Catheterization and Cardiovascular Interventions 76:993–997 (2010)

Complications Associated with Left Ventricular Puncture

Sridevi R. Pitta, MBBS, Allison K. Cabalka, MD, and Charanjit S. Rihal,* MD

Objective: To report complications in a consecutive series of patients undergoing percutaneous left ventricular apical puncture (LVAP) and sheath placement for diagnostic or interventional procedures. Background: Percutaneous LVAP is only rarely used to provide hemodynamic data in the presence of mechanical prosthetic valves. Recently, LVAP has been used to facilitate complex interventional procedures such as paravalvular leak closures. These frequently necessitate placement of 4–6 F sheaths, rather than smaller needles. Optimal technique and outcomes are largely unknown for this uncommon procedure. Methods: We retrospectively analyzed 32 patients undergoing LVAP with echocardiographic and fluoroscopic guidance at our institution between 2002 and 2009. These patients were referred to the cardiac catheterization laboratory for hemodynamic assessment to rule out prosthetic dysfunction and or to facilitate paravalvular leak closure. Sheaths ranged from 4 to 6 F were removed at the end of the procedure after reversing any anticoagulation. No specific closure devices were used for hemostasis. Frequency of access site complications associated with LVAP recorded. Results: Apical access site related complications were higher in patients requiring LVAP for intervention than for diagnostic purposes (25% vs. 12.5%). Hemothorax was the most frequent serious complication occurring in 6 (19%) patients and frequently required intervention 5(16%). Three patients had local bleeding with no drop in hemoglobin or need for intervention. Conclusions: LVAP is associated with a significant incidence of access-related complications. There is a need for safe and reliable methods of closing percutaneous LVAP access sites.

Key words: complications; left ventricular apical puncture; hemodynamics; hemothorax

INTRODUCTION

Percutaneous left ventricular apical puncture (LVAP) is a rarely used procedure, but has been performed to provide hemodynamic data and/or left ventricular angiography in the presence of mechanical prosthetic valves [1–3]. More recently, LVAP has been used to facilitate complex interventional procedures, such as paravalvular leak closure [4]. Interventional procedures typically require larger size sheaths. This technique is not without complications and an earlier series from our institution of 20 LVAP for hemodynamic assessment demonstrated a complication rate of 30%. All were minor complications [2]. Review of 38 patients from Mass General hospital from 1989 to 2000 indicated an 8% complication rate [5]. Other series of complications of LVAP after diagnostic or interventional catheterizations are limited to small case series and range of complications varied depending on definitions [4,6]

The purpose of this study is to report our more recent experience in a consecutive series of patients with prosthetic valves undergoing percutaneous LVAP for either diagnosis or intervention.

METHODS

We identified all cases of direct LVAP between 2002 and July 2009. Patients were referred to the cardiac catheterization laboratory for hemodynamic and angiographic assessment to rule out prosthetic dysfunction or for paravalvular leak closure. Procedures were performed under echocardiographic and fluoroscopic guidance. Size of sheaths depended on the choice of the operator and ranged between 4 and 6 F. Smaller

Division of Cardiovascular Diseases and Department of Internal Medicine, Mayo Clinic, Rochester, Minnesota

Conflict of interest: Nothing to report.

*Correspondence to: Charanjit S. Rihal, MD, Division of Cardiovascular Diseases, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA. E-mail: rihal@mayo.edu

Received 27 April 2010; Revision accepted 28 April 2010

DOI 10.1002/ccd.22640
Published online 6 October 2010 in Wiley Online Library (wileyonlinelibrary.com)

