Techniques

Direct Measurement of Left Atrial Pressure

during Routine Transradial Catheterization

Faisal Fa'ak, MD
Bahaeddin Shabaneh, MD
George Younis, MD

Left atrial pressure indicates the left ventricular filling pressure in patients who have systolic or diastolic left ventricular dysfunction or valvular heart disease. The use of indirect surrogate methods to determine left atrial pressure has been essential in the modern evaluation and treatment of cardiovascular disease because of the difficulty and inherent risks associated with direct methods (typically the transseptal approach). One method that has been widely used to determine left atrial pressure indirectly is Swan-Ganz catheterization, in which a balloon-flotation technique is applied to measure pulmonary capillary wedge pressure; however, this approach has been associated with several limitations and potential risks. Measuring left ventricular end-diastolic pressure has also been widely used as a simple means to estimate filling pressures but remains a surrogate for the gold standard of directly measuring left atrial pressure. We describe a simple, low-risk method to directly measure left atrial pressure that involves the use of standard coronary catheterization techniques during a transradial procedure. ***(Tex Heart Inst J 2016;43(6):503-6)***

Key words: *Blood pressure/left atrial; capillary wedge pressure/hemodynamics/physiology; cardiac catheterization/instrumentation/methods/transradial; catheterization, central venous; clinical protocols; heart atria; hemodynamics/physiology; risk factors*

From: *Department of Cardiology (Drs. Fa'ak and Shabaneh), Clear Lake Regional Medical Center, Webster, Texas 77598; and Department of Cardiology (Dr. Younis), Texas Heart Institute and CHI St. Luke's Health–Baylor St. Luke's Medical Center, Houston, Texas 77030*

Address for reprints:
Bahaeddin Shabaneh, MD, Clear Lake Regional Medical Center, 500 W. Medical Center Blvd., Webster, TX 77598

E-mail:
Shabanehb@msn.com

Hemodynamic evaluation of intracardiac pressures has for years been a crucial element of modern routine heart catheterization. Most often, however, these evaluations of left atrial pressure (LAP) are indirect—pulmonary capillary wedge pressure (PCWP) is obtained during right-sided heart catheterization, for example, or left ventricular end-diastolic pressure (LVEDP) is recorded during left-sided heart catheterization—and these numbers are used to estimate LAP. Left atrial pressure is not, as a matter of routine, measured directly, because of technical reasons and safety concerns. In this report, we present a simple, low-risk technique to directly measure LAP during routine transradial heart catheterization.

Technique

In December 2012, a 55-year-old man with a history of chronic uncontrolled hypertension, untreated obstructive sleep apnea, and morbid obesity (body mass index, 42 kg/m^2) presented with acute decompensated systolic congestive heart failure. His blood pressure was 213/103 mmHg on admission. Echocardiograms revealed noteworthy left ventricular (LV) hypertrophy and reduced systolic function (LV ejection fraction, 0.30–0.35), a pseudonormal mitral inflow pattern that suggested moderate diastolic dysfunction, and mild mitral and tricuspid regurgitation.

After 2 days of diuresis and optimal medical therapy, the patient was taken to the catheterization laboratory. Coronary angiography was performed via a right radial approach with a 5F right radial sheath and a 5F tiger-shaped (TIG) OPTITORQUE® Diagnostic Catheter (Terumo Interventional Systems; Somerset, NJ). The examination showed chronic total occlusion of the right coronary artery, adequate left-to-right collateral vessels, and mild left coronary artery disease. Selective left and right coronary angiography was performed via the TIG catheter, using standard methods. Then, with the use of a 0.035-in regular nonhydrophilic J-tip wire, we advanced the TIG catheter through the aortic valve in the straight right anterior oblique view with 30° angulation, and we measured the LV pressure. Counterclockwise rotation positioned the catheter in the left atrium, after it had crossed through the mitral valve in a retrograde fashion. The position of the catheter was confirmed via injection of iodinated contrast medium into the left atrium (Fig. 1). After flushing the catheter with heparinized saline, we recorded a direct measurement of the LAP (mean LAP, 32 mmHg) (Fig. 2).

