

Beneficial Effects of Surgical Closure of Atrial Septal Defect Outweigh Potential Complications in Sick Infants

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Abstract

Infants and children with isolated atrial septal defect (ASD) usually do not develop clinical signs or symptoms. However, infants with premature birth complicated by chronic lung disease may develop certain problems including respiratory distress, dependency upon supplemental oxygen and/or mechanical ventilation, failure to thrive, and prolonged hospitalization; these are induced largely by excessive pulmonary blood flow through ASD. Although transcatheter approach is less invasive than surgery, its feasibility is often limited by anatomical conditions of ASD and the size of the patients. In these circumstances, surgical closure can be performed safely and effectively even in sick infants to improve clinical status. When transcatheter approach is not feasible, the surgical closure of ASD results in a favorable outcome by eliminating excessive pulmonary blood flow, mitigating the need of positive pressure ventilation more quickly, and promoting better physical growth.

Keywords: Atrial septal defect (ASD), Infants, Prematurity, Bronchopulmonary dysplasia (BPD), Cardiac surgery, Pulmonary hypertension

Surgical Closure of Atrial Septal Defect in Infants and Young Children

Atrial septal defect (ASD) is a common congenital heart disease diagnosed during childhood. Persistently increased pulmonary blood flow and dilated right atrium (RA) and right ventricle (RV) result in multiple symptoms and morbidities in adulthood; untreated adults may develop exercise intolerance, congestive heart failure, atrial tachyarrhythmias, pulmonary hypertension (PH), embolic stroke, or even death [1,2]. Asymptomatic children with ASD are commonly referred for elective ASD closure around 3 to 6 years of age [2,3].

Closure of ASD during infancy has been controversial. An isolated ASD in infants and young children with chronic lung disease of prematurity or bronchopulmonary dysplasia (BPD), tracheo-bronchomalacia, chronic recurrent aspiration, or chromosomal anomalies can

cause substantial medical problems, including persistent respiratory distress, dependency of respiratory support, failure to thrive, and or pulmonary hypertension. These conditions inevitably mandate long hospitalization. Early closure of ASD, either by transcatheter approach or by cardiac surgery, is beneficial in these circumstances as it instantaneously normalizes pulmonary blood flow [4-9]. On the other hand, there is a potential for spontaneous closure, and some have recommended conservative medical management even for symptomatic ASD in young children [10-13].

Transcatheter ASD device closure appears less invasive than cardiac surgery and should be considered first, but certain underlying ASD anatomy precludes its feasibility [14-16]. Possible surgical morbidities and mortality in clinically unstable infants historically remain considerable concerns among referring providers [5]. However, these concerns are, in fact, not applicable in a contemporary

era. Surgical ASD closure can be safely accomplished in infants and younger children with a similar incidence of complications as reported in older children [3,17,18]. Lammers et al. emphasize the importance of surgical closure of ASD in symptomatic infants with multiple comorbidities without significant incidence of surgery-related complications [7]. This important therapeutic option for sick infants has been under-recognized despite its established effectiveness and safety.

Hemodynamic Improvement Granted by ASD Closure

The question is whether benefits provided by hemodynamic improvement exceed a potential risk of invasive interventions in small, clinically unstable infants. Recently, we published our institutional experience of the benefits and safety of surgical ASD closure in 31 symptomatic infants and young children less than 2 years of age who had significant clinical problems due to existing comorbidities and who were not candidates for transcatheter device closure due to anatomical restrictions of ASD and small body size [19]. Of 31 symptomatic patients presenting with respiratory symptoms (22 patients), failure to thrive (24 patients), and/or pulmonary hypertension (9 patients), 26 patients (84%) showed significant clinical improvement upon surgical ASD closure. Four of 8 ventilator-dependent infants were successfully weaned from positive-pressure ventilation within 3 days to 1 month after surgical ASD closure. In 14 patients with mild to moderate respiratory symptoms, 93% showed complete resolution of symptoms. No patient developed direct surgery-related major complications. Two patients died late after surgery (108 and 145 days); deaths were not related to surgical procedure or postoperative complications but due to complexity of underlying medical problems. For clinically complicated patients, the defect is best closed sooner to prevent the development of further pulmonary vascular damage, and it perhaps may improve their clinical outcomes [6,20].

The incidence of postoperative complications in symptomatic patients in our study was low [19] and comparable with reports in older asymptomatic patients [18,21,22]. Tanghoj et al. studied risk factors for adverse events following transcatheter and surgical ASD closure in children born preterm and concluded that prematurity was not a risk factor for post-procedural complications despite earlier procedural age, larger ASD size, and higher comorbidity than term infants [23,24].