size sheaths were generally used for diagnostic purposes with larger sheaths used to facilitate paravalvular leak closure. Preparation involved holding oral anticoagulation prior to the procedure (target INR < 1.5) and discontinuing intravenous heparin for 4 hr before the procedure. However, all interventional patients were actively anticoagulated at time of apical puncture. The chest was palpated for the maximal apical impulse and draped with sterile technique. After identifying the left ventricular apex by examination and transthoracic echocardiography (TTE) with the angle of approach being noted by two-dimensional imaging, 1% lidocaine was injected subcutaneously and intracostally to provide local anesthesia. Care was taken to avoid the neurovascular bundle. An 18 or 21 gauge Angiocath (6″ Teflon Catheter System, Becton-Dickson, San Jose, CA) needle was advanced with the presence of ectopic beats typically indicating contact with LV epicardium. The needle was advanced into the LV (Fig. 1) and pressure recorded. After cannulating the LV, the wire was advanced and the needle exchanged for a 4-F sheath or higher based on operator choice. However, in 18 patients, patients after withdrawing the needle and stylet, the sheath was directly connected for pressure measurement without upsizing. To facilitate paravalvular defect closure, either a 10 or 15-mm gooseneck snare (Amplatz GooseNeck® Snare Kit, EV3, Plymouth, MN) was used to snare the antegrade transeptal wire (Fig. 2). This wire was then exteriorized through the apical sheath, establishing an external rail to facilitate crossing of the defect with the delivery catheter through which the closure device was placed. At the end of the procedure, the sheath was removed after reversing any anticoagulation. No closure devices were used for hemostasis. Data were retrospectively analyzed for in-hospital complications. Complications associated with left ventricular puncture were defined as (1) new pericardial effusion identified on TTE or transesophageal echocardiogram (TEE); (2) new pleural effusion identified by chest X-ray, TTE, TEE, or chest computerized tomography; (3) external bleeding at the access site; (4) chest pain of pleuritic or pericarditic nature; (5) death.

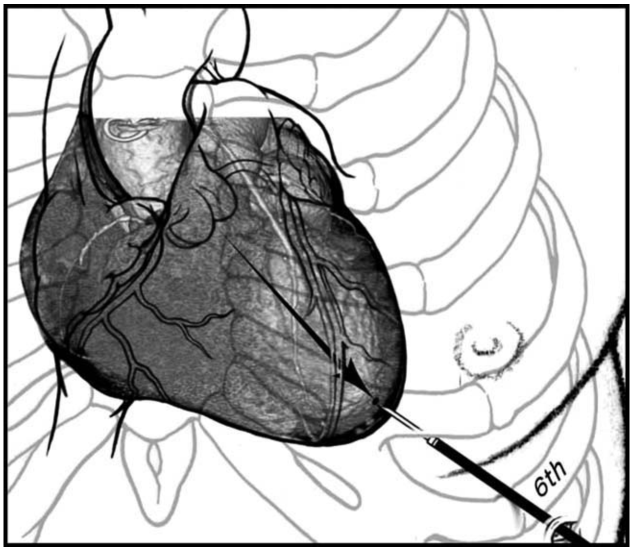

Fig. 1. Anatomical landmarks for LV apical puncture: schematic representation of heart and its relationship to surrounding anatomical structures.

