NAD(+) prevents diminished O(2) consumption by immunostimulated Caco-2 cells. *Am J Physiol Lung Cell Mol Physiol*. 2002;282:L1082-91.

7. Szabó C. Pathophysiological aspects of cellular pyridine nucleotide metabolism: focus on the vascular endothelium. Review. *Acta Physiol Hung*. 2003;90:175-93.
8. Bianchi C, Wakiyama H, Faro R, Khan T, McCully JD, Levitsky S, et al. A novel peroxynitrite decomposer catalyst (FP-15) reduces myocardial infarct size in an in vivo peroxynitrite decomposer and acute ischemia-reperfusion in pigs. *Ann Thorac Surg*. 2002;74:1201-7.
9. Pacher P, Liaudet L, Bai P, Mabley JG, Kaminski PM, Virág L, et al. Potent metalloporphyrin peroxynitrite decomposition catalyst protects against the development of doxorubicin-induced cardiac dysfunction. *Circulation*. 2003;107:896-904.

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Interventional atrial incision in the Fontan operation: Novel prophylaxis or iatrogenic substrate for intra-atrial reentrant tachycardia?

To the Editor:

In the March 2004 issue of the *Journal*, Collins and colleagues¹ published short-term results of their interesting prospective, randomized, blinded trial to assess the feasibility, safety, and efficacy of an interventional atrial incision placed at the time of the Fontan operation to reduce the development of intra-atrial reentrant tachycardia (IART). Although the idea sounds clever, there are serious concerns about the long-term efficacy of their modification.

Staged palliation culminating in a successful Fontan procedure is the current surgical goal for most patients with a functional single ventricle. Since its introduction in 1968, the Fontan procedure has undergone many modifications.² At present, two modifications in common use are the lateral tunnel and extracardiac conduit.³ The incidence of late supraventricular tachycardia after a lateral tunnel procedure varies from 0% to 22%, and that after an extracardiac conduit operation varies from 0% to 8%.³ These figures definitely do not justify undertaking a prophylactic procedure for IART in all patients who undergo Fontan operation in the modern era. It is extremely difficult to predict with accuracy the patients who will definitely have IART.

An even more important concern is the high incidence of early sinus node dysfunction among the study patients. Early sinus node dysfunction may carry long-term im-

plications because it predicts late sinus node dysfunction,⁴ which in turn is associated with late supraventricular tachycardia.⁵ Although Collins and colleagues¹ attributed this high incidence to a "broad definition" of sinus node dysfunction, I think that the interventional atrial incision may be partially if not wholly responsible for this phenomenon. There is a consensus of opinion that the presence of a region of structural or functional block within the atria is a substrate for atrial muscle reentry.⁵ The Fontan operation results in regions of structural block as a result of atrial incisions and multiple suture lines, as well as functional block from relative right atrial hypertension with right atrial dilation and hypertrophy.⁵ The "prophylactic atrial incision" not only will act as region of structural block in the long term but probably interferes with the blood supply of the sinus node in the short term. This could well explain the high incidence of early sinus node dysfunction in the study.

In conclusion, the high prevalence of atrial arrhythmias is a result of extensive atrial surgical procedures, elevated atrial pressures, and atrial enlargement. Until modifications aimed at avoiding atrial manipulation are discovered, earlier identification of sinus node dysfunction with early institution of atrial pacing may be the best prophylaxis to decrease the incidence of IART in this group of patients. My message for Collins and colleagues in particular and readers in general is that any "prophylactic atrial incision" made with the best of intentions will act as nothing but a substrate for IART.

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References

1. Collins KK, Rhee EK, Delucca JM, Alexander ME, Bevilacqua LM, Berul CI, et al. Modification to the Fontan procedure for the prophylaxis of intra-atrial reentrant tachycardia: short-term results of a prospective randomized blinded trial. *J Thorac Cardiovasc Surg*. 2004;127:721-9.
2. Fontan F, Baudet E. Surgical repair of tricuspid atresia. *Thorax*. 1971;26:240-8.
3. Kumar SP, Rubinstein CS, Simsic JM, Taylor AB, Saul JP, Bradley SM. Lateral tunnel versus extracardiac conduit Fontan procedure: a concurrent comparison. *Ann Thorac Surg*. 2003;76:1389-96.
4. Cohen MI, Bridges ND, Gaynor JW, Hoff-

man TM, Wernovsky G, Vetter VL, et al. Modifications to the cavopulmonary anastomosis do not eliminate early sinus node dysfunction. *J Thorac Cardiovasc Surg*. 2000;120:891-900.

5. Fishberger SB, Wernovsky G, Gentles TL, Gauvreau K, Burnett J, Mayer JE, et al. Factors that influence the development of atrial flutter after the Fontan operation. *J Thorac Cardiovasc Surg*. 1997;113:80-6.

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Reply to the Editor:

The Fontan population is heterogeneous in terms of the underlying anatomy and number and nature of surgical interventions before the Fontan operation. Many factors are thought to be associated with the development of atrial arrhythmias in this group. Animal studies have suggested that surgical incision and extended suture lines are particularly likely to create an arrhythmogenic substrate.¹⁻³ The more recent versions of the Fontan procedure (lateral tunnel or the extracardiac conduit) have had lower reported incidences of late atrial arrhythmias than the older types of Fontan operations.⁴ Long-term follow-up of the extracardiac conduit Fontan operation has not yet been reported with respect to arrhythmia, but Stamm and colleagues⁴ have recently shown that the lower incidence of atrial tachycardia in the lateral tunnel Fontan procedure persisted through a mean 10-year follow-up.⁴ One can interpret this finding to mean that the current Fontan techniques are in fact less arrhythmogenic than was initially projected when our study was undertaken. If so, placement of an interventional atrial incision to the lateral tunnel Fontan may not be warranted in every case, only for patients deemed at higher risk (eg, with a preoperative history of atrial tachycardia).

Although avoiding atrial manipulation and suture lines altogether has theoretic benefits, it is not practical in all cases. If atrial suture lines are required for the surgical intervention, then choosing to place or extend them in such a way to reduce the likelihood of atrial arrhythmias is warranted. Our interventional atrial incision to the lateral tunnel Fontan procedure was designed to transect potential arrhythmia circuits around the atriotomy or the right atrioventricular valve, the primary areas where atrial arrhythmias typically develop. It was designed to be simple, to be feasible in patients with varied anatomy, and to have low added risks for the patient. The location of the incision is inferior to the