Commentary: Pulmonary artery banding in infants with atrioventricular septal defect, valid strategy or backward move?

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Central Message

Pulmonary artery banding is a valid strategy in the management of various patients with atrioventricular septal defects. Outcomes are largely related to morphology and ventricular balance.

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Pulmonary artery banding (PAB) was introduced by Muller and Dammann¹ in 1952 to reduce excessive pulmonary blood flow in children born with various congenital heart defects. Advances in perfusion and surgical techniques, along with improvements in perioperative management, have allowed early definitive repair of small infants with complex congenital heart defects, and consequently the need for PAB has significantly decreased. Although the number of PAB procedures has declined in the modern era, operative mortality following PAB in neonates and small infants has remained among the greatest in our field. In the latest Society of Thoracic Surgeons Congenital Heart Surgery Database analysis (the period from 2015 to 2019), PAB was associated with hospital mortality risk of 8.7% in neonates and 6.2% in infants 1 to 12 months old.

One of the most common congenital heart defects that required PAB in the past was complete atrioventricular septal defect (AVSD).² However, PAB is rarely used now in those patients, especially that current operative mortality following AVSD repair is expected to be about 2%, making PAB seem like an unnecessary backward move that is associated with additional surgery at greater risk.³⁻⁵ On the other hand, even in the current era, primary AVSD repair might not be practical in several conditions. Those include heart failure in neonates and small infants with low body weight, concomitant illnesses (eg, intracranial hemorrhage) that increase cardiopulmonary bypass risk, or complex anatomy that commands complicated intracardiac repair.³⁻⁶ In addition, AVSD is a disease spectrum, and a number of patients have unbalanced ventricles and atrioventricular valves that dictate deferment of decision to perform biventricular repair to a later stage.⁷ In those conditions, PAB might seem necessary, despite the high-risk nature of this procedure.^{2,8,9}

In the current issue of the *Journal*, Devlin and colleagues⁸ reviewed the Congenital Heart Surgeons Society

complete AVSD cohort of patients (n = 474) and examined 50 patients (11%) who received initial PAB with focus on atrioventricular valve function and survival based on the intended management pathway: clear eventual biventricular repair (n = 24), definite single-ventricle repair (n = 3), and deferred decision for biventricular repair candidacy (n = 23).⁸ Their findings were interesting (although not overly surprising) and basically emphasized the important correlation between outcomes following PAB and the intended surgical strategy that is fundamentally linked to underlying morphology.

One group of patients includes those with adequate size ventricles and atrioventricular valves who develop early intractable heart failure requiring timely intervention. Nonetheless, surgeons might choose to delay definitive repair that is deemed too complicated or risky due to several factors such as young age, low weight, complex anatomy, or associated illnesses.³⁻⁶ In this group of patients, Devlin and colleagues⁸ demonstrated that PAB strategy is associated with low early mortality (1/24), whereas the 23 remaining patients achieved AVSD repair. They also demonstrated that the distribution of atrioventricular valve regurgitation severity remained largely unchanged following PAB, whereas survival following AVSD repair was comparable with that in patients who had primary AVSD repair.⁸ These results are assuring and helpful in current decision-making.

A recent review of the Society of Thoracic Surgeons database demonstrated that weight <3.5 kg and age ≤2.5 months were associated with greater operative mortality, increased complications, and longer recovery.⁵ In patients with AVSD and arch obstruction, a staged approach with initial arch repair plus PAB has been shown also to be associated with better survival and lower morbidity than neonatal single-stage repair.⁶ In addition, a number of single-institution series have shown that lower weight was associated with increased atrioventricular valve reoperation.^{3,4} Therefore, some patients with AVSD might be better served with initial PAB despite the damage to surgeon's pride for falling back to a dated treatment strategy. The current study from Devlin and colleagues underscores that PAB is a valid strategy in those patients.

Another group of patients includes those with borderline ventricle or atrioventricular valve sizes who undergo initial PAB to defer biventricular repair decision until they are larger. In the current series by Devlin and colleagues, 10 of 23 patients (43%) achieved AVSD repair and survived. However, 2 patients died before definitive repair and 7 underwent single-ventricle palliation with 3 of 7 dying subsequent to palliation. In addition, the 3 patients who underwent PAB for definite single-ventricle palliation (all had dominant right ventricle) died within 1.5 months from PAB.⁸ Those results in patients with unbalanced AVSD are much more sober than those in the balanced counterparts. The question arises whether those inferior results are the product of the underlying cardiac pathology (unbalanced AVSD), the result of failed palliation strategy (PAB), or both.

