organs, it would be of interest to determine whether remote organ injury is blocked by therapeutic gas therapy.

The suggestions made by Dr Schibilsky et al regarding selective treatment of either donors or recipients are insightful. We also believe that testing the combined gas for different durations and with different timing (pre- or post-reperfusion) is important and will allow us to determine the minimal therapeutic dose and duration of inhaled gas and also to differentiate the protective effects of combined gas therapy at various stages. Reactive oxygen species (ROS) are generated to a greater extent at the onset of reperfusion; therefore, the best timing for combined gas therapy is likely immediately after reperfusion when ROS are generated. We have some reservations regarding donor pre-treatment, because this would be difficult to undertake in clinical practice. However, both CO and hydrogen prevent organ injuries and reduce systemic inflammation, suggesting that the combined gas therapy may mitigate graft injury prior to transplantation and may increase the number of potential donors.

We believe organ-targeted exposure of the therapeutic gas by dissolving the gas in perfusion and storage solution before implantation is likely a more clinically applicable and promising approach.[4] We agree that cardiac reperfusion using leukocyte-depleted blood cardioplegia solution followed by leukocyte-depleted non-cardioplegic blood is a promising, although technically demanding approach.[5] It is of interest to compare both strategies. Finally, we believe that blood cardioplegia can be administered concurrently with therapeutic medical gases during heart transplantation, and may lead to "additive" benefits.

Disclosure statement

The authors have no conflicts of interest to disclose.

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Biventricular support with the HeartWare implantable continuous flow pump: An additional contribution

To the Editor:

Although pulsatile device designs provide adequate cardiac output support, their large size and limited durability have hindered long-term success. Efforts in miniaturization of continuous-flow ventricular assist devices (VADs) enabled their application in patients of a broader range of body sizes.[1–3]

The HeartWare HVAS (HeartWare Inc, Miramar, FL) uses a hybrid system for suspending the impeller, the only moving part, within the pump. The suspension uses a combination of passive magnets and a hydrodynamic thrust bearing that operates by establishing a cushion of blood between the impeller and the pump housing. Once power is applied to the device, there are no points of mechanical contact within the pump, ensuring a completely "wearless" system.[1–3]

We report our novel surgical approach in an implantable bi-VAD by using the novel HeartWare HVAS, a concept recently reported by the Berlin group.[1] A 44-year-old Korean man with end-stage biventricular heart failure received a HeartWare HVAS as bi-VAD for idiopathic dilative cardiomyopathy and Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) score of 2. The patient's body surface area was 1.6 m^2, associated with an extremely small chest size, with an anteroposterior distance from the posterior sternum to the anterior vertebral body at T10 on a computed tomography (CT) scan of < 10 cm.

After median sternotomy and during cardiopulmonary bypass, the left pump was implanted conventionally into the left ventricle apex, and the outflow graft was connected to the ascending aorta. The second pump as a right VAD was placed on the diaphragmatic wall of the right ventricle, just below the acute margin by transesophageal echocardiography guidance, with the inflow cannula associated with 2 additional silicone rings placed under the fixation ring (Figure 1). The outflow graft was narrowed before surgery to 5 mm, according to the Berlin diagram,[1] and was sutured to the pulmonary artery (Figure 1). The narrowing was similarly achieved by suturing a 3-cm-long piece of graft with 6-0 Prolene (Ethicon, Somerville, NJ) just 2 cm from the outflow connector over a 5-mm Hegar dilator introduced into the graft.

Both pumps were intrapericardial (Figure 2). The drivelines were tunneled and emerged in the lower abdominal quadrant on the left (left pump) and right (right pump) side (Figure 2). The pump speeds were adjusted individually, depending on hemodynamics, to achieve flow of approximately 5 to 6 liters/min (left pump) and 3 to 4 liters/min (right pump).

Anti-coagulation was targeted to an international normalized ratio 2.5 to 3. Aspirin was used as an anti-platelet agent. The anti-coagulation assessment was managed with

thromboelastometry analysis (ROTEM, Tem Intl GmbH, Munich, Germany).

The patient's postoperative course was uneventful. He was discharged home with 2 controllers and 4 batteries on postoperative Day 23. There has been no system malfunction, and no minor or major cerebrovascular events have occurred with the current duration of support of 59 days.