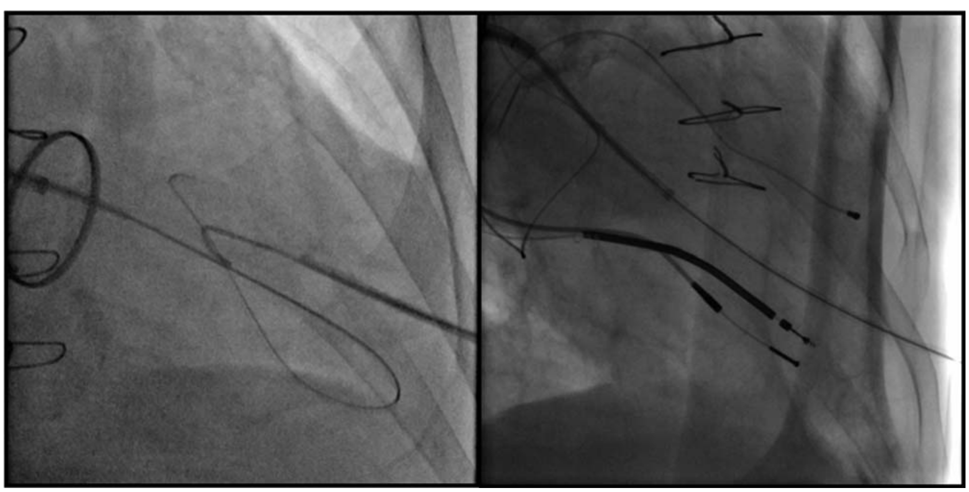

Fig. 2. Fluoroscopic image of LV puncture with snare: LV cannulated using the 18 gauge needle and upsized to a 4-F sheath or higher based on operator choice. During the paravalvular leak closure, a 10-mm gooseneck snare was used to snare the antegrade transseptal wire (Fig. 2A). Transseptal wire is exteriorized to the chest wall, establishing an arterial venous rail and assisting in the placement of the closure device (Fig. 2B).

TABLE I. Summary of Literature on Left ventricular Apical Puncture

Author	Year	Number of patients	Diagnostic[a]	Intervention	Total complications	Major[b]	Minor[c]	Hemostasis
Morgan et al. [3]	1989	112	112	None	25 (23%)	3 (2.6%)	22 (20%)	Manual
Ommen et al. [2]	1998	20	20	None	6 (30%)	None	6 (30%)	Manual
Walters et al. [5]	2003	38	38	None	3 (8%)	2 (5%)	1 (3%)	Manual
Lim et al. [4]	2008	6	1	5[d]	1 (17%)	1 (17%)	None	Purse string suture
Brown et al. [6]	2009	5	0	5[e]	2 (40%)	1 (20%)	1 (20%)[f]	Surgical & device[g]

[a]LVAP performed for hemodynamic evaluation.
[b]Major complications defined as pericardial tamponade and moderate to large hemothorax effusions requiring interventions.
[c]Minor complications: pleuritic or pericarditic chest pain, ventricular tachycardia, bradycardia, hypotension, vasovagal reaction.
[d]Indication: Paravalvular leak ($n = 4$), VSD ($n = 1$).
[e]Indication: Paravalvular leaks ($n = 3$), ventricular tachycardia ablation ($n = 1$), fontan conduit leak ($n = 1$).
[f]Left anterior descending coronary artery was punctured and dissected requiring coronary stent.
[g]Minithoracotomy ($n = 3$), percutaneous ($n = 2$), surgical closure ($n = 4$), closure device (Prostar XL TM, Perclose Europe, Berkshire, UK).

RESULTS

We identified 32 patients who underwent LVAP; there were 18 males and 14 females, and age range between 35 and 83 years. All patients had had prior cardiac surgeries ($n = 32$). Direct LVAP was performed for hemodynamic assessment of prosthetic valve dysfunction in 19 (59%) patients and to facilitate paravalvular leak closure in 13 (41%) patients. Twenty-four patients had both mechanical aortic and mitral valves, 1 patient had mechanical valves in aortic, mitral, and tricuspid positions, one mechanical valve in either aortic or mitral ($n = 4$), bioprosthetic aortic and mitral ($n = 2$), and mechanical aortic and bioprosthetic tricuspid valve ($n = 1$).

Inhospital Complications

Access site-related complications occurred in 12 (37%) patients undergoing LVAP. Patients requiring LV puncture for intervention had a higher complication rate than for diagnostic purposes (25% vs. 12.5%). Hemothorax was the most frequent serious complication, occurring in 6 (19%) patients (Fig. 3). Five patients developed large effusions and one patient had a small effusion, three required a chest tube, one required thoracotomy, and one needed ultrasound-guided thoracentesis. Four patients with hemothorax required multiple transfusions of packed red blood cells. Hemothorax was identified the day of the procedure in all but one patient. This patient experienced acute bleeding with hemothorax the day after a procedure and after being dismissing in stable condition. This occurred after using a snowblower, and presenting with chest pain, pallor, and respiratory distress. A large left hemothorax required chest tube drainage and blood transfusion. Four patients had small pericardial effusions by TTE or TEE, but none developed tamponade or required urgent pericardial aspiration. Three patients had chest wall or access site bleeding with no drop in hemoglobin or requiring any intervention. Chest wall pain characteristic of pericarditic or pleuritic occurred in 4 (12%). The complications are detailed in Figure 4.

