Measuring Nonpulsatile Blood Pressure
Say Goodbye to the Doppler?

David W. Markham, MD, MSc; Mark H. Drazner, MD, MSc

We are in a unique era of human physiology: the era of nonpulsatility. The benefits of pulsatile blood pressure (BP) have been debated for decades, but now this debate is growing with the emergence of continuous flow left ventricular assist devices (LVAD) as an accepted therapy for patients with refractory heart failure. The question is this: do humans require pulsatile BP for adequate end-organ function in the acute and chronic settings; or to turn the question around: are humans deleteriously affected by nonpulsatile flow?

The short- and medium-term outcomes associated with continuous flow LVADs are well known and have significantly improved as compared with first generation pulsatile devices.1–3 Current devices are more durable, with smaller rotors, pumps, and drive lines. Indeed, we have seen a steady rise in the adoption and application of LVADs over the last several years (ie, the HeartMate II continuous flow device was approved for bridge to transplant [BTT] in 2008 and destination therapy [DT] in 2010; the HeartWare device was approved for BTT in 2012). Despite lack of pulsatile flow in the arterial system, end-organ function improves as compared with the preimplant state.2 Nevertheless, we have much to learn about these devices, particularly how to optimize pump speed for long-term use (potentially over the course of decades), how best to manage anticoagulation, how to promote improved exercise capacity, and how to lower the incidence of complications such as stroke. Recently, we have shown that muscle sympathetic nerve activity in nonpulsatile patients was significantly increased compared with patients supported with pulsatile LVADs and healthy controls during head-up tilting, likely as a result of the unloading of the baroreceptors from lack of arterial pulsatility.4 The consequences of this chronic activation of the sympathetic nervous system in this setting, including its impact on the potential for myocardial recovery, are currently unknown but worthy of further investigation.

Optimization of BP control in patients supported with continuous flow LVADs is another critical question which remains largely unanswered. Some recent guidelines on the management of LVAD patients recommend the following:

The goal is to maintain the mean arterial BP in the range of 70 to 80 mmHg. It should not exceed 90 mmHg. (. . .) Maintaining the mean arterial pressure in the desired range will optimize cardiac support. It may also reduce stroke because of hypertension.5

This mention of stroke is important because stroke rates in LVAD patients remain high, including 1 recent study that reported a stroke rate (ischemic and hemorrhagic) of ≈19% in DT patients.6 However, other data show that stroke rates may now be lower.7 We await updated reports on BTT and DT outcomes. Certainly, the clinical management of BP in LVAD patients is a complicated formula where several factors have to be considered, including optimization of afterload, volume status, and pump speed, although it is not recommended to change pump speed to achieve a desirable BP.5

Management of BP in patients with continuous flow LVADs is further complicated because standard methods of measuring BP, for example with a stethoscope or a routine automated cuff in the clinic, are not successful in the absence of pulsatile arterial flow. The arterial line, although the gold standard, is an invasive procedure and is not practical for routine outpatient use. Currently, many LVAD centers, including ours, use Doppler to measure the BP as suggested by the Hopkins group.6 However, Doppler BP measurement requires technical expertise. Additionally, it is not clear whether Doppler measures the systolic blood pressure (SBP) or the mean arterial pressure (MAP).

In this issue of Circulation: Heart Failure the study by Lanier et al8 begins to fill an important void in this field. In a cohort of 60 patients supported with the HeartMate II, the authors compared 4 methods of measuring BP (arterial line, a slow cuff deflation device [Terumo Elemano], a standard automated BP monitor [GE CARESCAPETM V100], and Doppler). They demonstrated that the Terumo Elemano was more reliable than the standard automated device and that the Terumo was quite accurate compared with the arterial line. Furthermore, the Terumo device was successful in 88% of BP measurement attempts compared with 71% for the standard automated cuff device. The mean absolute differences for the Terumo device versus arterial line measurements of SBP and MAP were 4.6±0.6 mm Hg and 4.2±0.6 mm Hg, respectively. There were, however, a substantial number of patients who had >10 mm Hg differences between the Terumo device and the arterial line.
Importantly, the study also showed limitations of the Doppler method. Doppler BP measurement in nonpulsatile patients underestimated SBP by ≈4 mm Hg and overestimated MAP by ≈9 mm Hg, data which suggest that the Doppler method more closely reflected the SBP than the MAP. Perhaps not surprisingly, this limitation of the Doppler method was particularly evident with increasing pulse pressure, when the SBP (which could trigger the Doppler signal) and the MAP are increasingly separated. These findings are particularly relevant because patients supported with continuous flow LVADs have variable levels of aortic valve opening and pulsatility, ranging from fixed aortic valve closure with complete nonpulsatility in some patients to routine aortic valve opening and high-pulse pressure in others. If the degree of pulsatility was not accounted, then antihypertensive therapy could be altered based on a Doppler measurement of BP which was considered to be the MAP, but in reality was the SBP. If so, up-titration of antihypertensive medications could produce unwanted side effects such as dizziness, syncope, and hypotension. Because Doppler is the current clinical standard in many centers, this study, therefore, provides important and practical information to providers who care for patients with continuous flow LVADs on a daily basis.

Overall, the authors conclude that the Terumo device offers significant advantages versus Doppler when assessing BP in patients supported with continuous flow LVADs. Additionally, they note that the Terumo device is relatively inexpensive and could even be appropriate for home use. By providing more accurate ambulatory data, the Terumo device could be an important step in the process of identifying optimized BP goals for patients supported by continuous flow LVADs. Ideally, confirmatory data about the comparative benefits of the Terumo device will be brought forth and pulsatility in some patients to routine aortic valve opening and high-pulse pressure in others. If the degree of pulsatility was not accounted, then antihypertensive therapy could be altered based on a Doppler measurement of BP which was considered to be the MAP, but in reality was the SBP. If so, up-titration of antihypertensive medications could produce unwanted side effects such as dizziness, syncope, and hypotension. Because Doppler is the current clinical standard in many centers, this study, therefore, provides important and practical information to providers who care for patients with continuous flow LVADs on a daily basis.

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References

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