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Device-specific evaluation of intraventricular left ventricular assist device position by quantitative coaxiality analysis

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ABSTRACT

Background: Patient-specific anatomy may influence the final intraventricular positioning of inflow cannula in left ventricular assist device (LVAD) recipients. An association exists between such positioning and clinical outcomes (specifically, orientation toward the interventricular septum has negative prognostic implications). Alternative commercially available LVADs are characterized by markedly different design, with potential consequences on intrathoracic fitting among individual patients.

Material and methods: A cohort of 13 LVAD recipients (either HeartMate II—group A or Jarvik 2000 Flowmaker—group B) was evaluated. On postoperative computed tomography scans, we reconstructed the implanted LVAD (semiautomatic segmentation), defined the target mitral orifice (3D Slicer software), and built a coordinate system to quantify the coaxiality of the cannula with the mitral valve axis (angles φ and θ, expressed as percentage variation from the ideal value $\varphi = \theta = 0°$).

Results: Group A presented significantly greater average percentage variation of the φ angle (significantly greater orientation of the intraventricular cannula toward the interventricular septum; 33.2% ± 32.1% *versus* 1.9% ± 0.9%, $P = 0.001$). Group A presented significantly greater average percentage variation of the θ angle (52.7% ± 23.6% *versus* 14.5% ± 6.3%, $P = 0.013$).

Conclusions: The device assessed in group B showed in the present series better average coaxiality with the mitral orifice. Such finding is related with its design (total intraventricular placement) and interaction with thoracic structures. The present method is being integrated in the development of LVAD virtual implantation tools and may help physicians in patient-specific selection among alternative devices.

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Introduction

Left ventricular assist device (LVADs) are increasingly used for the treatment of advanced heart failure, with significant improvement of survival and quality-of-life in appropriately selected patients.[1,2] Nonetheless, LVAD therapy remains associated with noteworthy rates of early and late complications. Thrombotic and thromboembolic events are particularly dreadful; the risk of stroke is about 20% after 2 y on LVAD support in the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS).[3] Although thromboembolic events under LVAD therapy are of multifactorial origin, the underlying mechanisms are not fully understood.[4]

Recently, we have suggested that further insights into this issue can be obtained through analysis of postoperative computed tomography (CT) scan of LVAD recipients, based on computer segmentation and three-dimensional reconstruction.[5,6] Indeed, we found a relationship between suboptimal intraventricular inflow cannula positioning and adverse events at follow-up.[5] Such approach is ultimately intended at assisting the physicians, not only in the "customization" of implantation technique and late management but also in the decision-making among different devices in individual patients. Herein, we propose the use of a software tool developed by our team to describe device-specific features of intraventricular LVAD positioning.

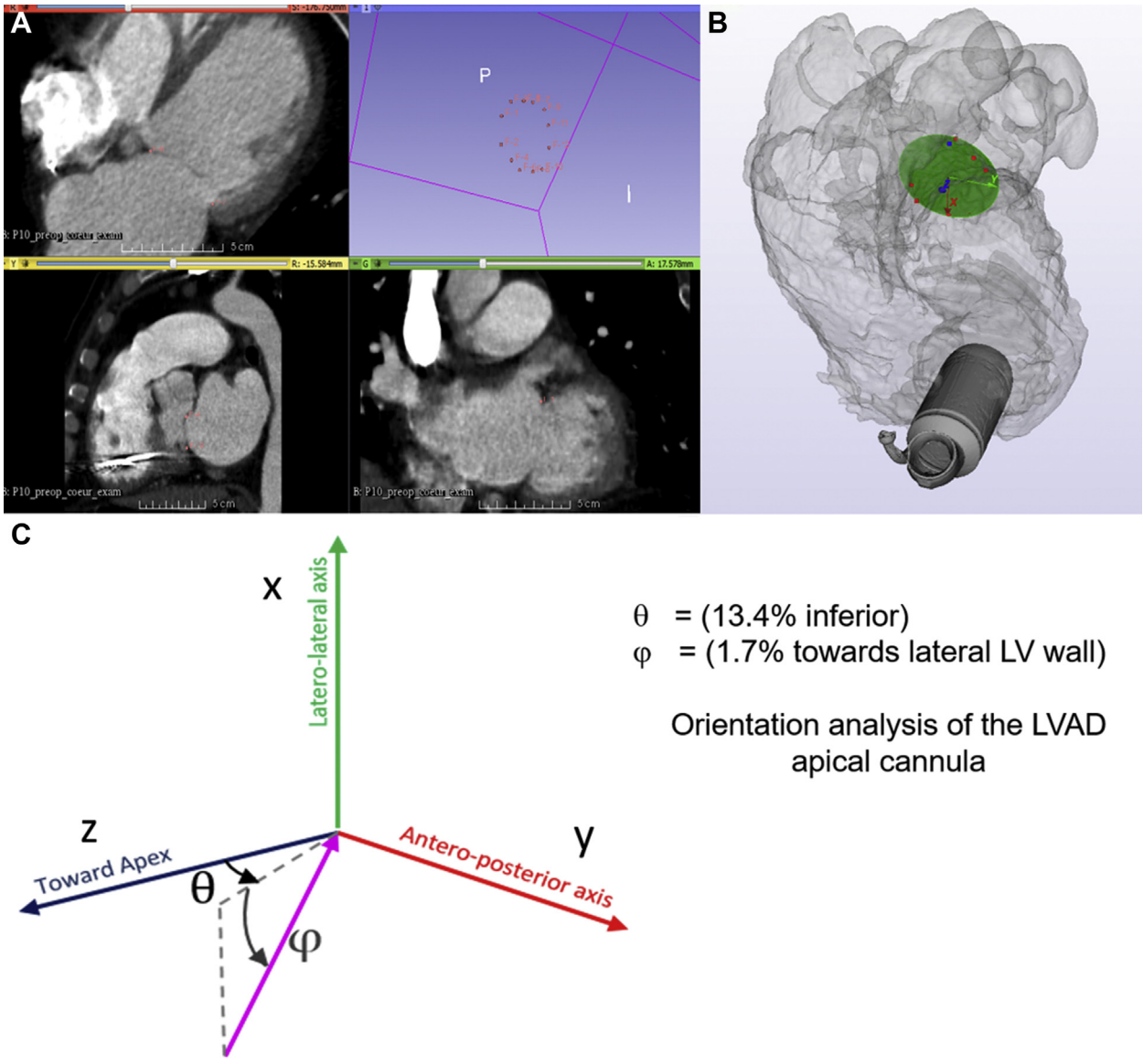

Fig. 1 – (A) Representation of postimplantation CT scan and identification by the user of the contour of the mitral valvular annulus (screenshot of a dedicated software tool). (B) Three-dimensional representation of the cardiac chambers after segmentation, of the target mitral valvular orifice with coordinates system and of an implanted Jarvik 2000 LVAD. (C) Detail of the coordinates system for analysis of LVAD inflow cannula orientation. The angles θ and φ describe the deviation of the inflow cannula axis with respect to the ideal orientation. Color version of figure is available online.