We demonstrated that, similar to the experience with DSC in left ventricular assist device recipients,^{7,8} this strategy for the management of refractory bleeding is effective because it breaks the cycle of pericardial tamponade and low-output events of the artificial ventricles and contributes to a decrease in major perioperative complications. As in the case of patients with LVADs, concerns regarding infection proved to be unfounded. There was a single case of deep sternal wound infection; however vacuum-assisted closure therapy was effective, and an infection of the TAH system was not documented. The main limitations of this study are retrospective data collection and analysis, as well as limited comparability of baseline data. For this reason, further possible implications of a general adoption of DSC strategy in routine operative management, such as a significant decrease in transfusion requirements and thus allogeneic sensitization, still have to be prospectively examined.

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EDITORIAL COMMENTARY

Delayed sternal closure after assist device implantation: Not all bleeding stops

David D. Yuh, MD, FACC, FACS

See related article on pages 417-8.

Since its initial description in the mid-1970s for “tight mediastinal syndrome,”¹ delayed sternal closure (DSC) has been adopted in pediatric and adult cardiac surgery as a temporizing strategy in the setting of severely impaired cardiac function or uncontrollable hemorrhage.²⁻⁶ Fortunately, most of the published experience with this strategy, including patients undergoing ventricular assist device implantation,⁷ describes successful outcomes with

the use of DSC. Surprisingly, low rates of mediastinitis or device colonization, presumably due to meticulous attention to sterility, antibiotic prophylaxis, and expedient wound closure, have been the norm rather than the exception in these published series.

Spiliopoulos and colleagues⁸ have taken this precedent further by reporting the successful use of DSC for the management of intractable bleeding in patients implanted with the SynCardia total artificial heart (TAH) (SynCardia Systems Inc, Tucson, Ariz) system. The investigators observed a lower incidence of prolonged mechanical ventilation and acute renal failure with DSC compared with primary sternal closure (PSC), as well as shorter hospitalizations with no significant differences in overall mortality at 90 days. Moreover, only 1 of 11 patients in the DSC group developed a deep sternal wound infection with no documented infection of the implanted device. By acknowledging the limitations of such a retrospective study and

From the Section of Cardiac Surgery, Yale University School of Medicine, New Haven, Conn.

Disclosures: Author has nothing to disclose with regard to commercial support.

Received for publication May 11, 2015; accepted for publication May 12, 2015; available ahead of print June 11, 2015.

Address for reprints: David D. Yuh, MD, FACC, FACS, Section of Cardiac Surgery, Yale University School of Medicine, 333 Cedar St, PO Box 208039, New Haven, CT 06520 (E-mail: david.yuh@yale.edu).

J Thorac Cardiovasc Surg 2015;150:418-20

0022-5223/\$36.00

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<http://dx.doi.org/10.1016/j.jtcvs.2015.05.037>

heterogeneous patient cohort, the authors have provided useful evidence that DSC is a valid approach even in the setting of relatively large implantable systems such as the SynCardia TAH.

Despite the documented successes associated with DSC, a patient leaving the operating room with an open chest is still viewed as an anathema among many cardiac surgeons. Whether this is derived from a conscious or subconscious reluctance to convey a sense of technical failure or instinctive concern for incurring a catastrophic infection, many surgeons will opt to “take their chances” with PSC, even in the setting of significant hemorrhage. This often subjects the patient to massive transfusions of blood products, dangerously high levels of inotropic and vasoconstrictive agents, inadequate systemic perfusion, and emergency chest reopening in the intensive care unit under less than sterile conditions.

The independent association of high-volume blood transfusions with postoperative complications among cardiac surgical patients, including infection, renal failure, respiratory failure, and mortality, is well documented.⁹⁻¹⁴ Given the comparatively low incidence of infections in patients with a left ventricular assist device and a TAH in whom DSC was used, DSC would seem to be a logical strategy in cases of refractory hemorrhage. However, the practical utility of the analysis by Spiliopoulos and colleagues⁸ is somewhat handicapped by its broadly defined indication for the use of DSC, namely, “persistent nonsurgical bleeding despite intensive haemostatic therapy.” Because multiple factors contributing to coagulopathic bleeding are in play with assist device implantation (eg, congestive hepatopathy, hypothermia, heparinization, artificial blood surfaces, extracorporeal circulation, massive transfusion), this definition is not specific enough to apply DSC in a consistent, data-driven manner. Fortunately, the uncertainty in determining when coagulopathy is truly refractory after separation from cardiopulmonary bypass and heparin reversal is becoming more clear with the use of thromboelastography and rotational thromboelastometry to guide transfusion therapies.

The lower incidence of long-term ventilation and acute renal failure noted in the DSC group despite higher preprocedural transfusion requirements than in the PSC group may have been due to a lower predisposition toward pericardial tamponade and low cardiac output states. The more frequent reoperations for tamponade among patients undergoing PSC is notable given that Ranucci and colleagues¹⁵ found that the act of reexploration itself induces a mortality rate that is higher than 3% even in the absence of blood transfusions.

The heightened potential for allogeneic sensitization with massive blood transfusions carries significance in the population with a TAH because the majority of these patients are considered for transplantation. Leffell and colleagues¹⁶ recently reported that allosensitization from transfusion can occur in up to 20% of transplant candidates, resulting in higher panel reactive antibody values that adversely affect

access to donor organs. Allosensitization as defined by panel reactive antibody levels in heart transplant recipients bridged with ventricular assist devices is associated with increased antibody-mediated rejection and mortality.¹⁷

The study by Spiliopoulos and colleagues⁸ provides justification for more extensive investigation of DSC as a means to improve outcomes in a very ill patient population subjected to high bleeding and transfusion rates requiring frequent mediastinal reexploration. With excessive bleeding noted in 43 of a series of 101 patients (42.6%) undergoing SynCardia TAH implantation, including 25 (24.7%) requiring mediastinal reexploration for hemorrhage,¹⁸ one could make the argument that a more liberal or even universal application of protocolized DSC in these patients would significantly improve clinical outcomes. Unless and until a better understanding of coagulopathic processes associated with end-stage heart failure and ventricular assist device implantation is achieved or improved, and biocompatible blood-bearing surfaces in these devices are developed, a paradigm change in the form of more routine, protocolized DSC after device implantation may be an important strategy in the early postoperative management of these patients.

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