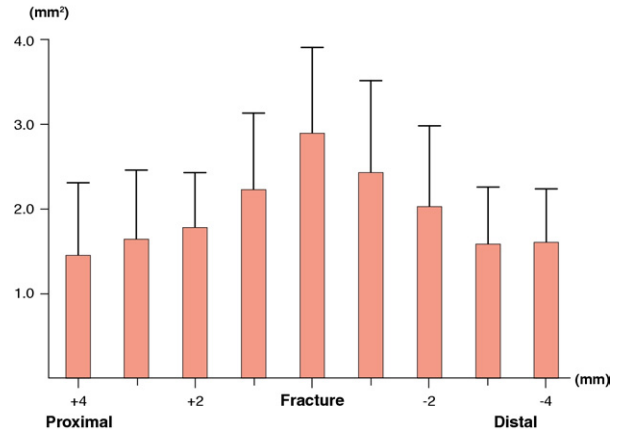

Figure 2. Neointimal Hyperplasia Area and Distance From the Fracture Site

The distribution of neointimal hyperplasia shows a peak at the fracture site. Data are shown as mean with SD.

28.0% vs. 14.9 ± 23.6%, $p < 0.01$) compared with the nonfractured stent group. The absence of stent strut was the common morphological feature of stent fracture in OCT. Both mean and maximal neointimal area were larger in the stent fracture group (fracture 1.59 ± 0.75 mm^2 vs. nonfracture 0.55 ± 0.46 mm^2, $p < 0.01$; and fracture 3.30 ± 1.73 mm^2 vs. nonfracture 1.28 ± 1.10 mm^2, $p < 0.01$, respectively). Although neointima grew equally in the nonfractured stent group, the distribution of neointimal area showed a peak at the fracture site in the fractured stent group (Fig. 2). The longitudinal length of the absence of stent struts was positively correlated with the neointimal area at the fracture site ($r = 0.79$, $p < 0.01$). From the receiver-operating characteristics curve, the best cutoff value of the length of the absence of stent struts to diagnose stent fracture was 1.07 mm (area under the curve 0.85, sensitivity 93%, and specificity 80%).

The absence of stent strut was the common morphological feature of stent fracture, and its length was correlated with the neointimal area. These results suggest that the loss of stent strut itself is one of the important contributors to excessive neointimal growth. Previous ex vivo studies reported that cyclic stretch on cultured cells induces the proliferation of vascular smooth muscle cells. We have reported that stent fracture frequently occurs at bend lesions (4). When stent fracture occurs, the stent loses its ability to scaffold the artery wall against mechanical stress. We speculate that occurrence of these mechanical stresses at the fracture site could contribute to excessive neointimal growth. Furthermore, many previous studies have postulated other causes for SES restenosis including stent under-expansion, polymer disruption, stent strut inconsistent distribution, and stent fracture. These factors could directly or indirectly affect the drug delivery. Even though it is difficult to know when the stent was fractured, we speculate that a loss of stent struts at the fracture site may impede effective local drug delivery, resulting in failure to prevent the neointimal growth.

This study has several limitations. We only analyzed a small number of fractured stents. Fluoroscopy might miss small stent fractures because of its low spatial resolution. Thrombus or lipid components may disturb the accurate assessment of neointima area. There is also a possibility that stent struts covered with thick neointima may be misdiagnosed as the disappearance of stent struts. In conclusion, OCT could diagnose stent fracture, and neointimal hyperplasia is enhanced at the fracture site.

Manabu Kashiwagi, MD, Atsushi Tanaka, MD,*
Hironori Kitabata, MD, Yasushi Ino, MD, Hiroto Tsujioka, MD,
Kenichi Komukai, MD, Yuichi Ozaki, MD, Kohei Ishibashi, MD,
Takashi Tanimoto, MD, Shigeho Takarada, MD,
Takashi Kubo, MD, Kumiko Hirata, MD,
Masato Mizukoshi, MD, Toshio Imanishi, MD,
Takashi Akasaka, MD

