surpasses CABG in these selected short-term and mid-term clinical and resource outcomes. On the other hand, as far as bypass graft patency is concerned, CABG is superior to OPCAB according to several more recent meta-analyses of randomized controlled trials, including our meta-analysis.[2,4,5] The choice of which technique of OPCAB or CABG to use should be based not on the clinical experiences of respected authorities (type IV evidence) but on the above-mentioned best evidence.

We completely agree with Dr Gardner's statement: "Were it (OPCAB) not for our young colleagues who have championed OPCAB, the option of successfully using this approach when preferable to conventional CABG surgery would not exist today." We emphasize that OPCAB should not be performed when preferable to CABG because OPCAB sacrifices graft patency in such patients as were enrolled in the randomized controlled trials reviewed in our meta-analysis.

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doi:10.1016/j.jtcvs.2007.01.019

Precise quantification of pressure-flow waveforms during pulsatile and nonpulsatile perfusion

To the Editor:

We would like to congratulate Kassab and colleagues[1] on their experimental design and results concerning pulsatile cardioplegic delivery in improved subendocardial perfusion of the open failing ventricle when compared with nonpulsatile perfusion. We believe that their investigation is a good attempt to use pulsatile flow as a myocardial protective strategy during the cardiopulmonary bypass (CPB) procedure. Such information may be critical to enhance cardioprotective strategies in cardiac patients in the near future.

We would like to make several comments concerning direct comparison between pulsatile and nonpulsatile modes. We believe that it is essential to acquire precise quantification of pressure and pump-flow waveforms during direct comparison between perfusion modes.[2,3] It is insufficient to use the pulse pressure as the only criteria to define the pulsatile flow, because the generation of pulsatile flow depends on an energy gradient.[2-4] In addition to the pressure waveforms, the pump flow waveforms should also be included in the quantification. The precise quantification of pressure-flow waveforms in terms of hemodynamic energy, energy equivalent pressure (EEP), and surplus hemodynamic energy (SHE) levels is a must. Surplus hemodynamic energy is the "extra energy" generated only under adequate pulsatility.

The EEP formula is based on the ratio between the area beneath the hemodynamic power curve ($\int fpdt$) and the area beneath the pump flow curve ($\int fdt$) during each pulse cycle[4]:

$$\text{EEP} = (\int fpdt)/(\int fdt)$$

where f is the pump flow rate, p is the arterial pressure (mm Hg), and dt indicates that the integration is performed over time (t). The unit of the EEP is mm Hg. Therefore, it is possible to compare the EEP with the mean arterial pressure (MAP). The difference between the EEP and MAP is the extra energy or SHE generated by each pulsatile or nonpulsatile device.

In our studies on myocardial flow in direct comparison between two different modes in terms of EEP and SHE, pulsatile perfusion produced significantly higher hemodynamic energy than did nonpulsatile perfusion during CPB.[2,3,5] The pulsatile group had significantly better myocardial blood flow than had the nonpulsatile group; particularly, pulsatile flow improved left- and right-ventricular blood flow after 60 minutes of ischemia and hypothermic CPB in a piglet model.[5] In a recent clinical study, it has also been clearly documented that pulsatile flow resulted in significantly less inotropic support, shorter intubation time, and shorter duration of intensive care unit stay and hospital stay in 50 pediatric CPB patients.[6]

We congratulate the authors for their promising results and strongly suggest that they consider using the EEP and SHE formulas for direct comparisons of pulsatile and nonpulsatile perfusion for their future experiments.

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doi:10.1016/j.jtcvs.2006.10.076