Indications for ASD Closure in Premature Infants with BPD and Pulmonary Hypertension

We recommend a proactive approach in eliminating excessive pulmonary blood flow in premature infants with

BPD when the patient's clinical status is not improving despite maximum medical treatment. The presence of ASD may lead to multiple pulmonary pathologies in premature infants with BPD [9]: 1) excessive pulmonary blood flow into underdeveloped lung vasculature that worsens lung mechanics (compliance) [25] and stimulates adverse vascular remodeling causing pulmonary hypertension [26], and 2) RV volume overload and dilatation resulting in secondary LV filling abnormality via ventriculo-ventricular interaction causing pulmonary edema [27]. These interrelated cardiopulmonary events may be responsible for persistence of the pathological condition.

Pulmonary hypertension worsens the prognosis of premature infants with BPD. A small or moderate increase in pulmonary blood flow can induce unfavorable effects for which earlier closure of shunts can improve the outcome [28]. A meta-analysis by Vyas-Read et al. showed that low birth weight infants with ASD are more than two-fold more likely to develop late PH in the first 250 days of life than infants without ASD [29]. However, a high rate of spontaneous closure or decrease in size of the defect is known to occur in the first few months of life, during which continuous close echocardiographic screening efforts are warranted [28]. Whereas catheter-guided ASD closure has become feasible for this population [30,31], surgical ASD closure can be performed just as safely as in older children when catheter-guided intervention is not achievable.

Where We Stand

Although some small secundum-type ASD and patent foramen ovale (PFO) are known to close spontaneously, large secundum-type ASD, sinus venosus-type ASD, and primum-type ASD will never close without intervention. Prompt decision-making for ASD closure is imperative when young children cannot be weaned from ongoing respiratory support or require escalation of care. The decision to perform transcatheter intervention or surgical repair should be assessed carefully depending upon the underlying ASD anatomy and the patient size as the transcatheter procedure has its specific limitations and complications [32,33]. Surgical ASD closure remains as a safe and effective treatment option for symptomatic infants and young children despite the fact that the patients are exposed to cardiopulmonary bypass. Ventilator-dependent premature infants with chronic respiratory failure due to BPD and ASD are encouraged to transfer to a tertiary-care pediatric cardiac center for ASD closure for better clinical outcome and shorter hospital course rather than continuing conservative medical management.

References

1. Geva T, Martins JD, Wald RM. Atrial septal defects. *The Lancet.* 2014 May 31;383(9932):1921-32.

2. Webb G, Gatzoulis MA. Atrial septal defects in the adult: recent progress and overview. *Circulation.* 2006 Oct 10;114(15):1645-53.
3. Roos-Hesselink JW, Meijboom FJ, Spitaels SE, Van Domburg R, Van Rijen EH, Utens EM, et al. Excellent survival and low incidence of arrhythmias, stroke and heart failure long-term after surgical ASD closure at young age: a prospective follow-up study of 21–33 years. *European Heart Journal.* 2003 Jan 1;24(2):190-7.
4. Bull C, Deanfield J, De Leval M, Stark J, Taylor JF, Macartney FJ. Correction of isolated secundum atrial septal defect in infancy. *Archives of Disease in Childhood.* 1981 Oct 1;56(10):784-6.
5. Hunt CE, Lucas JR RV. Symptomatic atrial septal defect in infancy. *Circulation.* 1973 May;47(5):1042-8.
6. Phillips SJ, Okies JE, Henken D, Sunderland CO, Starr A. Complex of secundum atrial septal defect and congestive heart failure in infants. *The Journal of Thoracic and Cardiovascular Surgery.* 1975 Oct 1;70(4):696-700.
7. Lammers A, Hager A, Eicken A, Lange R, Hauser M, Hess J. Need for closure of secundum atrial septal defect in infancy. *The Journal of Thoracic and Cardiovascular Surgery.* 2005 Jun 1;129(6):1353-7.
8. Tanghøj G, Liuba P, Sjöberg G, Naumburg E. Predictors of the Need for an Atrial Septal Defect Closure at Very Young Age. *Frontiers in Cardiovascular Medicine.* 2020 Jan 10;6:185.
9. Kumar KR, Clark DA, Kim EM, Perry JD, Wright K, Thomas SA, et al. Association of atrial septal defects and bronchopulmonary dysplasia in premature infants. *The Journal of Pediatrics.* 2018 Nov 1;202:56-62.
10. Riggs T, Sharp SE, Batton D, Hussey ME, Weinhouse E. Spontaneous closure of atrial septal defects in premature vs full-term neonates. *Pediatric Cardiology.* 2000 Mar;21(2):129-34.
11. Mahoney LT, Truesdell SC, Krzmarzick TR, Lauer RM. Atrial septal defects that present in infancy. *American Journal of Diseases of Children.* 1986 Nov 1;140(11):1115-8.
12. Cockerham JT, Martin TC, Gutierrez FR, Hartmann Jr AF, Goldring D, Strauss AW. Spontaneous closure of secundum atrial septal defect in infants and young children. *The American Journal of Cardiology.* 1983 Dec 1;52(10):1267-71.
13. Brassard M, Fouron JC, van Doesburg NH, Mercier LA, De Guise P. Outcome of children with atrial septal defect considered too small for surgical closure. *The American Journal of Cardiology.* 1999 Jun 1;83(11):1552-5.
14. Cardenas L, Panzer J, Boshoff D, Malekzadeh-Milani S, Ovaert C. Transcatheter closure of secundum atrial defect in small children. *Catheterization and Cardiovascular Interventions.* 2007 Feb 15;69(3):447-52.
15. Wyss Y, Quandt D, Weber R, Stiasny B, Weber B, Knirsch W, et al. Interventional closure of secundum type atrial septal defects in infants less than 10 kilograms: indications and procedural outcome. *Journal of Interventional Cardiology.* 2016 Dec;29(6):646-53.
16. Ohno N, Chaturvedi R, Lee KJ, Benson L. Characteristics of secundum atrial septal defects not percutaneously closed. *Catheterization and Cardiovascular Interventions.* 2015 Feb 1;85(2):234-9.
17. Galal MO, Wobst A, Halees Z, Hatle L, Schmaltz AA, Khougeer F, et al. Peri-operative complications following surgical closure of atrial septal defect type II in 232 patients—a baseline study. *European Heart Journal.* 1994 Oct 1;15(10):1381-4.
18. Jones DA, Radford DJ, Pohlner PG. Outcome following surgical closure of secundum atrial septal defect. *Journal of Paediatrics and Child Health.* 2001 Jun;37(3):274-7.
19. Tsuda T, Davies RR, Radtke W, Pizarro C, Bhat AM. Early Surgical Closure of Atrial Septal Defect Improves Clinical Status of Symptomatic Young Children with Underlying Pulmonary Abnormalities. *Pediatric Cardiology.* 2020 Aug;41:1115-24.
20. Haworth SG. Pulmonary vascular disease in secundum atrial septal defect in childhood. *The American Journal of Cardiology.* 1983 Jan 15;51(2):265-72.
21. Baskett RJ, Tancock E, Ross DB. The gold standard for atrial septal defect closure. *Pediatric Cardiology.* 2003 Sep;24(5):444-7.
22. Heching HJ, Bacha EA, Liberman L. Post-pericardiotomy syndrome in pediatric patients following surgical closure of secundum atrial septal defects: incidence and risk factors. *Pediatric Cardiology.* 2015 Mar;36(3):498-502.
23. Tanghøj G, Liuba P, Sjöberg G, Rydberg A, Naumburg E. Adverse events within 1 year after surgical and percutaneous closure of atrial septal defects in preterm children. *Cardiology in the Young.* 2019 May 1;29(5):626-36.
24. Tanghøj G, Liuba P, Sjöberg G, Naumburg E. Risk factors for adverse events within one year after atrial septal closure in children: a retrospective follow-up study. *Cardiology in the Young.* 2020 Mar;30(3):303-12.

