hearts. Computed imaging technologies will get better, as every technology does.

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Commentary: Validation of our understanding of atrioventricular conduction anatomy using phase-contrast computed tomography

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CENTRAL MESSAGE

Phase-contrast computed tomography validates our existing knowledge of atrioventricular conduction relationship to ventricular septal defects based on previous histologic studies.

The anatomy of the atrioventricular conduction system in relation to ventricular septal defects (VSDs) has been demonstrated histologically since the early 1960s.[1,2] Subsequently, surgeons adopted strategies to close VSDs while avoiding atrioventricular conduction and that has resulted in a remarkable decrease in the incidence of complete heart block following surgical repair of VSDs.[3,4] In the account following up the early pioneering work of Lillehei repairing congenital heart defects, 4 of 27 patients in whom defect closure was attempted developed complete heart block.[5] Subsequent to the surgical modifications in suturing techniques, the incidence of complete heart block following surgical closure of VSDs has substantially decreased, with the current expected risk being less than 1% to 2%.[3,4]

Phase-contrast computed tomography (PCCT) is an advanced imaging technology that allows visualization of fine-density distribution that regularly represents key structural information in soft tissues with 1000 times greater resolution and considerably greater contrast than conventional computed tomography.[6] Using PCCT technology, recent studies have demonstrated the feasibility of 3-dimensional visualization of the atrioventricular conduction axis in normal human hearts.[6,7] In the current issue of the *Journal*, Yoshitake and colleagues[8] examined hearts from 8 deceased children known to have unrepaired VSDs. They imaged these hearts using PCCT available at the SPring-8 synchrotron radiation facility in Hyogo, Japan. They were able to identify the atrioventricular conduction system in 7 of 8 specimens and were able to describe precisely the relationship between the conduction system, VSDs, and ventricular septum. In essence, they provided outstanding 3-dimensional images that validated our existing knowledge of conduction system anatomy based on the previous histologic studies and assured that the current suturing techniques

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should allow avoidance of the conduction system during surgical closure of VSDs.

The study by Yoshitake and colleagues is a nice, reassuring confirmation of the relationship of the conduction system and VSDs, and that explains the low incidence of postoperative complete heart block in the current era.[3,4] However, there are several other complex congenital heart defects in which our comprehension of conduction system anatomy continues to be uncertain and deficient. Examples of these defects include atrioventricular discordance, common atrium, isomerism of the atrial appendages, and various single-ventricle anomalies. Therefore, examination of heart with these defects using PCCT technology would be especially helpful locating the conduction system and modifying our surgical technique to avoid postoperative heart block that continues to be greater than wanted. Unfortunately, this is practically a difficult task to currently achieve, given several limitations: (1) PCCT is different from computed tomography technology and is currently not available at medical institutions and rather at very few locations. (2) Current PCCT technology is not available for use in living patients; the lungs, bronchi, and ribs surrounding the heart make the detection of phase shift values inside the living heart more challenging than in the cadaver heart. (3) Given the rarity of these complex congenital heart defects, provision of adequate nonoperated cadaver hearts to study in the current era is challenging, especially since it is not clear how far from death those specimens continue to be suitable for accurate examination. Therefore, while clearly useful in demonstrating the location of the conduction system, until a commercially obtainable device that can perform in vivo heart examination (and maybe hopefully real-time intraoperative examination) is available, the value of PCCT enriching our knowledge in these more complex congenital defects will be restricted.

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