CONTEMPORARY REVIEW

Natural history of postoperative heart block in congenital heart disease: Implications for pacing intervention

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After half a century of major progress in congenital heart disease management, atrioventricular conduction block continues to complicate 1–3% of surgical procedures. Unless treated with an implanted pacemaker, permanent postoperative heart block is associated with 28–100% mortality. Postoperative heart block often proves to be transient, typically resolving within 10 days of onset. The duration of postoperative heart block is widely used as a key determinant for permanent pacemaker implantation. Current professional pacemaker implantation guidelines are largely based on this criterion. However, available natural history data suggest that other factors, such as residual conduction system injury, likely play a role in increasingly recognized cases of very late postoperative mortality and morbidity in patients who have experienced transient postoperative heart block. As growing numbers of congenital heart disease patients survive into adulthood, and artificial pacemaking capabilities continue to improve, it might be necessary to reconsider and refine currently accepted pacing indications for postoperative heart block.

KEYWORDS Heart block; Heart surgery; Congenital heart disease; Permanent pacemaker

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Tremendous advances in the surgical management of congenital heart disease (CHD) have been achieved over the past half century. Nevertheless, conduction system injury continues to be a leading cause of long-term postoperative cardiac morbidity. The incidence of postoperative AV conduction block has declined significantly since it was first explored in detail in a landmark paper by Lillehei et al[1] in 1963, but heart block continues to complicate approximately 1% to 3% of operations performed at major CHD surgical centers.[2,3]

This review was undertaken in response to a management conundrum that arises quite regularly at our institution and is reflected in current practice guidelines endorsed by leading professional organizations.[4] Postoperative heart block reportedly resolves spontaneously in 43% to 92% of cases,[1,5–10] with the large degree of variation among studies attributable to a variety of factors, such as era, case identification and inclusion criteria, and follow-up duration. Decisions with respect to permanent pacemaker implantation are fraught with uncertainty regarding optimal timing of intervention and long-term risks associated with nonintervention, as well as the morbidity of lifelong pacemaker therapy.

Based on mortality data from the "dark days" before permanent pacing became available in 1962 and widely implemented in the years that followed (Table 1), it seems clear that pacemaker implantation is appropriate in CHD patients whose postoperative heart block does not resolve. Indeed, current American College of Cardiology/American Heart Association/North American Society of Pacing and Electrophysiology (ACC/AHA/NASPE) guidelines list "postoperative advanced second- or third-degree AV block that is not expected to resolve or persists at least 7 days after cardiac surgery" as a class I indication for pacemaker im-

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Table 1 Mortality in congenital heart disease patients with permanent, unpaced postoperative heart block

Reported mortality	Era	Reference
100%	Pre-1956	1
80%	1956–1961	1
30%	1956–1966	19
38%	1957–1973	7
28%	1957–1978	15
100%	1960–1967	10
64%	1962–1968	8

plantation.[4] Interestingly, the full text version of the document provides slightly less interpretive latitude, stating that "the presence of advanced second- or third-degree AV block persisting for 7 to 14 days after cardiac surgery is considered a Class I indication for pacemaker implantation."

Conversely, the notion that transient, spontaneously resolving heart block does not require permanent pacing is also broadly accepted, but its application is rendered less clear by the risk of late recurrence of heart block (discussed later). The ACC/AHA/NASPE guidelines list "transient postoperative AV block with return of normal AV conduction" as a class III indication—essentially a contraindication—for permanent pacing.[4] This would pose no difficulty *vis-à-vis* the class I indication already mentioned if spontaneous recovery invariably occurred within 7 to 14 days of onset, setting aside for a moment the issue of late recurrence. Analysis of the available data suggests that spontaneous recovery usually does take place within 7 to 10 days (Figure 1). However, late recovery is well recognized. Batra et al[11] reported recovery of AV conduction in 7/72 (9.6%) cases of postoperative heart block persisting beyond 14 days. Recovery was noted at postoperative time points ranging up to 113 days (median 41 days), and four of the seven patients exhibited residual right bundle branch or first-degree AV block. Bruckheimer et al[12] identified very late recovery of AV conduction up to 20 years (median 5.5 years) after onset of heart block in 14 (32%) of 44 patients who had undergone pacemaker implantation. They were unable to identify any factors predictive of recovery. Once again, a substantial proportion (12/14) of patients who recovered demonstrated residual bundle branch and/or first degree AV block.[12]