There were no deaths related to the procedure; however, three patients subsequently died during hospitalization. One patient died from severe hypoxia and multiorgan failure, one from advanced heart failure, and a third died from multiorgan failure after undergoing open heart surgery for the fifth time.

DISCUSSION

The key finding in our study was that left ventricular puncture is associated with a significant number of serious access-related complications, particularly hemothorax. Experience with LVAP is limited to a small series of patients or to case reports. In the majority of the cases, LVAP was performed for assessing hemodynamics. Morgan et al. [3] has classified LVAP associated complications into major (pericardial tamponade and pneumothorax) and minor complications (pericardial effusion, pericardial pain, bradycardia, hypotension, and pleuritic pain). However, this classification did not include hemothorax. We further classified LVAP-associated complications into major (large to moderate hemothorax requiring intervention, pericardial tamponade); all other access-related complications are categorized as minor. Review of the literature (table 1) showed major complications ranging between 3 and 5% in earlier series, when LVAP was primarily used for diagnostic purposes. Major complications increased to 17–20% in the interventional era. In our series, major complications occurred in 5 (16%) patients, and all these patients developed large hemothorax requiring intervention. Potential sources of hemothorax could be the puncture site bleeding, laceration of a coronary artery, a pleural artery, or intercostal vessel trauma. All patients were previously anticoagulated, and all patients undergoing interventional procedures were actively anticoagulated with heparin, which would inherently increase the risk of bleeding. Pointing

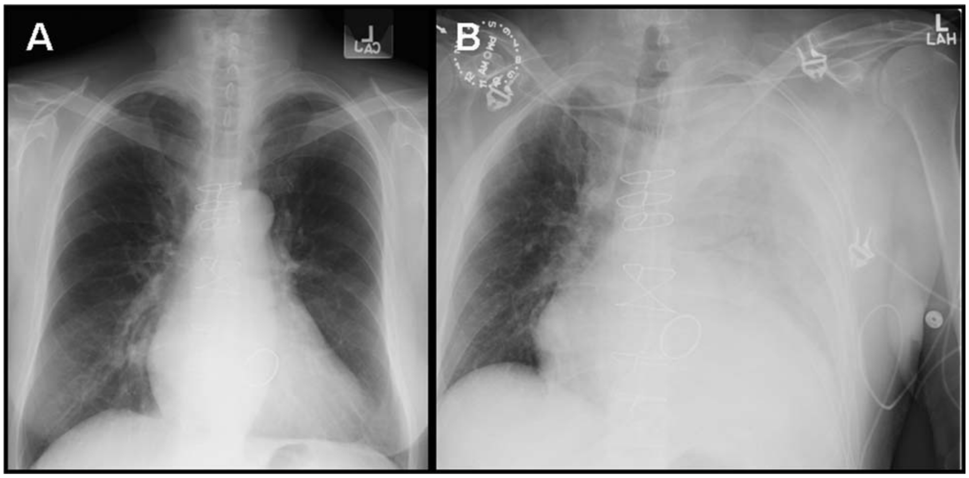

Fig. 3. Chest radiographs: preprocedure chest X-ray showing no evidence of pleural effusion (Fig. 3A). Postprocedure chest X-ray showing large left sided pleural effusion (Fig. 3B).