Fig. 1 *Coronary angiogram shows the* O*PTITORQUE* *catheter with its tip placed in the left atrium, as confirmed by iodinated contrast injection.*

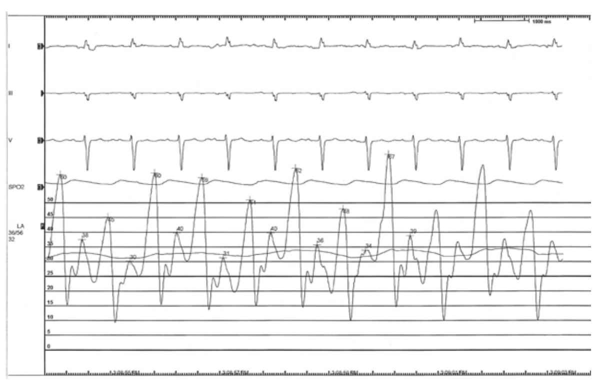

Fig. 2 *Hemodynamic tracing shows the left atrial pressure obtained directly by the* O*PTITORQUE* *catheter.*

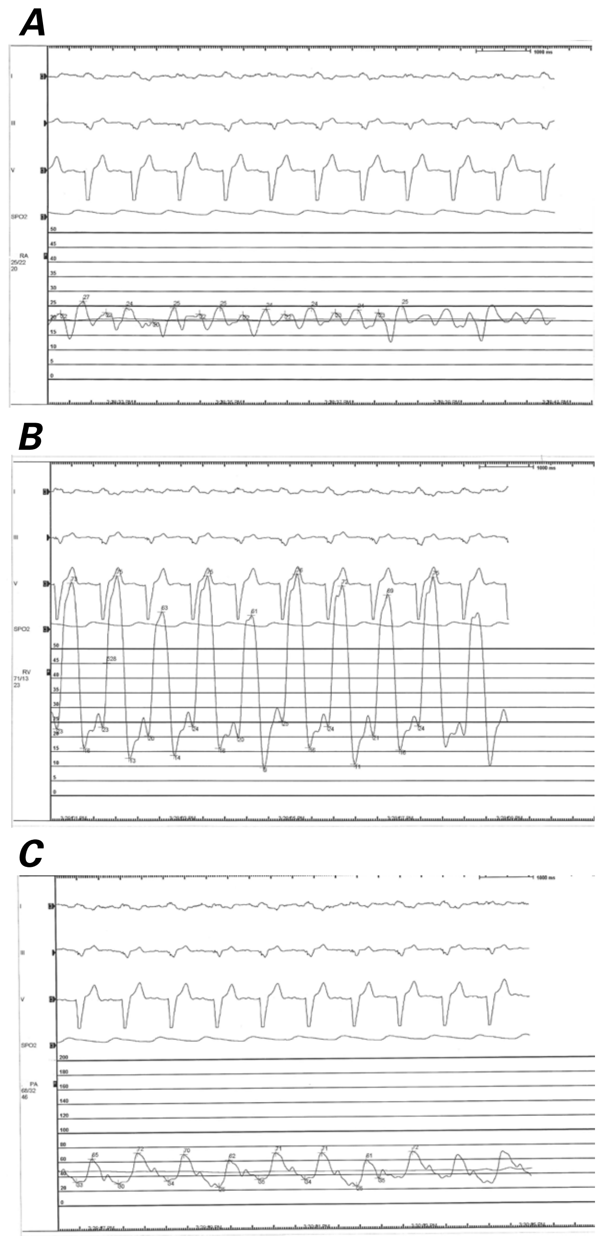

Fig. 3 *Serial hemodynamic tracing obtained by means of right-sided heart catheterization shows* ***A****) right atrial pressure,* ***B****) right ventricular pressure, and* ***C****) pulmonary artery pressure.*