Support with HeartWare HVAS bi-VAD may allow patients with terminal biventricular heart failure to be discharged home and reintegrated into family life. The right pump placement on the diaphragmatic wall of the right ventricle may offer a solution for extremely small chest sizes. This novel strategy provides a good outcome and extends the indications criteria in terms of "system fitting."

The development of 1 controller and 2 batteries for both pumps in this type of support system should be investigated. The HeartWare MVAD axial flow-pump, not yet approved for use in human beings, might be an even "smaller" support solution for such particular patients.[4] However, further studies concerning this kind of mechanical biventricular support are necessary to evaluate the correct solution in such clinical scenarios.

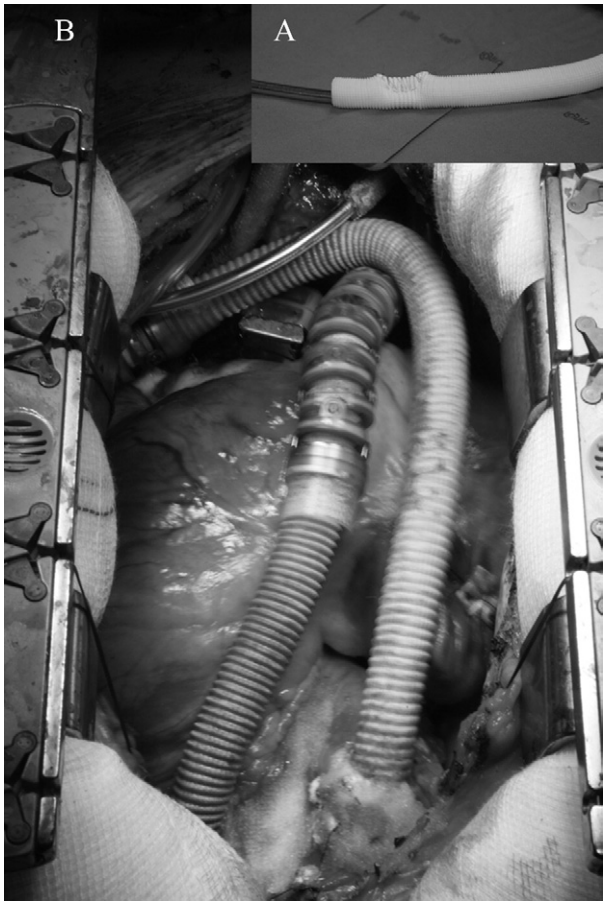

Figure 1 (A) The narrowing of HeartWare right ventricular assist device outflow graft. (B) Intraoperative view of HeartWare biventricular support placement.

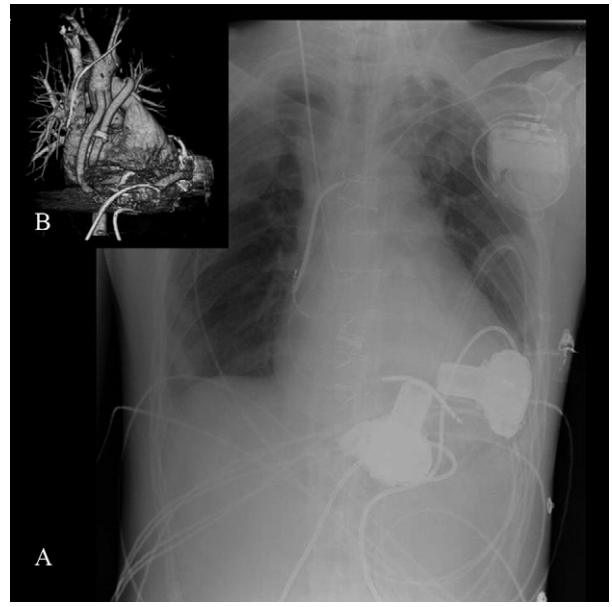

Figure 2 (A) Chest X-ray imaging shows the position of the HeartWare biventricular support device. (B) Position of the mechanical support HeartWare devices is shown in a 3-dimensional computed tomography (CT) reconstruction.

Disclosure statement

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