Cardiac implantable electronic devices in end-stage renal disease patients: preservation of central venous circulation

Gustavo Lopera · Gerald A. Beathard · Jose Exaire ·
Roger Carrillo

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Cardiovascular disease is the leading cause of death in patients with end-stage renal disease (ESRD). In the United States Renal Data System database, 25–29.7% of cardiac deaths are attributable to arrhythmic mechanisms [1, 2]. Ventricular fibrillation (VF) and hemodynamically unstable ventricular tachycardia (VT) likely remain the most common initiating and potentially reversible mechanisms of out-of-hospital sudden cardiac death (SCD). Defibrillation is the only predictably effective therapy for reverting VF and pulseless VT to an effective rhythm for restoration of blood flow [3]. The expanding indications of implantable cardioverter-defibrillator (ICD) therapy for primary and secondary prevention of SCD have significantly increased the

patient population with cardiac implantable electronic devices (CIEDs) [4].

A meta-analysis of secondary prevention trials showed a 28% relative risk reduction (RRR) in all-cause mortality ($p=0.0006$) with ICD therapy that was due almost entirely to a 50% RRR in arrhythmic death ($p<0.0001$); similarly, primary prevention trials showed a 28% reduction in the risk of death in the ICD-treated patients as compared with the conventionally treated patients and an overall absolute 2-year mortality reduction of 3% [3]. Despite the high incidence of SCD among patients with ESRD and the proven survival benefits of ICD therapy, the benefit of ICD therapy in this patient population has been questioned. This is probably due to the fact that all major ICD trials excluded patients with advanced renal dysfunction and transvenous ICD therapy is associated with higher complications rates in this patient group; especially, on hemodialysis (HD) patients. Our current knowledge regarding the efficacy of ICD therapy in this population relies on observational data and secondary post hoc analyses of major ICD trials [5–11].

Initially, ICDs were implanted via thoracotomy, which was associated with mortality rates of 3% to 5.4%. The development of transvenous ICD systems in the early 1990s was associated with an operative mortality of <1%, lower costs, and shorter hospital stays [12–14]. For these reasons, the transvenous route has become the most frequently used method for implantation of CIEDs. However, the use of the transvenous CIEDs can be associated with significant complications in chronic HD patients including central venous stenosis, tricuspid regurgitation (TR), and device infection [15–31].

Varies degrees of central venous stenosis have been reported in 23% to 67% patients with transvenous CIEDs [15–17]. This complication is asymptomatic in most patients. However, the situation is different in patients on

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G. Lopera · R. Carrillo
Division of Cardiology, University of Miami,
Miller School of Medicine,
Miami, FL, USA

G. A. Beathard
University of Texas Medical Branch Galveston,
Galveston, TX, USA

J. Exaire
University of Oklahoma Health Sciences Center,
Oklahoma City, OK, USA

G. Lopera · G. A. Beathard · J. Exaire · R. Carrillo
Division of Cardiothoracic Surgery, University of Miami,
Miller School of Medicine,
Miami, FL, USA

G. Lopera (✉)
Miami Veterans Affairs Health Care System,
University of Miami Miller School of Medicine,
1201 N.W. 16th Street,
Miami, FL 33125, USA
e-mail: GLOpera@med.miami.edu

HD. This population is particularly prone to develop edema of the face, neck, breast, shoulder, and the arm as a consequence of central venous stenosis [18, 19]. Central venous stenosis can also lead to loss of the patient's dialysis access. It is not unusual to encounter patients whose central venous occlusion prevents all upper extremity dialysis access. The presence of significant TR and development of infection of CIEDs in a dialysis patient are also important considerations.

The incidence of CIED-induced TR is largely unknown since the prevalence of TR in “normal” echocardiographic studies ranges from 0% to 53% and TR is usually well tolerated in the absence of pulmonary hypertension. Isolated case reports describe severe TR following CIED implantations. Severe TR might be poorly tolerated on HD patients, which are already on cardiac output state due the presence of an arteriovenous fistula. Thus, the development of severe TR can lead to development of right-sided heart failure, which could further complicate their management [20–22].

Reported device infection rates vary widely, from 0.1% to 19.9% [23]. However, patients with moderate to severe renal disease exhibit higher device infection rates as compared to the general population [24–26]. Cardiac device infection can be a potentially life-threatening if untreated and can also lead to endocarditis [27, 28]. Device infection usually requires device removal and lead extraction [29].

Infection is the second leading cause of death in end-stage renal disease patients [1]. The annual mortality secondary to sepsis is approximately 100- to 300-fold higher in dialysis patients compared to the general population [30]. Repeated cannulation of arteriovenous fistulas and the use of tunneled catheters for HD are potential sources for bacteremia in this population. The intravascular location of the CIEDs makes the leads vulnerable to bacterial seeding during HD [31]. In recent years, we have also observed an evolution of implantation techniques of epicardial and subcutaneous CIEDs, making it accessible to patients in whom the traditional transvenous implantation could be associated with high complication rates [32–36].

Among patients treated by HD who also require CIEDs for treatment, the use of an epicardial or subcutaneous approach could decrease the risk of device infection, TR, and central venous stenosis. Therefore, epicardial or subcutaneous CIEDs should be considered in these patients. Recently published preliminary information lends validity to the epicardial approach in HD patients. In this study, the development of CIED infection and central stenosis were markedly reduced after the endocardial devices were removed and replaced with epicardial CIEDs [31]. Bardy et al. reported recently that subcutaneous ICD consistently detected and converted spontaneous and induced VF [36].

In consideration of these facts, the following recommendations are suggested:

- 1- Epicardial or subcutaneous CIEDs could be offered as treatment alternative to transvenous CIEDs in ESRD patients who meet criteria for CIEDs and are receiving therapy with an arteriovenous fistula or tunneled dialysis catheter. Detail explanation of the indications, risks, and benefits of each therapeutic approach should be shared with patients, if this approach is selected.
- 2- HD patients with an existing transvenous CIEDs who require laser lead removal for development of device infection or central venous stenosis should be considered for epicardial or subcutaneous CIEDs if device reimplantation is required.

It is important to emphasize that these recommendations represent our personal opinion based on our experience treating patients on HD with CIEDs. Prospective clinical trials are needed to further improve our understanding and establish the best clinical practice in patients with ESRD who also require CEIDs.

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