We also performed right-sided heart catheterization. We obtained access to the right brachial vein by using a modified Seldinger technique and placed a 5F sheath. A Swan-Ganz catheter was then advanced to the right side of the heart, and serial measurements were taken in the right atrium (mean, 20 mmHg), right ventricle (71/13 mmHg), and pulmonary artery (68/32 mmHg; mean, 46 mmHg) (Fig. 3). Pulmonary capillary wedge pressure was also measured (mean, 35 mmHg) (Fig. 4). The measurement of LAP—obtained directly by using the coronary catheter—related well to the PCWP measurement. These measurements indicated increased filling pressures and volume overload from left-sided heart failure due to hypertensive cardiomyopathy. The patient was given further diuresis and showed substantial improvement.

After this first success, we attempted to apply this technique in 20 other patients undergoing standard transradial coronary catheterization. During the procedures, we advanced the TIG catheter into the LV and then crossed the mitral valve in a retrograde fashion by pulling the catheter while rotating it counterclockwise. We successfully crossed the mitral valve in 13 patients (approximately two-thirds of the cases). Occasionally, ventricular ectopy was noted during the procedure, with no subsequent deleterious effects. We noticed more ventricular ectopy upon clockwise rotation of the catheter than upon counterclockwise rotation.

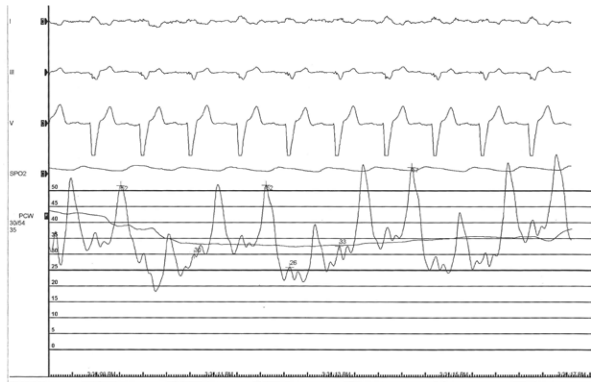

Fig. 4 *Hemodynamic tracing shows pulmonary capillary wedge pressure obtained by means of right-sided heart catheterization.*

Discussion

Accurate direct measurement of LAP has been the gold standard for evaluating potentially complex hemodynamic situations, such as mitral stenosis and decompensated congestive heart failure. Direct measurements of LAP are usually obtained by direct transseptal puncture or by traversing a patent foramen ovale. However, direct transseptal puncture has been associated with high rates of negative sequelae, including puncture of the cardiac wall, pericardial tamponade, fatal coronary embolism, systemic embolism, vasovagal reactions, and coronary ischemia.[1,2]

Routine transseptal puncture for diagnostic purposes is being replaced by less invasive, indirect methods of estimating LAP. One indirect method that has been widely used for decades is measuring PCWP via Swan-Ganz catheterization (SGC).[3] However, using the PCWP measurement as a surrogate for LAP has some important limitations. Generally, PCWP tracings are temporally delayed and can slightly overestimate the actual LAP. Although SGC is generally safe, numerous potential sequelae[4] range from minor ventricular ectopy to fatal events (such as pulmonary artery rupture). Over the last several years, the risk-benefit ratio has favored less routine use of SGC in patients with decompensated congestive heart failure and in critically ill patients at large. The decision to perform SGC should be dictated by the condition of the individual patient.

