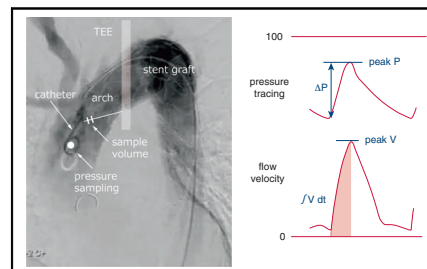


A simplified assessment of increased afterload by thoracic endovascular aortic repair



Kazumasa Orihashi, MD, Nankoku, Japan

From the Second Department of Surgery, Kochi Medical School, Nankoku, Japan.
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 Address for reprints: Kazumasa Orihashi, MD, Second Department of Surgery, Kochi Medical School Kohasu, Oko-cho, Nankoku, Kochi 783-8505 Japan (E-mail: orihashik@kochi-u.ac.jp).
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Afterload and workload drawn from simultaneous recordings of blood flow and pressure in the arch.

CENTRAL MESSAGE

Cardiac afterload and workload calculated from blood flow and pressure in the arch showed significant increases following TEVAR.

See Commentary on page 14.

▶ Video clip is available online.

Thoracic endovascular aortic repair (TEVAR) has been extensively applied to those patients with a life-threatening aneurysm who have inferior tolerance to open surgery,

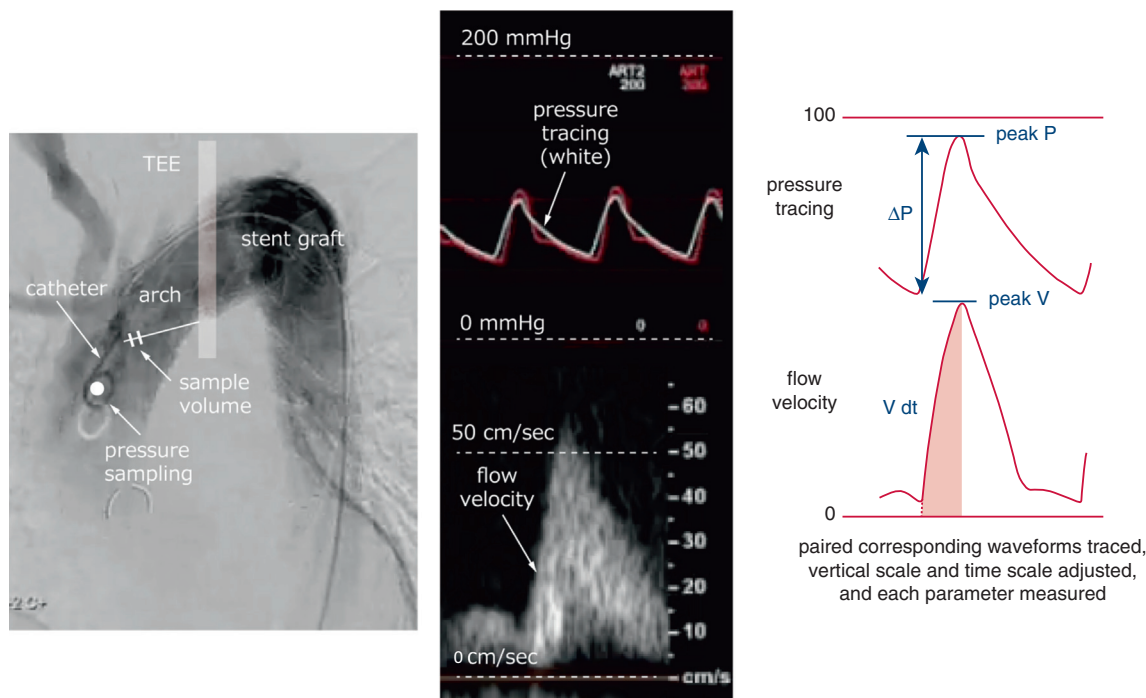
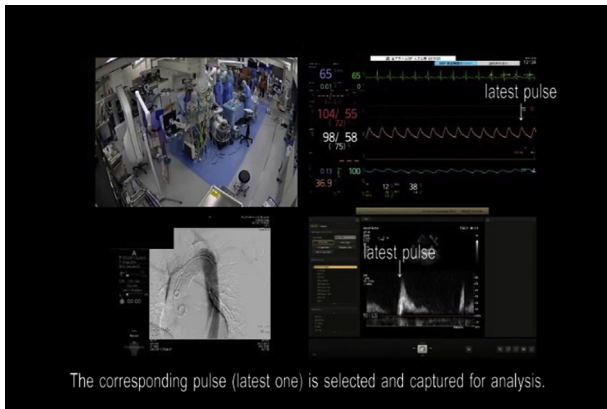


FIGURE 1. Method of data collection and parameters. The pressure and flow velocity were recorded simultaneously via a catheter for angiography and with transesophageal echocardiography. Pairs of corresponding waveforms were traced, and each parameter was measured (see also [Video 1](#)). TEE, Transesophageal echocardiography.



