Minimally invasive epicardial implantable cardioverter-defibrillator placement for infants and children: An effective alternative to the transvenous approach

Andrew E. Schneider, MD,[*] Harold M. Burkhart, MD,[†] Michael J. Ackerman, MD, PhD,[*‡§] Joseph A. Dearani, MD,[†] Philip Wackel, MD,[*] Bryan C. Cannon, MD, FHRS[*]

From the [*]Department of Pediatric and Adolescent Medicine/Division of Pediatric Cardiology, Mayo Clinic, Rochester, Minnesota, [†]Department of Surgery/Division of Cardiothoracic Surgery, Mayo Clinic, Rochester, Minnesota, [‡]Department of Medicine/Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota, and [§]Department of Molecular Pharmacology & Experimental Therapeutics/Windland Smith Rice Sudden Death Genomics Laboratory, Mayo Clinic, Rochester, Minnesota.

BACKGROUND Young patients have high rates of implantable cardioverter-defibrillator (ICD) lead fractures and are at risk for venous occlusion or tricuspid regurgitation with transvenous lead placement. Epicardial ICDs have the potential to circumvent complications associated with transvenous ICDs, but the literature on young patients remains limited.

OBJECTIVE The purpose of this study was to evaluate the results of a minimally invasive epicardial ICD lead placement approach in young patients.

METHODS A retrospective, institutional review board–approved electronic medical record review of all patients undergoing epicardial ICD placement at our institution from January 2011 to December 2015 was performed.

RESULTS A total of 46 patients (20 female [43%]; mean age 10.3 years, range 0.7–18.2 years; mean weight 41 ± 21 kg) were identified; 24 (52%) were ≤10 years old. A minithoracotomy was used in 28 patients (61%). All had acceptable defibrillation, right ventricular sensing, and stimulation thresholds. Median follow-up was 2.0 ± 1.3 years (range 0.02–4.5 years). Eight surgical complications occurred in 7 patients (15%), and 8 device-related complications occurred in 6 patients (13%). Fifty-eight appropriate shocks were delivered in 7 patients (15%). Four patients received inappropriate shocks in relation to lead fractures/microfractures. One patient in this cohort who had long QT syndrome type 8 died of a hypoglycemic seizure.

CONCLUSION Minimally invasive epicardial ICD placement provides an effective, alternative method for implanting an ICD system, particularly in very young patients (<6 years of age) or patients who are concerned about cosmetic appearance. This technique is an acceptable alternative to traditional transvenous ICD placement.

KEYWORDS Implantable cardioverter-defibrillator; Epicardial ICD placement; Minimally invasive surgical approach; Long QT syndrome; Hypertrophic cardiomyopathy

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Introduction

The utility of the implantable cardioverter-defibrillator (ICD) in preventing sudden cardiac death (SCD) in at risk adults has been well established. Although ICDs have also been shown to decrease the incidence of SCD in select pediatric populations,[1] implantation remains a relatively rare occurrence, accounting for <1% of all ICD placements.[2] As more groups of children at risk for SCD continue to be identified, the indications for primary and secondary prevention continue to evolve.[3–5] Consequently, placement of devices in children, including very young children (<6 years of age), has increased significantly over the past decade.[6,7] In this instance, the onus is on the physician to offer a system that not only is efficacious in its primary intent but also is discrete, dependable, and devoid of long-term complications as much as possible. An ideal device configuration has yet to be devised, and the literature on novel ICD systems in children remains limited.

Transvenous ICDs have long been the chosen device configuration in children, but by no means do they represent the ideal system. Potential complicating factors include anatomic restrictions on device delivery in patients with

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Address reprint requests and correspondence: Dr. Bryan C. Cannon, Mayo Clinic, 200 First St SW, Gonda 6, Rochester, MN 55905. E-mail address: cannon.bryan@mayo.edu.

