EDITORIAL COMMENT

Balloon Atrial Septostomy
Let’s Take a Closer Look*

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Advances in the treatment of patients with congenital heart disease (CHD) have led to a significant improvement in patient survival. Neonatal cardiac procedures, which carried a 10% to 40% mortality rate 20 years ago, now are routinely performed with survival rates approaching 90% to 97% (1). Although continued improvement is possible, efforts are now being concentrated on reducing perioperative morbidity, in particular, neurologic damage and its sequelae. Brain injury, neurologic events, and subsequent neurodevelopmental impairment vary by lesion, but in aggregate are far too common (2–4).

In order to begin to tackle this problem we must first understand its origins. The developing brain, albeit plastic and malleable, is at particular risk during the fetal and neonatal period. Patients with CHD are known to have concomitant neurologic abnormalities (5,6). Intrauterine cerebral blood flow varies with each particular lesion (7) and post-natal hypoxemia, hypotension, and elevated oxygen demand may exacerbate pre-existing injuries. Intravascular interventions may be associated with further neurologic stresses (8). Considerable discussion continues concerning the risk factors for brain injury during cardiopulmonary bypass (CPB). Improved techniques have permitted great advances in surgical therapy; however, they carry the risk of cerebral emboli, pressure-related damage to cerebral vasculature, and the potential for ischemia and reperfusion injury. Total CPB time, flow rates, the rate and degree of cooling, periods of hypothermic circulatory arrest, regional perfusion (9,10) techniques, hematocrit, and acid-based strategies all have the ability to affect cerebral perfusion. The best strategies are still being studied and may vary according to lesion (11). Genetic polymorphisms likely affect the manner in which an individual patient will respond to CPB and the resulting inflammation and reperfusion injury (12). Perhaps of equal importance, post-operative cardiac output and the influences of any post-operative complications must be considered as well (13). Finally, familial and socioeconomic influences work to shape neurodevelopmental outcomes after hospital discharge (14).

In this issue of the Journal, Beca et al. (15) sought to determine the prevalence and pattern of brain injury in infants with transposition of the great arteries (TGA) compared with other complex CHD and to define the risk of balloon atrial septostomy (BAS) for brain injury. The study was undertaken in part as a response to other reports delineating the disturbingly high rate of brain injury in this population and the disparate results in regard to the patterns of damage, white matter injury (WMI) as opposed to ischemic arterial strokes (16). In particular, the practice of routine elective BAS has been questioned as contributory in these injuries (17).

When introduced, the technique of BAS was the most important single factor influencing survival in patients with TGA. Creating a nonrestrictive atrial communication optimizes mixing at the atrial level, improving systemic arterial oxygen content and cardiac output as well as lowering left atrial pressure. These beneficial effects often lead to a rapid stabilization of these neonates and improve their condition before they undergo a major neonatal operation. Initially, a number of neurologic complications were noted after BAS, primarily relating to balloon rupture and embolization of balloon fragments. These have been minimized with newer equipment and techniques. BAS has also simplified the technical aspects of the arterial switch procedure, allowing for efficient left- and right-sided drainage on CPB with a single atrial cannula. Given these benefits, it is important that any findings that impugn the use of BAS be verified.

A number of recent publications have underscored the high prevalence of neurologic injury in newborns with CHD as well as neurobehavioral abnormalities. The nature of these injuries, their relationship to the underlying CHD, and the pre-supposed etiology vary widely, however. McQuillen et al. (16) found pre-operative brain injury to occur in approximately 40% of patients. The majority of these patients suffered ischemic strokes and all had undergone recent BAS. These incriminatory findings were confounded, however, by the presence of lower arterial oxygen saturations, lower Apgar scores, and a greater incidence of hemodynamic instability in this same cohort. The current study by Beca et al. (15) also revealed a high incidence of pre-operative brain injury (30%). The pattern of injury was predominantly WMI. Strokes were uncommon. The authors were not able to indentify any risk factors for these injuries. They found no association between BAS and brain injury in the patients with TGA. Finally, brain injury occurred with equal frequency in other diagnostic subsets.

The disparate findings of the 2 studies are difficult to reconcile. It is apparent that neurologic abnormalities and brain injury are far too common in patients with CHD. The
vast majority of these injuries likely has its substrate in the fetal and early neonatal period and may be exacerbated by intraoperative and post-operative variables. The finding that there were no identifiable risk factors for brain injury in the current study may be more evidence that newborns with CHD have widespread abnormalities in brain maturation, making them vulnerable to any further stressors. One criticism of both papers is that baseline magnetic resonance imaging (MRI) scans were not performed before the intervention in question (BAS). Yet, given the emergent nature of some of the septostomy procedures, MRI scans before these interventions might not be feasible.

BAS has become a low-risk procedure with a number of benefits including improved intra-atrial mixing, lowering of left atrial pressure, and simplification of the operative procedure in some surgeons’ hands. Whenever a report surfaces condemning a time-honored procedure we should carefully scrutinize these findings and not be too quick to abandon it. Following the McQuillen et al. (16) paper, which may with time prove quite valid, not only were pediatric cardiologists beginning to change their practices, but adult cardiologists used this information to generalize to pediatric cardiologists beginning to change their practices, which may with time prove quite valid, not only were pediatric cardiologists beginning to change their practices, but adult cardiologists used this information to generalize to the treatment of patients with patent foramen ovale (18). Applying this rationale to the approximately 40 million patients in the U.S. with a patent foramen ovale would have significant clinical and financial implications. A randomized controlled trial in patients with TGA who are hemodynamically stable would be helpful. Patients would be randomized to a control group (no BAS) or treatment group (BAS). Newborn MRI scans and neurologic examination would then be followed by repeat evaluations after BAS and in the post-operative period. This may begin to dissect the relative contributions of the factors mentioned by all of the authors. Further study must continue into all potential causes of neurologic injury and methods to minimize its occurrence. If this occurs, I have no doubt that in 40 years, these morbidities, as was the case with perioperative mortality, will be largely historic in nature.

**REFERENCES**


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