emphasize that stenting can be an effective mode of treatment of persistent coronary artery and graft vasospasm.

Pankaj Saxena, MCh, DNB
Igor E Konstantinov, MD, PhD
Mark A. J. Newman, FRACS
Department of Cardiothoracic Surgery
Sir Charles Gairdner Hospital
Nedlands, WA, Australia

References

1. Schena S, Wildes T, Beardslee MA, Lasala JM, Damiano RJ, Lawton JS. Successful management of unremitting spasm of the nongrafted right coronary artery after off-pump coronary artery bypass grafting. *J Thorac Cardiovasc Surg.* 2007;133:1649-50.
2. Saxena P, Konstantinov IE, Koniuszko M, Singh T, Newman MAJ. Persistent severe vasospasm in off-pump coronary artery bypass surgery: the value of intraluminal stenting. *J Thorac Cardiovasc Surg.* 2006;131:237-8.

doi:10.1016/j.jtcvs.2007.07.023

Surgery of Ebstein anomaly

To the Editor:

I read with great interest the article by Quinonez and colleagues¹ concerning surgical treatment of the Ebstein anomaly. This very informative article underlines the role of the right ventricle in the outcome of this congenital anomaly. As my colleagues and I² pointed out almost 10 years ago, impairment of the right ventricle is a major prognostic factor after surgery for the Ebstein anomaly. Inasmuch as medical therapy is difficult to manage, it seemed to us that the association of a bidirectional cavopulmonary shunt (BCPS) would be helpful in the early follow-up period. This continues to be our policy.

The term used by the authors, "1.5-ventricle," does not seem to me to be adequate. The flow of the superior vena cava varies between one third and one half of the cardiac output.³ The 1.5-ventricle concept is valid when one of the ventricles is anatomically partially deficient.

The article by Quinonez and associates does not answer a question that arises immediately: what are the indications for the BCPS? Their definition of "failing right ventricle" is not clear. In their series, 2 children were free of symptom, whereas, on the other hand, 3 adult patients were on the transplantation list. Right ventricular enlargement could be an indicator, but we

are still looking for quantitative data. In a study of the right and left ventricular volumes before and after surgery, my colleagues and I⁴ were unable to determine a threshold value for patients "at risk" and those that were "safe." In our experience, a large atrialized right ventricle (even if excluded after surgery), a very thin infundibular right ventricular wall, and/or a paradoxical septal motion are indications for a superior vena cava derivation. Among 105 patients with Ebstein repair and BPCS, we did not observe any deleterious effect of the shunt except for a transient swelling of the neck in 1 patient.

The BCPS does not solve all of the left and right ventricular problems. One of the patients in the authors' series is not improved and 2 in our own series had to undergo transplantation.

However, the associated anastomosis is an excellent additional procedure in patients with difficult indications.

S. Chauvaud, MD
Cardiovascular Surgery Department
Hôpital Européen Georges Pompidou
Paris, France

References

1. Quinonez LG, Dearani JA, Puga FJ, O'Leary PW, Driscoll DJ, Connolly HM, et al. Results of the 1.5-ventricle repair for Ebstein anomaly and the failing right ventricle. *J Thorac Cardiovasc Surg.* 2007;133:1303-10.
2. Chauvaud SM, Fuzellier JF, Berrebi A, Lajos P, Marino JP, Mihaileanu S, et al. Bidirectional cavopulmonary shunt associated with ventriculo and valvuloplasty in Ebstein's anomaly: benefits in high risk patients. *Eur J Cardiothorac Surg.* 1998;13:514-9.
3. Selim MA, Baffa JM, Vetter JM, Chen SL, Chin AJ, Norwood WI Jr. Changes in right ventricular geometry and heart rate early after hemi-Fontan procedure. *Ann Thorac Surg.* 1993;55:1508-12.
4. Chauvaud SM, Hernigou AC, Mousseaux ER, Sidi D, Hébert JL. Ventricular volumes in Ebstein's anomaly: x-ray multislice computed tomography before and after repair. *Ann Thorac Surg.* 2006;81:1443-9.

doi:10.1016/j.jtcvs.2007.06.036

Reply to the Editor:

My colleagues and I thank Dr Chauvaud for his comments and acknowledge the contribution of his team to the surgical treatment of Ebstein anomaly.