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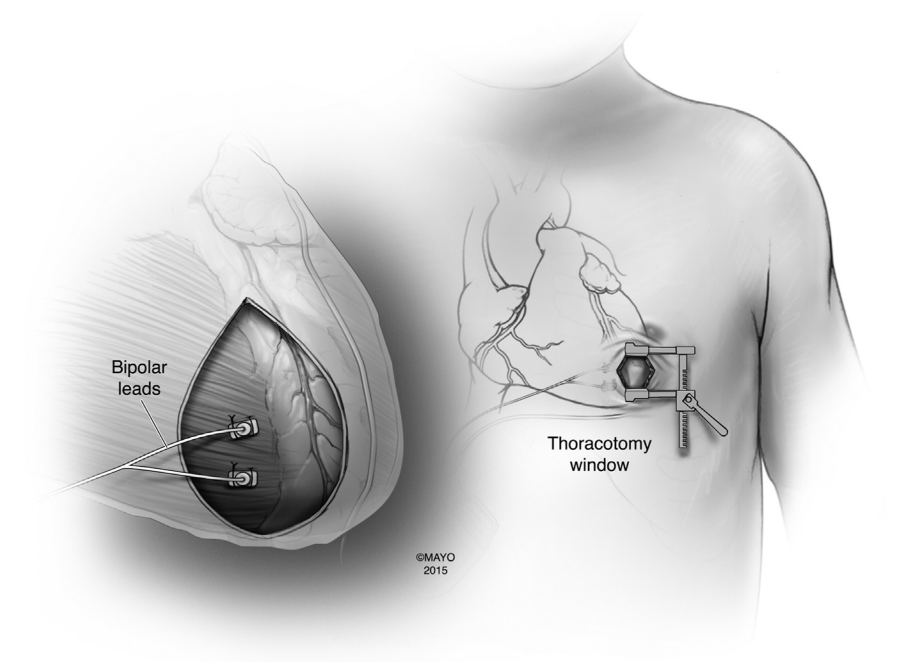

Figure 1 Schematic view of the exposed right ventricle, through a 2- to 3-cm inframammary thoracotomy window. Pericardium has been bisected. Bipolar steroid-eluting epicardial pacing leads are secured to the right ventricular free wall.

congenital heart disease or limited venous access, the presence of intracardiac shunting with risk of emboli, tricuspid valve regurgitation, lead failure, and venous occlusion. Occlusion rates as high as 25% have been reported in pediatric studies.[8] Thus, development of novel systems that could circumvent risks associated with transvenous systems have value. Epicardial ICD systems have the potential to skirt many of the problems associated with transvenous ICDs. However, the literature on this technique is limited to small case series in children,[1,7,9–14] and the technique frequently requires a large incision or sternotomy. The goal of this study was to describe our experience with epicardial ICD placement using a minimally invasive anterior thoracotomy technique.

Methods

Data collection

A retrospective electronic medical record review was conducted for all patients younger than 18 years undergoing epicardial ICD placement at our institution from January 2011 to December 2015. Patient demographic variables were gathered, including age and weight at the time of device placement, underlying cardiac disease, and indication for ICD implantation. Initial stimulation thresholds, defibrillation thresholds (DFTs), incidence of appropriate and inappropriate shocks, surgical complications, and follow-up data were analyzed. The study protocol was approved by the Mayo Clinic Institutional Review Board.

Surgical technique

All procedures were performed in an operating room with the patient under general endotracheal anesthesia. A mini-anterior thoracotomy was performed using a left-sided 2- to 3-cm inframammary incision, allowing entry of the chest cavity over the anteroapical area of the heart. After the pericardium was opened, bipolar steroid-eluting pacing leads (model 4968, Medtronic Corp, Minneapolis, MN) were sutured to the right (or left) ventricular free wall (Figure 1). If a dual-chamber ICD was indicated, atrial leads were placed in the same fashion via a mini-right anterior thoracotomy. Intraoperative sensing, threshold, and impedance testing was performed on all leads. An additional screw-in lead (model 5071, Medtronic) was used in 1 patient with complex congenital heart disease and poor pacing thresholds. After the epicardial leads were fixed, the ICD coil was placed through the same incision.

The opened pericardium was lifted up through the small incision, allowing for direct visualization of the phrenic nerve. An incision was made in the pericardium deep to the phrenic nerve (Figure 2A). A Penrose drainage tube was threaded through the incision (Figure 2B), and anterior rightward traction was applied to the tubing, exposing the posterolateral pericardium (Figure 2C). The tip of the ICD coil was sutured directly to the pericardium through the tip of the lead, taking care to avoid the coil, and the proximal portion was secured using sutures on a tie-down sleeve. After the coil was secured to the posterolateral pericardium, the Penrose drain was removed, allowing the coil to take its position around the posterolateral heart. Four different types of coils were used in this cohort, the vast majority (93%) being a lead with a dedicated shocking coil (Transvene model 6937A, Medtronic). One adult patient with cardiomegaly received a larger coil designed for subcutaneous use (model 6996SQ, Medtronic). Two patients had standard ICD leads used with the pace–sense portion capped and only the