HeartWare Left Ventricular Assist Device Pump Thrombosis
A Shift Away From Ramp*

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Ventricular assist device (VAD) thrombosis is a frequent and potentially devastating complication of mechanical circulatory support. Recent studies have shown an abrupt increase in the incidence of HeartMate II device thrombosis (Thoratec Corporation, Pleasanton, California) (1,2), whereas the incidence of HeartWare (HeartWare Inc., Framingham, Massachusetts) ventricular assist device (HVAD) thrombosis remains stable (3,4). With the increase in the number of patients treated with durable mechanical circulatory support, the magnitude of this complication will continue to rise, mandating a pragmatic approach for diagnosis and treatment. In this issue of JACC: Heart Failure, Jorde et al. (5) summarize the patterns of power consumption available from log-file analysis of the HVAD system during an acute syndrome of pump thrombosis, and it is in this context that it becomes clinically relevant.

The first step in the management of VAD thrombosis is establishing the diagnosis. The diagnosis of pump thrombosis can be challenging, requiring a high degree of vigilance. In a recently published case series, our group described for the first time that VAD thrombosis is a spectrum of clinical presentations with a broad range of signs and symptoms (6). On one side of the spectrum, patients may be completely asymptomatic with no change in their functional capacity, with signs of hemolysis as the only manifestation (6). Other more common presentations include exacerbating heart failure symptoms, new thromboembolic event, syncope, and cardiogenic shock (6).

To detect patients in early stages of device thrombosis, it is crucial to monitor the plasma markers of hemolysis, such as lactate dehydrogenase (LDH) levels and plasma-free hemoglobin. Uriel et al. (7) reported that an LDH level more than 5 times the normal limit is highly specific (92.5%) and sensitive (100%) for the diagnosis. In our series, 2 patients with confirmed pump thrombosis had a <3-fold increase in LDH, reducing the sensitivity of 5-fold LDH cutoff to 82% (6). Thus, in patients with normal LDH levels, other causes of the symptoms/signs of recurrent heart failure should be considered, such as aortic insufficiency and right ventricular failure.

In HeartMate II patients, the next step in the diagnosis in hemodynamically stable patients with suspected VAD thrombosis is the echocardiographic ramp study. In this study, repeat echocardiographic measurements are recorded at different pump speed, comparing changes in various parameters (e.g., left ventricular end-diastolic diameter, power of the device, frequency of aortic valve opening, mitral valve regurgitation). This study has high sensitivity and specificity in HeartMate II patients when used in conjunction with LDH levels (7). However, the utility and safety of using the echocardiographic ramp study in HVAD patients has not been demonstrated in the setting of HVAD thrombosis.

The recommended treatment of HeartMate II VAD thrombosis is pump replacement or heart transplant. Starling et al. (1) reported that patients with VAD thrombosis who were treated with pump replacement or heart transplantation had similar survival at
6 months as patients without VAD thrombosis. On the other hand, HeartMate II patients with VAD thrombosis who were treated medically had 50% mortality rate (1) or a high rate of recurrence (8,9).

However, in HVAD thrombosis the decision on the treatment strategy is more complex. Najjar et al. (3) reported a 50% success rate in treating patients with suspected HVAD thrombosis with thrombolytic or anticoagulant/antiplatelet treatment. However, these therapies are not benign and associated with severe side effects, mostly bleeding. Moreover, it was unclear which HVAD patients will respond to medical therapy and the common practice in most centers weighed the risks associated with pump exchange versus thrombolytic therapy in an individualized manner. In the current study, Jorde et al. (5) successfully identified the characteristic waveform pattern in an acute HVAD thrombosis that will be responsive to thrombolysis. The nuanced findings, which the manuscript by Jorde et al. bring forth is that the increase in the power consumption can be modeled to provide 2 characteristic patterns that may have clinically relevant
differences: 1) growth rate <1.25; and 2) and peak power <200% of baseline. These parameters may predict a favorable clinical response to thrombolysis of pump thrombosis.

The authors should be complimented for this important study, which can potentially change the management of patients with HVAD thrombosis. The relevance of the Jorde et al. (5) findings cannot be overstated in this era of highly scrutinized patient selection when considering the risks and benefits of a pump exchange. The findings from this study, which highlight the utility of log file analysis in the HVAD, along with the previous research which has instructed our field in the use of the echocardiographic ramp study for a suspected thrombosis of the HeartMate II (7,10) are now providing a more complete clinical algorithm for the diagnosis and treatment of VAD thrombosis in patients with either continuous flow devices (Figure 1).

The main limitations of the study were detailed by Jorde et al. (5). Because a prospective protocol was not available to capture all patients with a suspected pump thrombosis, a selection bias might be present in that patients who were treated with thrombolysis without any log file analysis might have not demonstrated the characteristic patterns of power consumption. Conversely, patients who were in the throes of hemodynamic collapse or died suddenly would have not had any opportunity for rescue with lytic therapy and therefore constitute a group for which we do not have equivalent data on the predictive value of the power consumption curves for a thrombolytic-responsive outcome.

Despite these limitations, the study by Jorde et al. (5) provides a glimpse of what may be possible in the near future—the identification through carefully measured parameters derived from log files of patients who are more likely to succeed with a specific, high-risk therapy in the throes of a pump thrombosis. The reason why only some patients respond to thrombolysis is unclear and mandates further research. It is unknown whether early diagnosis of VAD thrombosis may allow successful medical management and avoidance of the need for pump replacement even in HeartMate II patients or whether early pump replacement will improve survival and decrease adverse event rates. In the broadest perspective, the current study highlights the potential of understanding the patient-device interface to inform the most crucial clinical decisions in the acute and long-term care of mechanically assisted heart failure patients.

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