The use of the term "1.5-ventricle" was a semantic choice used to represent an operation, rather than a quantitative or physi-

ologic descriptor. It is widely understood that diversion of blood flow by a bidirectional cavopulmonary shunt (BCPS) varies from one third to one half of the systemic venous return, depending on the patient's age.

To decide when to construct a BCPS, the surgeon has to use his or her judgment and experience and take into consideration the patient's clinical condition, echocardiographic data, magnetic resonance imaging data (if available), preoperative and intraoperative hemodynamic data, and the intraoperative morphologic appearance of the right ventricle. The status of the left ventricle is also very important. Our series is too limited to advise as to the specific indications of a BCPS in Ebstein anomaly, yet with further experience and follow-up these will become apparent. It is our impression that it is only needed in a few selected cases.

The term "failing right ventricle" is deliberately general. It may describe a right ventricle that cannot sustain the circulation after cardiopulmonary bypass; it may describe a right ventricle that is severely dysfunctional or dilated on echocardiography, magnetic resonance imaging, or intraoperative inspection; or it may describe a right ventricle with a large atrialized component, a thin wall, and paradoxical septal motion, as pointed out by Dr Chauvaud. In any of these circumstances, the patient may be free of symptoms. The underlying difficulty arises in the precise quantification of right ventricular function by the currently available methods. We are exploring the use of magnetic resonance imaging to better describe and quantitate the morphology and function of the right ventricle.

Luis G. Quinonez, MD
University of Alberta Hospital
Edmonton, Alberta, Canada
doi:10.1016/j.jtcvs.2007.07.018

The conduct of experimental circulatory arrest: The search for clinical relevance

To the Editor:

I read with great interest the excellent laboratory study by Dr Ananiadou and colleagues¹ detailing the neuroprotective effect of profound hypothermia at 10°C after 75 minutes of circulatory arrest in an acute porcine model (N = 12). The described neuroprotective mechanism

may involve antiapoptotic effects. The discussion about this study focused on the neuroprotective balance between the degree of hypothermia and the duration of circulatory arrest.¹

An important consideration is that the 75-minute duration of circulatory arrest in this animal study exceeds the typical clinical range of minutes (30–50 minutes).^{2–4} Why not study the effects of profound hypothermia in an experimental model that includes clinically relevant durations of circulatory arrest? Why not study brain apoptosis during profound hypothermia at time intervals of 10 minutes within the clinical range to calibrate the degree of hypothermia with the duration of ischemia? The answers to this series of questions would provide additional laboratory evidence that could perhaps guide clinical conduct of hypothermia for optimal neuroprotection.

This kind of pitfall may be a theme in experimental circulatory arrest: The conduct of hypothermic circulatory arrest in the laboratory setting is significantly different from that in the clinical setting. As a consequence, the laboratory findings are diluted in translation, resulting in a laboratory–clinical divide that may slow progress toward the optimal clinical conduct of circulatory arrest.

Perhaps it is time for the development of guidelines for the laboratory study of circulatory arrest and regional cerebral perfusion, given the considerable current controversy in infant perfusion management.^{2–4} To my knowledge, no such guidelines have been published. The guidelines could follow a series of deliberations among both clinical and laboratory experts in this area to develop answers to questions such as the following:

1. What is the recommended study interval of circulatory arrest?
2. What depths of hypothermia should be studied at which durations of circulatory arrest?
3. What neuroprotective interventions require further laboratory study in a clinically relevant model?
4. How should a particular neuroprotective intervention best be studied in the laboratory for maximal clinical utility?
5. Which is the most clinically relevant laboratory model of regional cerebral perfusion?