VIDEO 1. Demonstration of the process of simplified analysis from the 4 simultaneous displays to measurements of each parameter. Video available at: [https://www.jtcvs.org/article/S2666-2507\(19\)30061-6/fulltext](https://www.jtcvs.org/article/S2666-2507(19)30061-6/fulltext).

such as those with chronic heart failure. However, TEVAR has been shown to increase aortic stiffness in animal models^{1,2} and can potentially lead to decompensated heart failure. By means of exercise echocardiography, Hiraoka and colleagues³ found higher afterload in patients following TEVAR compared with patients who did not undergo TEVAR. However, there are no clinical data on the variations in cardiac afterload and workload in individual patients following TEVAR. Here we present a simplified method for assessing immediate changes following TEVAR.

In a 76-year-old male patient who underwent TEVAR for a distal arch aneurysm, aortic pressure was recorded via a catheter for aortography, and blood flow velocity in the arch was simultaneously recorded by transesophageal echocardiography (TEE) before and after stent graft deployment. The pressure and velocity data recorded in a single screen were imported to an offline personal computer, and the corresponding pressure and velocity wave forms of 5 continuous beats was manually traced using a graphic software program, Adobe Illustrator CS 6 (Adobe Systems, San Jose, Calif). The following measurements were carried out

with the scales in the images used for calibration (Figure 1, Video 1).

First, aortic stiffness was assessed by the pressure rise relative to the volume of blood pumped into the arch, represented by the pulse pressure (ΔP , in mm Hg) and the time velocity integral of blood flow from the initial rise to the peak ($\int V dt$, in m). Second, the workload for pumping blood into the arch was assessed by the product of peak pressure (peak P, in mm Hg) and peak velocity (peak V, in m/seconds). The data were expressed as mean \pm standard deviation. Statistical analysis was performed using Student's *t* test.

The mean stiffness, $\Delta P / \int V dt$, increased significantly, from 0.82 ± 0.08 mm Hg/m to 1.34 ± 0.11 mm Hg/m ($P < .0001$), a 63.4% increase (Figure 2, A). The workload, peak P \times peak V, also increased significantly, from 41.1 ± 3.8 mm Hg \cdot m/second to 53.1 ± 4.1 mm Hg \cdot m/second ($P = .0018$), a 29.2% increase (Figure 2, B).

COMMENTS

This simplified assessment was feasible in the practical TEVAR procedure without the need for special equipment, and data collection took only a few minutes, although off-line analysis was necessary. Significant increases in aortic arch stiffness and cardiac workload were observed, although several parameters might have been omitted in the foregoing indices, and further investigation in a larger sample size is warranted to validate the accuracy of these assessments and determine whether they are relevant to prognosis. In this study, a pressure–volume curve analysis was not done, for 2 reasons: synchronization between pressure and velocity data could be inaccurate, and low flow velocity during diastole could be affected by nonlongitudinal rather than spiral flow in the arch, and only parameters of systolic phase were analyzed. The parameters shown in this study also may be applied to assess the risk of decompensation before TEVAR. However, because TEE and catheterization are invasive procedures, this method is suitable

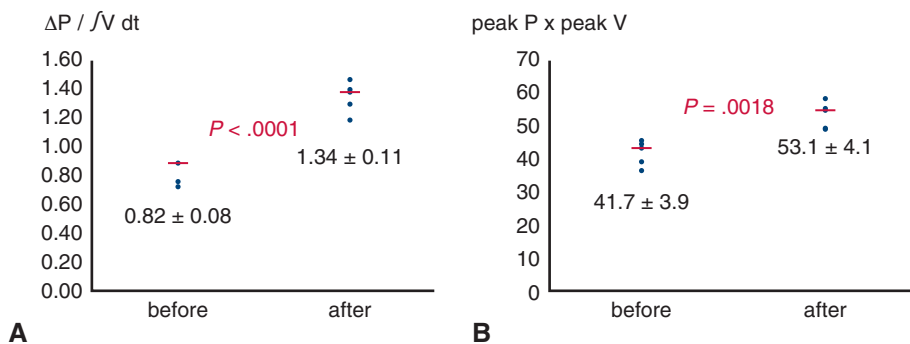


FIGURE 2. Changes in aortic stiffness and cardiac workload following stent graft deployment. A, The parameter of aortic stiffness, $\Delta P / \int V dt$, was significantly increased. B, The parameter of cardiac workload, peak P \times peak V, was also increased significantly. The red lines indicate median values.

for intraoperative use, especially when a large area of aorta is covered or when the heart is diseased, but not for determining the indication for TEVAR, but rather for evaluating risk during the postoperative care.

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