EDITORIAL COMMENT
Lessons From Cardiopulmonary Testing After Device Closure of Secundum Atrial Septal Defects
A Tale of Two Ventricles*
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There has been much controversy during the past 50 years as to which patients with secundum atrial septal defects (ASDs) should have them repaired. Because there was little evidence to support a mortality benefit, a morbidity advantage, or a clear and objective functional improvement after surgical closure, many physicians and patients waited until symptoms developed before seeking the surgeon’s help. Such reluctance was reinforced by the necessary consequences of surgical ASD repair—an incision and a scar, a period of pain and discomfort, the need for convalescence, and exposure to cardiopulmonary bypass. The fact that 75% of ASD patients were female made it even more common not to recommend surgery for asymptomatic patients.

The era of device closure of ASDs has arrived, and data on outcomes of this relatively new form of therapy are accumulating. It is of interest that, at least in some places, the availability of closure by device seems to have caused an epidemic of secundum ASDs. Cardiac surgeons at Toronto General Hospital performed about 30 secundum ASD closures annually until 1998. Our group at the same hospital has received almost 200 referrals for closure of ASD by device in the past year, an experience also reported by Veldtman et al. (1) to have received almost 200 referrals for closure of ASD by device.

Within one month of closure of ASD by device, they noted an important reduction in echo-measured right ventricular (RV) dimensions as well as the disappearance of paradoxical septal motion (60% to 5%) in most patients. By six months, right atrial size was smaller, and there had been normalization of echo-measured pulmonary artery systolic pressure in 60% of those in whom it had been elevated. Recently, Brochu et al. (2) studied 37 asymptomatic or mildly symptomatic adults undergoing closure of secundum ASDs by device. At baseline and using standard echo measures, the RV was severely dilated in 21, mildly dilated in 14, and of normal dimensions in two patients. Six months after device occlusion, the RV was severely dilated in one, mildly dilated in 17, and of normal size in 17 patients.

After closure, dilated RVs often returned to normal size, but objective measures of improved cardiopulmonary performance were lacking until recently. Brochu et al. (2) reported the results of cardiopulmonary exercise testing on 37 adults undergoing closure of secundum ASDs by device to investigate whether there were beneficial changes in exercise capacity and RV function in patients who were asymptomatic or mildly symptomatic before the procedure (2). They demonstrated a rise in mean peak oxygen consumption (peak VO₂) after ASD closure from 23.5 ± 6.4 ml/kg/min to 26.9 ± 6.9 (15%) ml/kg/min. Interestingly, the increase was as significant in New York Heart Association (NYHA) functional class I patients (+22%) as it was in NYHA functional class II patients (+12%). The NYHA functional class I patients normalized their performance when compared with age-matched controls, whereas NYHA functional class II patients significantly improved their performance. Six patients had a normal peak VO₂ at baseline (three patients diagnosed as class I, and three diagnosed as class II). Five of these six patients increased their oxygen uptake at follow-up. They found a consistent overall improvement in peak oxygen uptake both in patients older than 40 and in patients younger than 40 and in those with left-to-right shunt sizes both above and below 2:1. Subjectively, 15 of 37 patients were diagnosed as NYHA functional class I before the procedure, improving to 35 of 37 patients at six-month follow-up. The Brochu et al. (2) study was the first major study in adults to show a prompt improvement in functional capacity after closure of ASD by device.

In this issue of the Journal, Giardini et al. (3) report a small but careful study of cardiopulmonary exercise testing, spiroscopy, and echocardiography in 32 adults (mean age, 42 ± 16.7 years) before and six months after percutaneous device closure of their secundum ASDs. This study’s important contribution lies in its clarification of the mechanisms underlying the cardiopulmonary improvement in adults after closure of ASD by device. The population of the Giardini et al. study (3) also was clinically well. Of their patients, 84% were diagnosed as NYHA functional class I at the beginning of the study, and 16% were NYHA functional class II; 91% experienced an improved peak VO₂ at follow-up (21.9 ± 10.3 ml/kg/min before closure and 25.6

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± 9.9 ml/kg/min after closure, p < 0.0001). After ASD closure, increases in peak oxygen uptake were observed in patients of all ages regardless of pre-procedural shunt size, reinforcing the observations of the Brochu et al. (2) study. The Giardini et al. report (3) also showed a significant increase in left ventricular ejection fraction (LVEF) by the Teicholz method and left ventricular end diastolic diameter (LVEDD) without any change in left ventricular end systolic diameter (LVESD) after closure. Peak oxygen uptake and peak oxygen pulse improvement after closure correlated with increases in both LVEF and LVEDD, but LVESD did not increase.

Thus, the Giardini et al. report (3) adds to our understanding of the mechanisms underlying the functional improvement of these patients. The increased LVEF and LVEDD in the presence of an unchanged LVESD indicate that an increased LV stroke volume accompanies the increased oxygen consumption after closure by device. Their finding that the oxygen pulse, an indirect marker of stroke flow, which is in fact chronically subnormal. Overall, the patients in this study, mildly symptomatic at worst, improved after closure by device because of improved systemic cardiac output with exercise.

Another important issue is glimpsed in the Giardini et al. (3) report. The precipitation of heart failure in two patients in this series after closure by device deserves comment and a note of caution. Patients with left heart dysfunction and a secundum ASD should receive special scrutiny. It has not been uncommon in ASD device series to have a few patients go into pulmonary edema soon after closure by device (4). Candidate patients may have either systolic or diastolic left heart dysfunction. Typical heart-failure management strategies will usually settle things down, but occasionally a patient encounters significant acute morbidity. We need more information to identify these candidate patients and clarify their long-term outcomes after closure by device. Some of these patients may need special preparation and optimization before closure to ensure a safe outcome. Other patients with left heart dysfunction should not have their ASDs closed.

Other notes of caution must be added. Device closure of ASDs can be complicated; therefore, a methodical case selection process should be followed. There should be evidence that the ASD is large enough to have volume-loaded the right heart. There must be careful screening of candidates for device closure to ensure that the ASD is technically suitable and to exclude patients with anomalous pulmonary venous return who require surgical correction. We strongly recommend that devices for closure of ASD be inserted by individuals with sufficient training and experience to keep risks to a minimum. Such operators will, unlike colleagues without special training, have the skills needed to deal safely with technical issues when they do occur. Chessa et al. (5) recently reported 36 (8.6%) complications in 417 patients undergoing closure by device. Their review of the literature demonstrated a major complication rate of 4% (22/599). The closure of ASDs by device carries a major complication rate equal to or greater than that of complex coronary angioplasty.

Overall, there is a positive message here for asymptomatic and mildly symptomatic patients with a hemodynamically important secundum ASD. Closure by device can be undertaken safely and can be expected to lead to a reduction in size of dilated right heart chambers and an improved exercise capacity based on an enhanced cardiac output. There is every reason to believe these benefits, if they occur in the individual patient, will be long-lasting. It is also likely that treatment of the asymptomatic or minimally symptomatic patient, as in the studies discussed here, will be associated with better outcomes than will occur in ASD patients who have already developed substantial exercise limitations or other complications such as arrhythmias. For the vast majority of patients, the fears evoked in the surgical era for surgical closure of secundum ASDs can be left behind. Still, the relative ease of closure by device should not be construed as justification for closing small ASDs in patients who do not need treatment. Closure of secundum ASDs by device offers a quick and presumably lasting benefit to appropriately selected adult patients with few or no symptoms.

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