25. Broccard AF, Hotchkiss JR, Kuwayama N, Olson DA, Jamal S, Wangenstein DO, et al. Consequences of vascular flow on lung injury induced by mechanical ventilation. *American Journal of Respiratory and Critical Care Medicine.* 1998 Jun 1;157(6):1935-42.

26. Choi EK, Jung YH, Kim HS, Shin SH, Choi CW, Kim EK, et al. The impact of atrial left-to-right shunt on pulmonary hypertension in preterm infants with moderate or severe bronchopulmonary dysplasia. *Pediatrics & Neonatology.* 2015 Oct 1;56(5):317-23.

27. Friedberg MK, Redington AN. Right versus left ventricular failure: differences, similarities, and interactions. *Circulation.* 2014 Mar 4;129(9):1033-44.

28. del Cerro MJ, Sabaté Rotés A, Cartón A, Deiros L, Bret M, Cordeiro M, et al. Pulmonary hypertension in bronchopulmonary dysplasia: clinical findings, cardiovascular anomalies and outcomes. *Pediatric Pulmonology.* 2014 Jan;49(1):49-59.

29. Vyas-Read S, Guglani L, Shankar P, Travers C, Kanaan U. Atrial septal defects accelerate pulmonary hypertension diagnoses in premature infants. *Frontiers in pediatrics.* 2018 Nov 23;6:342.

30. Petit CJ, Justino H, Pignatelli RH, Crystal MA, Payne WA, Ing FF. Percutaneous atrial septal defect closure in infants and toddlers: predictors of success. *Pediatric Cardiology.* 2013 Feb;34(2):220-5.

31. Bartakian S, Fagan TE, Schaffer MS, Darst JR. Device closure of secundum atrial septal defects in children < 15 kg: Complication rates and indications for referral. *JACC: Cardiovascular Interventions.* 2012 Nov;5(11):1178-84.

32. Bishnoi RN, Everett AD, Ringel RE, Owada CY, Holzer RJ, Chisolm JL, et al. Device closure of secundum atrial septal defects in infants weighing less than 8 kg. *Pediatric Cardiology.* 2014 Oct;35(7):1124-31.

33. Spence MS, Qureshi SA. Complications of transcatheter closure of atrial septal defects. *Heart.* 2005;91:1512-1514.