Measuring LVEDP during left-sided heart catheterization has been another popular surrogate method for estimating LAP and LV filling pressures. The LVEDP correlates well with the LAP a wave, rather than with the mean LAP.[5] Some shortcomings of this method for estimating LAP include its limited usefulness in certain patient populations, such as those with valvular heart disease, atrial fibrillation, or frequent atrial and ventricular ectopy, and the fact that the procedures for measuring LVEDP have not been standardized across laboratories and trials.[6]

The LVEDP is a single-point measurement taken at a specific time during diastole, whereas an LAP recording encompasses the whole cardiac cycle and enables one to obtain data for several elements, including waveform morphology, systolic and diastolic measurements, and the mean measurement. All these elements have been well described in the relevant literature for various cardiac abnormalities. The LAP measurements provide additional information beyond what LVEDP measurements do for different valvular abnormalities. Besides indicating LV filling pressures, LAP is also a better indication of left atrial systolic and diastolic function than is LVEDP. The LVEDP is generally lower than LAP in patients with mitral stenosis, whereas simultaneous or pullback measurements can provide an accurate indication of the severity of the stenosis, if needed.

Some physicians recommend against routine crossing of the aortic valve in cardiac catheterization procedures to measure LVEDP, even without left ventriculography. Reasons cited for this recommendation include increases in fluoroscopy time and ventricular ectopy, and the possibility of patient discomfort; in addition, echocardiography has increasingly replaced angiography in valvular and hemodynamic evaluations.

Conversely, proponents of routine hemodynamic appraisal refer to the Prevention of Contrast Renal Injury with Different Hydration Strategies (POSEIDON) trial.[7] In that randomized trial, an LVEDP-guided hydration strategy was compared with a standard hydration approach in patients who underwent percutaneous intervention. After 6 months of monitoring, patients in the LVEDP-guided hydration arm showed a 68% decrease in the composite endpoint of death, myocardial infarction, or dialysis (relative risk, 0.32; 95% confidence interval, 0.13–0.79). The primary outcome of contrast nephropathy was significantly reduced (by 59%, P=0.005). This study highlights the importance of hemodynamic measurements during standard heart catheterization.

We believe that this report is the first to show the application of a routinely used radial catheter to the direct determination of LAP. This was done simply by rotating the catheter within the LV. Although substantial intrinsic risks are associated with direct measurement of LAP by the transseptal approach, our retrograde method is much simpler and carries a much lower risk of adverse events. We used a radial catheter for a transradial catheterization procedure, but we think that the same technique could be used in transfemoral procedures. However, performing this maneuver during a transfemoral procedure might require the use of a nonstandard catheter with special physical characteristics, or possibly even a newer design. Our method is comparable, in terms of simplicity, to that of measuring LVEDP, but we think that it more accurately reflects LAP and LV filling pressures. A larger study is needed to validate the findings set forth in this case report, before widespread adoption of this technique can be recommended.

References

1. Adrouny ZA, Sutherland DW, Griswold HE, Ritzmann LW. Complications with transseptal left heart catheterization. Am Heart J 1963;65:327-33.
2. B-Lundqvist C, Olsson SB, Varnauskas E. Transseptal left heart catheterization: a review of 278 studies. Clin Cardiol 1986;9(1):21-6.
3. Swan HJ, Ganz W, Forrester J, Marcus H, Diamond G, Chonette D. Catheterization of the heart in man with use of a flow-directed balloon-tipped catheter. N Engl J Med 1970; 283(9):447-51.
4. Evans DC, Doraiswamy VA, Prosciak MP, Silviera M, Seamon MJ, Rodriguez Funes V, et al. Complications associated with pulmonary artery catheters: a comprehensive clinical review. Scand J Surg 2009;98(4):199-208.
5. Mark JB. Atlas of cardiovascular monitoring. New York: Churchill Livingstone; 1998; p. 278. Fig. 6-1.
6. Mielniczuk LM, Lamas GA, Flaker GC, Mitchell G, Smith SC, Gersh BJ, et al. Left ventricular end-diastolic pressure and risk of subsequent heart failure in patients following an acute myocardial infarction. Congest Heart Fail 2007;13(4):209-14.
7. Brar SS, Aharonian V, Mansukhani P, Moore N, Shen AY, Jorgensen M, et al. Haemodynamic-guided fluid administration for the prevention of contrast-induced acute kidney injury: the POSEIDON randomised controlled trial. Lancet 2014;383(9931):1814-23.