6. Which are the most important questions for further study with respect to optimizing the practice of regional cerebral perfusion?

I congratulate Dr Ananiadou and colleagues¹ on their excellent study that has raised many thought-provoking questions. I look forward to their feedback and the ongoing progress in this area.

John G. T. Augoustides, MD, FASE

Department of Anesthesiology and

Critical Care

Hospital of the University of Pennsylvania

Philadelphia, Pa

Financial Support: Department of Anesthesiology and Critical Care Hospital of the University of Pennsylvania.

References

1. Ananiadou OG, Bibou K, Drossos GE, Charchanti A, Bai M, Haj-Yahia S, et al. Effect of profound hypothermia during circulatory arrest on neurologic injury and apoptotic repressor protein Bcl-2 expression in an acute porcine model. *J Thorac Cardiovasc Surg.* 2007;133:919-26.
2. Hanley FL. Religion, politics . . . deep hypothermic circulatory arrest. *J Thorac Cardiovasc Surg.* 2005;130:1236.
3. Wypij D, Newburger JW, Rappaport LA, du Plessis AJ, Jonas RA, Wernovsky G, et al. The effect of duration of deep hypothermic circulatory arrest in infant heart surgery on late neurodevelopment: the Boston Circulatory Arrest Trial. *J Thorac Cardiovasc Surg.* 2003;126:1397-403.
4. Goldberg CS, Bove E, Devaney EJ, Mollen E, Schwartz E, Tindall S, et al. A randomized clinical trial of regional cerebral perfusion versus deep hypothermic circulatory arrest: outcomes for infants with functional single ventricle. *J Thorac Cardiovasc Surg.* 2007;133:880-7.

doi:10.1016/j.jtcvs.2007.05.068

Reply to the Editor:

Although the deleterious effects of prolonged exposure to cardiopulmonary bypass on brain function and structure have been demonstrated, neuroprotective strategies, particularly deep hypothermia and circulatory arrest (DHCA), remain an issue of debate. This is related in part to the gap between the experimental understanding of brain injury and the clinical application of various neuroprotective strategies. As suggested by Dr Augoustides, this gap can be attributed to the lack of clinically relevant guidelines for effective laboratory study of circulatory arrest.

Our goal was to assess one possible mechanism of neuronal injury after DHCA. Because apoptosis seems to involve a subtle and complex cascade of events, the paradigm applied, although not totally clinically relevant, would allow a robust response for assessment. Further study is clearly warranted to unravel relevant mechanisms and sensitive markers, which in turn would allow us to appreciate the potential clinical relevance of these experimental findings. Dr Augoustides makes a valid point for the need to develop appropriate guidelines that would enhance this investigative process.

Evaluating various strategies in animal studies to determine clinical feasibility has been limited to large-animal models (porcine, canine, and ovine). These are expensive, demanding, and usually performed without neuropsychologic assessment. Each model system, however, from cell cultures to rats, large animals, and ultimately clinical trials, has its advantages and disadvantages, and its place in these investigations.

Most animal models require an extended period of arrest to produce a reproducible level of neuronal injury that would facilitate elucidating the mechanisms of injury and efficacy of neuroprotective interventions. Many large animal models require DHCA for at least 90 to 120 minutes to demonstrate neurologic deficits.^{1,2} Although such prolonged DHCA intervals might not be considered clinically realistic, they may be more appropriate for demonstrating the molecular pathways behind acute neuronal injury and thus modes of intervention.

Study of a neuroprotective strategy includes the appropriate selection of an animal model and functional indices. The model is selected with respect to the relevance and feasibility of assessing the parameters of interest. Investigations of promising neuroprotective methods require validation (validation study), use in experimental settings to optimize cerebral protection during cardiopulmonary bypass and DHCA (performance study), and test during routine cardiac surgery (clinical study).

A clearer understanding of the consequences of DHCA will be pivotal in clinical decision-making, including when to initiate circulatory arrest and the appropriate interval. Delayed cell death is of