It is difficult to answer this question from the series by Devlin and colleagues; however, some insights can be determined from some recently related published studies. A recent study from Atlanta examined outcomes of single-ventricle palliation in 80 patients with unbalanced AVSD. In that study, 8-year survival was 64% and was 100%, 55%, 43%, and 43% in those who had initial Glenn, Norwood, PAB, and aortopulmonary shunt, respectively.⁹ Similarly, a study from Melbourne showed that 15-year survival was 66% following single-ventricle palliation of 139 patients with unbalanced AVSD.¹⁰ An additional study from Atlanta examined outcomes of single-ventricle patients who were initially palliated with PAB. That study showed overall 5-year survival following PAB of 86%; however, unbalanced AVSD was independently associated with lower survival.¹¹ Those studies suggest that the greater mortality associated with PAB in patients with unbalanced AVSD is in part due to the nature of disease. Patients with unbalanced AVSD are at greater risk for mortality compared with other single-ventricle anomalies; this is due to many factors, including genetic conditions (association with Down and heterotaxy syndromes), extracardiac malformations, and associated cardiac problems

(atrioventricular valve regurgitation, heart block, pulmonary venous anomalies, double outlet right ventricle, etc).⁹ At the same time, those studies, along with the current series from Devlin and colleagues, highlighted specific problems related to PAB in patients with unbalanced AVSD, especially those with dominant right ventricle and associated arch obstruction.⁸⁻¹¹ In those patients, initial palliation with PAB might produce double-outlet obstruction by intensifying the degree of left ventricular outflow tract obstruction (a well-recognized problem). A different strategy such as aortopulmonary amalgamation and shunt might be a better approach in those patients.

In summary, PAB is a valid initial procedure in a number of patients with complete AVSD. Outcomes in those patients are related to the intended management strategy that is, in turn, essentially linked to cardiac morphology (namely balance of the ventricles and atrioventricular valves). In patients with balanced AVSD, surgeons should not hesitate to employ PAB in small infants when primary repair is considered too complicated or high risk. This is not considered a move backward, and those patients are expected to have good early and late results that are comparable with those in infants who undergo primary AVSD repair. In contrast, patients with unbalanced AVSD continue to have inferior single-ventricle palliation outcomes, mainly related to associated cardiac and extracardiac anomalies. Despite the high early mortality risk, PAB is again the proper initial palliation in a number of those patients with unbalanced AVSD. A specific concerning group includes infants with unbalanced AVSD, dominant right ventricle, and commonly arch obstruction. Those are risk of developing systemic outflow tract obstruction following PAB and an alternative initial palliation strategy should be considered.

References

1. Muller WH, Dammann JF. The treatment of certain congenital malformations of the heart by the creation of pulmonic stenosis to reduce pulmonary hypertension and excessive pulmonary blood flow. *Surg Gynecol Obstet.* 1952;95:213-9.
2. Buratto E, Khoo B, Ye XT, Daley M, Brizard CP, d'Udekem Y, et al. Long-term outcome after pulmonary artery banding in children with atrioventricular septal defects. *Ann Thorac Surg.* 2018;106:138.
3. Atz AM, Hawkins JA, Lu M, Cohen MS, Colan SD, Jagers J, et al. Surgical management of complete atrioventricular septal defect: associations with surgical technique, age, and trisomy 21. *J Thorac Cardiovasc Surg.* 2011;141:1371-9.
4. Prifti E, Bonacchi M, Bernabei M, Crucean A, Murzi B, Bartolozzi F, et al. Repair of complete atrioventricular septal defects in patients weighing less than 5 kg. *Ann Thorac Surg.* 2004;77:1717-26.
5. St Louis JD, Jodhka U, Jacobs JP, He X, Hill KD, Pasquali SK, et al. Contemporary outcomes of complete atrioventricular septal defect repair: analysis of the Society of Thoracic Surgeons Congenital Heart Surgery Database. *J Thorac Cardiovasc Surg.* 2014;148:2526-31.
6. Shuhaiber J, Shin AY, Gossett JG, Wypij D, Backer CL, Hanley FL, et al. Surgical management of neonatal atrioventricular septal defect with aortic arch obstruction. *Ann Thorac Surg.* 2013;95:2071-7.
7. Overman DM, Dummer KB, Moga FX, Gremmels DB. Unbalanced atrioventricular septal defect: defining the limits of biventricular repair. *Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu.* 2013;16:32-6.

8. Devlin PJ, Jegatheeswaran A, McCrindle BW, Karamlou T, Blackstone EH, Williams WG, et al. Pulmonary artery banding in complete atrioventricular septal defect. *J Thorac Cardiovasc Surg*. 2020;159:1493-503.e3.
9. Alsoufi B, McCracken C, Kanter K, Shashidharan S, Border W, Kogon B. Outcomes of multistage palliation of infants with single ventricle and atrioventricular septal defect. *World J Pediatr Congenit Heart Surg*. 2019. in press.
10. Buratto E, Ye XT, King G, Shi WY, Weintraub RG, d'Udekem Y, et al. Long-term outcomes of single-ventricle palliation for unbalanced atrioventricular septal defects: Fontan survivors do better than previously thought. *J Thorac Cardiovasc Surg*. 2017;153:430-8.
11. Alsoufi B, Manlhiot C, Ehrlich A, Oster M, Kogon B, Mahle WT, et al. Results of palliation with an initial pulmonary artery band in patients with single ventricle associated with unrestricted pulmonary blood flow. *J Thorac Cardiovasc Surg*. 2015;149:213-20.