The Left Ventricular Apex

Opening and Closing a New Port Into the Human Heart*

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The human heart has been variously regarded as the seat of the soul, the mind, emotions, and morals. The heart is gradually giving up its secrets under the onslaught of scientific and technologic advances. For interventional cardiologists and cardiovascular surgeons interested in novel therapeutic approaches to heart diseases, gaining safe access to its internal structures remains a formidable challenge. The history of percutaneous access for diagnostic purposes is fascinating, if not hair-raising.

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Direct left heart puncture was described by Brock et al. (1) in the 1950s and remained a standard approach to pressure measurement for years. Many cardiologists who trained in the 1960s and 1970s were familiar and comfortable with this technique, whereas those of us who trained subsequently are less familiar with it. What many may be unaware of are other fascinating approaches, such as the extended super-sternal puncture technique (2), where a patient lies supine with the neck hyperextended and a long, thin needle is passed into the super-sternal fossa directly into the center of the chest through the innominate vein, the aorta, pulmonary artery, and left atrium. A transbronchial approach to simultaneous left atrial and left ventricular pressure measurements was described by Morrow et al. (3), and in the laboratories of Dr. Earl Wood at the Mayo Clinic, multiple transthoracic needles were placed into the hearts of research subjects (imagine trying to get this through your Institutional Review Board now) for physiological studies. Although many of these transthoracic techniques have passed into the annals of medical history and catheterization laboratory lore, the development of transapical aortic valve implantation and percutaneous paravalvular leak closure have rekindled interest in the left ventricular apex as a therapeutic port into the heart.

The left ventricular apex has advantages as an access site. It is close to the surface and major structures, such as the aortic and mitral valves, which are only a few centimeters from the apex. For transapical aortic valve implantation, a mini thoracotomy is required, which is typically performed in a hybrid operating room. For diagnostic procedures requiring intracardiac pressure measurement or angiography, small IV-type catheter-on-needle cannulae can be readily introduced in the cardiac catheterization laboratory by experienced operators and simply pulled out without fear of major bleeding complications.

More challenging are therapeutic procedures that require larger caliber (≥6-F) sheaths. There are no purpose-built closure devices for such procedures, and a variety of approaches have been attempted. Among patients with prior cardiovascular surgery, sheaths have simply been pulled out and the access tracts left to clot and heal on their own. Because left ventricular systolic ejection occurs due to strong myocardial contraction, theoretically there would be a low risk of bleeding during systole, and because left ventricular pressures are often minimal during diastole, there should be a low risk of diastolic bleeding. Nonetheless, we (4) have observed a significant rate of bleeding complications when the apex is accessed percutaneously for interventional procedures. The most common serious complication is hemothorax, which requires chest tube drainage and results in a prolonged hospital stay. The hemothorax may be due to continued bleeding from the puncture site, inadvertent coronary artery laceration, or laceration of an intercostal vessel.

In this issue of JACC: Cardiovascular Interventions, Dr. Vladimir Jelnin and his innovative colleagues at Lenox Hill Hospital (5) describe their techniques and outcomes with left ventricular apical access and exit. Using sophisticated 3-dimensional computed tomographic imaging for pre-procedural planning purposes as well as intraprocedural guidance, a safe “puncture window” is defined. This window ensures access to the myocardium away from the left anterior descending artery and its branches and away from lung tissue. The pre-operative computed tomographic scan also identifies the most appropriate intercostal space to enter and the appropriate angulation and trajectory of the needle. With this information in mind, operators can confidently cannulate the left ventricular apex directly using standard Seldinger techniques, upsizing to the required sheath size, and perform the indicated therapeutic procedure. Equally innovative is the investigators’ use of Amplatzer (St. Jude Medical, Maple Grove, Minnesota) closure devices to plug apical access tracts. They favored ductal occluders followed by Surgiflo (Ethicon, Inc., Summerville, New Jersey) instillation into the delivery tract back to the skin. Using these techniques, they were able to successfully close holes as large as 12-F with almost no complications, which is a remarkable achievement. Taken at face value, these techniques repre-
sent a significant advance in the field of structural heart interventions and will facilitate further development of complex therapeutic procedures. Access to the sophisticated imaging technology and careful pre-procedural planning should be considered a prerequisite before performing such complex procedures. Apical closure will undoubtedly evolve and numerous closure possibilities exist including adaptation of suture-based technologies, other currently available plugs, or the development of purpose-built devices. To be successful, such devices should be easy to deploy; have a low risk of acting as a wick for infectious agents; and have a minimal risk of dislodgement, embolization, or late erosion of adjacent anatomic structures. Jelnin et al. (5) did not observe dislodgements nor embolizations, which is encouraging. Based on their findings and reported complication rates in the literature, both pre-procedural imaging as well as apical closure should be considered the new standards after apical access for therapeutic procedures. A larger clinical experience and use in different laboratories will be needed to further assess the efficacy and safety of these novel approaches. For pressure measurement or angiography with small-caliber needles and catheters, the current approach of simply pulling is probably adequate.

For structural interventionalists who are planning to undertake percutaneous apical access, the following should be considered. First, case observation and proctorship by experienced operators is invaluable. Operators should have a thorough understanding of abnormal cardiac anatomy in advanced valvular heart disease. Massively dilated left atria and rotated and upwardly displaced hearts are the rule rather than the exception. The apex is frequently diffuse and displaced in such patients, and the location of the coronary arteries may not be obvious. If a computed tomographic angiogram is not available, then intraprocedural left coronary angiography performed in the anteroposterior and lateral projections is useful in selecting the access site. Palpation and echocardiography are also useful, but it must be remembered that the true anatomic apex can frequently be hidden underneath a rib, so fluoroscopy should also be used. Taking care to understand the angle of approach along the orientation of the long axis of the left ventricle is key as wires may become entangled in the mitral apparatus with risk of subsequent injury. If these are carefully assessed, then puncturing the apex can be a relatively simple procedure that can be done under local anesthesia. Care must be taken not to tether stiff needles, as there is a risk of apical laceration. Softer vascular sheaths, by contrast, can be placed up into the ventricle and will flex with cardiac motion. Closure devices can be readily deployed as described by the investigators. Due to the risk of embolization, I would be very hesitant to use gelatin or other surgical glues until a relatively large experience has been built up.

If structural interventionalists master the technique of percutaneous apical access and closure, this will open up a new port into the heart and facilitate the development of new approaches and procedures. For example, placement of artificial chordae on the mitral valve leaflets, pulmonary vein stenting, stenting of branch pulmonary artery stenoses, and closure of left ventricular pseudoaneurysms readily come to mind. Jelnin et al. (5) are to be congratulated for these important steps forward.

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REFERENCES

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