The role of endomyocardial biopsy (EMB) for the evaluation of cardiomyopathy and monitoring for cardiac transplant rejection has evolved over the past 40 years. EMB is typically done with fluoroscopic guidance and femoral or jugular venous access for sampling the right ventricle (RV) endocardium. Left ventricular biopsy requires arterial access, is associated with approximately a 1 in 300 to 1 in 500 risk of stroke (1), and is therefore not routinely done unless there is a specific concern for isolated involvement of the left ventricle such as cardiac sarcoidosis or giant cell myocarditis, where a tissue diagnosis would likely change prognosis or management.

The current indications for EMB are on the basis of recommendations from the 2007 American Heart Association/American College of Cardiology/European Society of Cardiology Scientific Statement (2) and the 2011 consensus statement from the Association for European Cardiovascular Pathology (3). The 2013 American Heart Association/American College of Cardiology Guidelines for the Management of Heart Failure (4) recommend considering EMB for patients presenting with heart failure when a specific diagnosis is suspected that would influence therapy (Class IIa, Level of Evidence: C) such as giant cell myocarditis, fulminant lymphocytic myocarditis, or cardiac sarcoidosis. As a result, EMB is recommended in 3 specific patient scenarios: 1) fulminant acute heart failure: unexplained new-onset heart failure presenting within 2 weeks with hemodynamic compromise; and 2) unexplained new-onset heart failure (over 2 weeks to 3 months) with dilated left ventricle and new high-grade arrhythmias (ventricular tachycardia, Mobitz type II second-degree atrioventricular block, or third-degree atrioventricular block); and 3) routine monitoring for cardiac allograft rejection. A 2013 European Society of Cardiology position statement recommends extending the indications for EMB to include chronic, idiopathic dilated cardiomyopathy (5). EMB also has a role in the evaluation of other patients with heart failure when infiltrative or storage disorders are suspected and if noninvasive, laboratory, and clinical evaluation is inconclusive.

One of the main limitations of EMB is the difficulty in obtaining sufficient myocardial tissue affected by the underlying pathology to make a specific histological diagnosis using the traditional fluoroscopic-guided approach and vital histological stains. The rate of a specific diagnosis can be as low as 10% to 15% using only RV sampling in unselected cardiomyopathy patients (6). Patients presenting with acute heart failure of <2 weeks duration have a yield of 35% on EMB for a tissue diagnosis (7). However, in patients with suspected myocarditis, the yield of EMB is 79% when biventricular samples, immunoperoxidase stains, and viral genome analysis are used for diagnosis (8). Taking left ventricular EMB samples with cases of isolated left ventricular cardiomyopathy and using immunoperoxidase and molecular diagnostic techniques improves the yield to as high as 97.8% (9).

Multiparametric cardiac magnetic resonance imaging (CMR) allows for noninvasive tissue characterization in areas of myocardial edema, inflammation, and scar using techniques such as T2 mapping, T1 mapping, and late gadolinium enhancement (LGE). The multiparametric imaging approach is especially useful with myocarditis, where T1 mapping can identify areas of myocardial fibrosis not visible with LGE (10). Interestingly, the diagnostic yield of EMB was not improved when sampling areas of LGE on CMR imaging in 1 study of patients with myocarditis (8).
In this issue of *JACC: Basic to Translational Science*, Rogers et al. (11) studied a novel approach to EMB in a swine animal model of myocardial infarction and subsequent ischemic cardiomyopathy. They used real-time CMR to identify the areas of myocardial scar using LGE and a custom 6.5-F CMR-conditional biop吸取 to remove the tissue samples. The CMR-conditional biop吸取 has hinged jaws in a titanium alloy with a copper-beryllium housing, and the catheter has a dipole antennae. This design allowed for visualization of the catheter by CMR without a significant susceptibility artifact. A second EMB procedure was done using conventional fluoroscopy and commercially available biop吸取es by a separate proceduralist after reviewing the LGE images. For each animal, there were 10 to 20 biopsy specimens obtained by both EMB procedures (CMR-guided and traditional fluoroscopy). The study compares the diagnostic yield from EMB between the 2 procedures.

The swine infarct model results in transmural infarction. If there is subendocardial involvement of the myocardium, then left ventricular EMB is well suited to obtain a histological diagnosis. However, in cases of mid-myocardial or, in particular, isolated subepicardial myocardial pathology, even with CMR-guided EMB, the diagnostic yield would likely be reduced.

The study by Rogers et al. (11) provides an exciting view into a potential clinical use of CMR-guided EMB that may significantly improve the diagnostic yield of EMB. Unfortunately, post-viral myocarditis and even giant cell myocarditis does not uniformly affect the endocardium. The remaining gaps to demonstrate clinical utility can be met by demonstrating safety and studying suspected inflammatory cardiomyopathy in patients. The diagnostic yield with and without CMR guidance should be assessed using both vital stains (the Dallas Criteria for myocarditis) and the newer immunoperoxidase and molecular diagnostic studies. There will likely be a risk of stroke in any left ventricular biopsy procedure, and thus a modification of the CMR-compatible biop吸取 to sample the RV would be useful. Additionally, newer imaging sequences for inflammation such as native T1-mapping should be evaluated with real-time CMR guidance. The present study significantly advances the CMR-conditional biop吸取 toward clinical application in patients with unexplained cardiomyopathy.

**REFERENCES**


**KEY WORDS** cardiomyopathy, heart biopsy, myocarditis