Surgical Implantation of Intracorporeal Devices
Perspective and Techniques

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KEYWORDS

• Heart failure • Left ventricular assist device (LVAD) • Mechanical circulatory support (MCS)
• Surgical technique • Pump migration

KEY POINTS

- Implantation techniques for HeartMate and HeartWare devices, including open and minimally invasive approaches, are discussed.
- Methods of cannulation for pump implantation, including the option for off-pump as an alternative strategy, are also discussed.
- Pump position and driveline strategy to avoid migration and malfunction are examined.
- The importance of deairing maneuvers and proper weaning from cardiopulmonary bypass is stressed.
- Decision making with concomitant operations is considered.

The history of ventricular assist technology has evolved over the past several decades, creating a natural shift in style design and, therefore, methods and technique used for implantation. Second-generation and third-generation devices are noiseless, continuous-flow, axial, or centrifugal pumps with both improved durability and long-term survival compared with older-generation pulsatile-flow pumps. Surgical maneuvers, although surgeon specific, continue to be an important component to improving patient-reported outcomes and avoiding pump-related complications. No matter which device is implanted, following integral steps and conduct of operation has become the primary standard to care.

STERNAL ENTRY AND EXPOSURE

Among all of the devices described for implantation in the treatment of heart failure today, the 3 most common are the HeartWare HVAD (Medtronic, Minneapolis, Minnesota) (Fig. 1) and the HeartMate (Abbott Laboratories, Abbott Park, Illinois) devices, HeartMate II (Fig. 2) and HeartMate 3 (Fig. 3). The steps for each implantation are similar with only slight variations. Most commonly, a standard median sternotomy is performed. The pericardium is incised and divided left of midline to several millimeters before reaching the diaphragm, where it is then squared off in either direction. The dissection on the left continues several centimeters above the phrenic nerve to expose the apex of the heart.

Due to the size and structure of the HeartMate II pump, a preperitoneal pocket is created to orient both inflow and outflow cannula in a way that not only optimizes flow but also avoids compression of either ventricle. The incision beyond the diaphragm requires gentle dissection through subcutaneous tissue staying anterior to the posterior rectus sheath. An ideal pump pocket is one in which the incision is extended 7 cm to 10 cm below the xiphoid process and deep so that it

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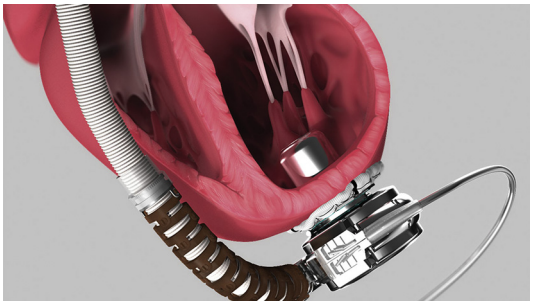

Fig. 1. HVAD. (*Courtesy of* Medtronic Inc, Minneapolis, MN.)

extends laterally under the costal arch.[1] With the lower-profile HeartMate 3 and HVAD, dissection proceeds without entry beyond the xiphoid and

Fig. 2. HeartMate II. (*Courtesy of* Abbott Laboratories, Abbott Park, IL.)

Fig. 3. HeartMate 3. (*Courtesy of* Abbott Laboratories, Abbott Park, IL.)

maintains the integrity of a closed left pleural space. In all cases, this dissection and creation of the driveline tunnel are most often performed prior to the administration of heparin.

THE DRIVELINE

Location of the percutaneous driveline is specific to a patient's anatomy and personal preference. The intention of placement is multifold: to avoid interference with pannus folds and beltlines as well as prevent line fractures and/or ascending infection. The drivelines in all 3 devices are silicone-covered cables with a portion covered in felt. The silicone covering the driveline acts to protect the cable from moisture and, when positioned appropriately, reduces complications associated with line fracture and malfunction. The velour or felt portion of the driveline allows for stability by creating an adherent effect to attach to internal surfaces and is intended to stay within the subcutaneous tissue. The silicone cover, on the other hand, is smooth and resistant to this inflammatory reaction. The recommended driveline placement is, therefore, known as a silicone-to-skin interface (**Fig. 4**). It has been described that maintaining this technique during the implantation of the HeartMate II device allows for a 50% reduction in driveline infections.[2]

Tunneling involves placement of the driveline through the rectus muscle along the anterior axillary line via a tunneling device approximately 2 cm below the costal margin on either side.[3] The driveline is passed through subcutaneous tissue, avoiding entry into the peritoneal space. It then exits through a skin incision at the predetermined location with the felt buried 1 cm to 2 cm from the exit site. An alternative scenario involves tunneling the device through the skin incision, passing through subcutaneous tissue, and entering the pericardial space 2 cm from the costal