.

Case Report

A 61-year-old woman was diagnosed with HOCM in 2001 and was followed up with administration of cibenzoline succinate. In 2016, she presented with dyspnea, which worsened with effort, and was admitted to our hospital for surgery. The level of brain natriuretic peptide was 444 pg/mL. A transthoracic echocardiogram (TTE) revealed that the peak pressure gradient of the left ventricular outflow tract (LVOT) was 110 mmHg, and the thickness of the interventricular septum (IVS) was 16 mm (Figure 1A). A transesophageal echocardiograph (TEE) showed asymmetric septal hypertrophy and subaortic stenosis with a circular fibrous shelf (Figure 1B). A volume-rendered image of contrast-enhanced CT scan revealed two abnormal muscular bundles attached to the IVS (Figure 2A). Preoperative simulation was performed using CT virtual endoscopy for minimally invasive transaortic septal myectomy (Figure 3A, D, G).

Minimally invasive surgery was performed through a 7-cm thoracotomy at the 3rd intercostal space, as we previously reported. The subvalvular membranous tissue (Figure 3B) was extended to the right coronary cusp and the circular fibrous shelf was completely removed (Figure 3C). Then the IVS was resected with a 1-cm wide, 8-mm deep, 2.5-cm long incision (Figure 3E), based on the oblique multi-planar reconstruction image of contrast-enhanced CT scan (Figure 2B). Two abnormal muscular bundles (Figure 2A) beyond the bulging septum were also excised to prevent systolic anterior motion of the mitral valve (Figure 3H, I). Finally, the tip of the papillary muscle became visible (Figure 3F).

Her postoperative course was uneventful except for air leaks. She was discharged 15 days after the surgery. A postoperative echocardiography revealed peak LVOT pressure gradient of 5 mmHg without systolic anterior motion of the mitral leaflet (Figure 1C).

Discussion

Recent advances in imaging technology are remark-
Figure 1. A: A preoperative TTE showed asymmetric septal hypertrophy (arrow). B: A TEE revealed a subaortic stenosis with a circular fibrous shelf (arrows) on the bulging septum. C: There was no LVOT stenosis on TTE after the surgery (arrow).

Figure 2. A: A three-dimensional CT scan revealed two abnormal muscular bundles (arrowheads) attached to the hypertrophic septum (asterisk) beneath the subaortic stenosis (arrow). B: The depth and distance of myectomy (double-headed arrows) was decided prior to surgery, based on the oblique multi-planar reconstruction image.

able. Virtual endoscopy is a new post-processing method to simulate the tracks like a flexible endoscope.3) Three-dimensional image datasets of the organ structures are required for virtual visualization; therefore, multidetector-row CT scan is the most popular modality today. There are some reports on virtual endoscopy for the diagnosis of cardiovascular diseases,4,5) however, we could not find a report on virtual endoscopy applied to simulation for sur-
**Figure 3.**  
A: A CT virtual endoscopic view of the circular subaortic stenosis. B: Surgeon’s view of the whitish subaortic stenosis. C: The bulging septum appeared after removal of the fibrous shelf. D: A CT virtual endoscopic view of the hypertrophic septum. The black line is the expected line of myectomy. AML, anterior mitral leaflet. E: Surgeon’s view of the bulging septum. The abnormal muscular bundles attached to the IVS were not seen because of the septal hypertrophy. F: Surgeon’s view after myectomy. The tip of the papillary muscle appeared (arrow). G: A CT virtual endoscopic view beyond the hypertrophic septum. Relationship between the two abnormal muscular bundles (arrowheads) and the expected myectomy area was well recognized by CT virtual endoscopy. PM indicates papillary muscle. H and I: The abnormal muscular bundles (black and white arrowheads) were successively resected using minimally invasive scissors following myectomy.

Surgery. This is the first report of preoperative simulation using CT virtual endoscopy for minimally invasive surgery for HOCM. The virtual endoscopic view enabled us to image clearly the relationship among the bulging IVS, the expected myectomy area, and the structures deep in the left ventricle, such as the papillary muscle and abnormal muscular bundles, which are usually hidden by the hypertrophic septum, thus preventing visualization. Although transaortic septal myectomy is a procedure that involves a learning curve for surgeons, preoperative simulation using CT virtual endoscopy could make this procedure safer and easier, as it is a minimally invasive approach.

**Disclosures**

**Conflicts of interest:** None.

**References**


