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Myocardial protection of the hypoxic heart

To the Editor:

The study of Bolling and associates¹ on myocardial protection in normal and hypoxically stressed hearts in this Journal concluded that good myocardial protection is independent of cardioplegic calcium concentration in nonhypoxic hearts and that hypoxic hearts are extremely sensitive to the cardioplegic calcium concentration. The authors lamented the absence of a clinically relevant hypoxic model. This is an important consideration, because many children who undergo cardiac operations in the first year of life have cyanotic heart disease, and the myocardium may be chronically perfused with hypoxic blood. Clearly it would be desirable to alter current techniques of myocardial management during surgery to provide better myocardial protection for children with cyanotic congenital heart disease and to further determine whether such techniques might also be applied to adults with acyanotic acquired heart disease. If the impact of prolonged periods of hypoxia on tolerance to subsequent ischemia could be elucidated, cardioprotection in these patients could be better understood and improved. The model of acute hypoxia described by Bolling and colleagues,¹ which was originally described by Buckberg,² Ihnken,³ and their associates, does not allow for the development of adaptive mechanisms in response to

chronic hypoxia that occur in children with cyanotic heart disease. In addition, it is unknown whether reoxygenation is a real source of cardiac dysfunction in the chronically hypoxic immature heart. Preexisting injury caused by acute hypoxia may be a prerequisite for reoxygenation injury in the studies described by Bolling's group.¹

Our laboratory has developed a rabbit model of hypoxia from birth that simulates the essential characteristics of cyanotic heart disease: decreased arterial oxygen levels, polycythemia, increased right ventricular mass, decreased weight gain, and overall failure to thrive.⁴ We have demonstrated that hypoxia from birth increases the tolerance of the heart to ischemia compared with that of age-matched normoxic control subjects.⁴ The mechanism for adaptation to prolonged hypoxia that confers increased tolerance to subsequent myocardial ischemia is currently unknown.

We have also examined the calcium content of St. Thomas' Hospital II cardioplegic solution and found in our model that the existing calcium content of 1.2 mmol/L is suboptimal to protect the ischemic immature myocardium. Optimal myocardial protection occurred with a calcium concentration of 0.4 mmol/L in hearts chronically hypoxic from birth⁵ and 0.3 mmol/L in hearts normoxic from birth.⁶ These previously published data may place in perspective the study by Bolling and coworkers, confirming their hypothesis of hypocalcemic cardioplegia being superior to normocalcemic cardioplegia in protection of immature myocardium. The response, however, of immature myocardium to acute versus chronic hypoxia before reoxygenation, with and without surgical ischemia, is speculative because neither we nor Bolling and his associates addressed this particular issue.

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