Notwithstanding the possibility of a late return of AV conduction, two contemporary considerations weigh against protracted delay in the decision to proceed with permanent pacemaker implantation. The first consideration is the ongoing improvement in longevity and miniaturization of pacing systems available for infants and children, reducing concerns over pacing-related morbidity. The second is cost-driven pressure for reductions in hospital length-of-stay, where a patient's need for temporary epicardial pacing while awaiting recovery of conduction can be a major limiting factor in discharge planning.

Although the immediate time course of recovery from transient postoperative heart block impacts significantly on management decisions, the risk of late heart block recurrence is a more ominous and poorly defined problem with potentially life-threatening implications. To begin with, the very concept of "recurrence" is challenged by the observation that heart block can appear, presumably *de novo,* long after CHD surgery. In a report from our institution, Goldman et al[13] divided 114 CHD patients undergoing permanent pacemaker implantation for postoperative AV block into "early"- and "late"-onset groups, defined as those whose heart block was initially detected either less than 30 days or at least 30 days after surgery, respectively. Fully 36% of the patients fell into the "late" group, with heart block identified at a mean of 4.7 years after CHD surgery in that group.[13] Although prophylactic pacemaker implantation in all surgical CHD patients judged to be at risk is impractical, cardiologists providing long-term follow-up care should be alert to this issue and respond promptly and proactively to suggestive symptoms such as syncope while undertaking heart rhythm monitoring at regular intervals in asymptomatic patients.

The most disturbing indirect data concerning remote implications of transient postoperative heart block come from a 2001 study detailing long-term (mean 28 years) outcomes among 288 survivors of tetralogy of Fallot repair performed at the University of Minnesota between 1954 and 1974.[14] The incidence of late sudden death in this cohort correlated strongly with transient postoperative heart block. Among 20 patients with postoperative heart block lasting more than 3 days, 8 (40%) subsequently died suddenly. The sudden death rate among 55 patients with heart block of shorter duration was 7.3%, similar to the 6.1% noted in the 196 patients who had no documented heart block. Beyond this study, data assessing the risk of late recurrence in

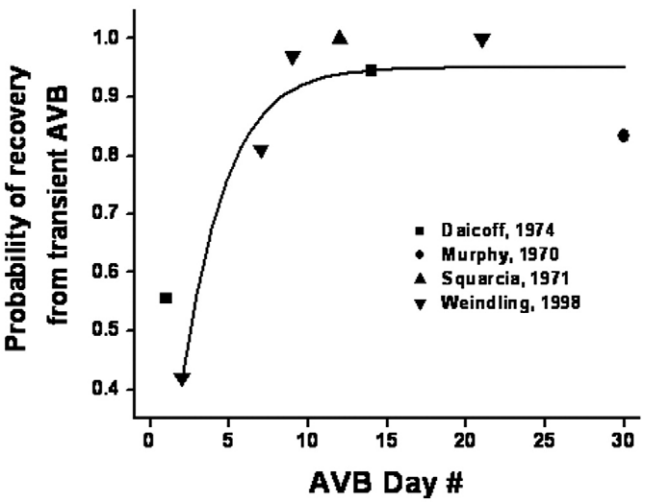

Figure 1 Cumulative probability of recovery from transient postoperative heart block (AVB), plotted as a function of number of days from AVB onset (typically equivalent to postoperative days), based on published studies as indicated.[3,5,8,10] Data points were fitted with an exponential equation ($R^2 = 0.81$).