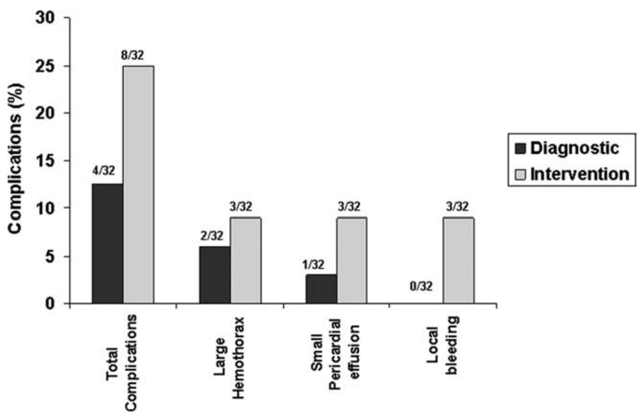

Fig. 4. Frequency distribution of access related complications: distribution of access related left ventricular apical puncture complications.

the needle superior to the rib can avoid intercostal vessel trauma. In addition, selective performing coronary angiography helps to avoid significant marginal or left anterior descending artery injury. Animal experiments by Semple et al. [7] have shed some insight into the potential cause bleeding from the left ventricle. This study noted that guidewire acted like a "saw" and could have been a major culprit for the bleeding. It also demonstrated that fewer punctures, smaller catheter, necessity for speed in exchanging the catheters over guidewire. Another interesting finding in this study was that retrosternal pain tends to be severe and occurs to occur earlier in the procedure; pleuritic pain is less severe, and occurs toward the end of the procedure. The pain is related to the extravasation of blood [7]. Relatively low incidence of pericardial effusion is thought be from left ventricular hypertrophy, scarring from previous surgery, and systolic contraction sealing the puncture site after catheter removal.

It is evident that complications vary among different studies and depend upon the indication for procedure, size of the access sheath, and type of hemostasis used for sheath removal. Thus far, there is no validated, safe, and reliable method of closing the percutaneous LVAP access site, but devices available for femoral puncture closure may or may not be applicable for the LV apex. Lim et al. [4] performed purse string sutures to the superficial skin after sheath removal in all eight patients undergoing LVAP ($n = 6$) or right ventricular puncture ($n = 2$) with good success. Only one patient developed hemothorax due to intercostal vein trauma. This was the first study using LVAP for interventional purposes and using large sheaths ranging from 6 to 9 F [4]. In another series, four patients had direct surgical closure of the puncture site and one patient had successful closure using percutaneous vascular occlusion device (Prostar XL, Perclose, Europe, Berkshire, UK) [6]. Use of closure devices is a novel idea, and further studies need to be conducted using newer devices and techniques to obtain better hemostasis to reduce access-related complications.

CONCLUSIONS

We conclude that LVAP is associated with a significant incidence of access-related complications, particularly in patients requiring LVAP for interventional purposes. There is a need for a safe and reliable method of closing percutaneous LVAP access sites.

REFERENCES

1. Kern MJ. Hemodynamic rounds series II: Left ventricular puncture for hemodynamic evaluation of double prosthetic valve stenosis. Cathet Cardiovasc Diagn 1998;43:466–471.
2. Ommen SR, Higano ST, Nishimura RA, Holmes DR Jr. Summary of the Mayo Clinic experience with direct left ventricular puncture. Cathet Cardiovasc Diagn 1998;44:175–178.
3. Morgan JM, Gray HH, Gelder C, Miller GA. Left heart catheterization by direct ventricular puncture: withstanding the test of time. Cathet Cardiovasc Diagn 1989;16:87–90.
4. Lim DS, Ragosta M, Dent JM. Percutaneous transthoracic ventricular puncture for diagnostic and interventional catheterization. Cathet Cardiovasc Interv 2008;71:915–918.
5. Walters DL, Sanchez PL, Rodriguez-Alemparte M, Colon-Hernandez PJ, Hourigan LA, Palacios IF. Transthoracic left ventricular puncture for the assessment of patients with aortic and mitral valve prostheses: The Massachusetts General Hospital experience, 1989–2000. Cathet Cardiovasc Interv 2003;58:539–544.
6. Brown SC, Boshoff DE, Rega F, Eyskens B, Budts W, Heidbuchel H, Meyns B, Gewillig M. Transapical left ventricular access for difficult to reach interventional targets in the left heart. Cathet Cardiovasc Interv 2009;74:137–142.
7. Semple T, McGuinness JB, Gardner H. Left heart catheterization by direct ventricular puncture. Br Heart J 1968;30:402–406.