*Department of Cardiovascular Medicine, Wakayama Medical University, 811-1 Kimiidera, Wakayama 641-8509, Japan.
E-mail: a-tanaka@wakayama-med.ac.jp

doi:10.1016/j.jcmg.2011.07.014

REFERENCES

1. Suzuki Y, Ikeno F, Koizumi T, et al. In vivo comparison between optical coherence tomography and intravascular ultrasound for detecting small degrees of in-stent neointima after stent implantation. J Am Coll Cardiol Intv 2008;1:168–73.
2. Tanaka A, Imanishi T, Kitabata H, et al. Morphology of exertion-triggered plaque rupture in patients with acute coronary syndrome: an optical coherence tomography study. Circulation 2008;118:2368–73.
3. Murata A, Wallace-Bradley D, Tellez A, et al. Accuracy of optical coherence tomography in the evaluation of neointimal coverage after stent implantation. J Am Coll Cardiol Img 2010;3:76–84.
4. Ino Y, Toyoda Y, Tanaka A, et al. Predictors and prognosis of stent fracture after sirolimus-eluting stent implantation. Circ J 2009;73:2036–41.

T_2-Weighted CMR

But Where Is Elvis in the End?

A few months ago, in an editorial by Raman et al. (1), T_2-weighted (T_2w) short tau inversion recovery (STIR) imaging, the only validated T_2 sequence that was tested against pathology in an experimental setting to assess the myocardial area at risk (AAR), was almost thrown out the window because of its limited accuracy and poor reproducibility due to the high sensitivity to artifacts. However, there was still hope, because better sequences have come out (T_2w ACUTE [Acquisition for Cardiac Unified T2 Edema], T_2prep steady-state free precession, T_2 mapping) with significantly better reproducibility and accuracy. But those sequences have not been validated against pathology.

In a recent issue of *iJACC*, Fuernau and Eitel et al. (2) have published successively several papers about large groups of acute ST-segment elevation myocardial infarction patients in whom T_2wSTIR was used to assess the AAR. Their results showed that T_2wSTIR had a significant prognostic value, and it was well correlated to angiographic surrogates of the myocardial AAR. At

the same time, we have shown (3) in an experimental model of ischemia reperfusion that T2wSTIR and T2wACUTE were significantly correlated to the AAR by pathology, but significantly overestimated it.

All of these recent publications leave the reader uncertain and confused about the utility and reliability of T_2w imaging.

In that same issue of *iJACC,* Friedrich et al. (4) boldly decided to open the debate between the AAR T_2w imaging pro and cons. As always, in such a debate, the truth probably lies somewhere in between.

What are the facts most of us agree on?

- T_2w imaging shows myocardial edema as a marker of acute injury.
- T_2w imaging is convenient and simple, can be applied retrospectively after reperfusion, and provides incremental data to delayed enhancement imaging.
- T_2w imaging and especially the classic T_2wSTIR sequence is sensitive to many artifacts that can alter the data interpretation and analysis.
- Myocardial edema detected by T_2w cardiac magnetic resonance is correlated to the myocardial AAR, although correlation does not mean causation.
- There currently are no guidelines for post-processing of T_2 hyperenhancement and association to delayed-enhancement measurement thresholds.

What are the main points of disagreement?

- T_2w imaging provides an accurate measurement of the AAR. If the definition of the AAR is purely perfusional (the area of jeopardized myocardium during the coronary occlusion), then using T_2w edema to assess the AAR assumes there is a perfect and direct relationship between the area of edema and the area of jeopardized myocardium. When we put this in a pathophysiological perspective, we know that edema is also influenced by many other factors such as microvascular obstruction, inflammation, reperfusion status, myocardial hemorrhage, reperfusion injury, and other unknown confounders. Therefore, the assumption of a direct linear relationship between the T_2w hyperenhanced area and the AAR is potentially submitted to many biases. This assumption ignores that retrospective T_2w imaging after reperfusion provides a global assessment of ischemic as well as reperfusion damage, 2 complex but cumulative and nonlinear phenomena. To accept T_2w imaging as a method of reference for the assessment of the AAR, you would have either to neglect the effect of factors other than ischemia, such as reperfusion injury, or create a new definition for the AAR.
- The place of interstitial edema in the explanation of T_2w enhancement is unclear. Friedrich et al. (4) provide a very elegant explanation of intracellular edema at the acute phase of infarction but do not mention interstitial edema. Edema in the interstitium follows a passive diffusion and would go out of the initial AAR vascular bed bounds as we showed recently (3). If the interstitial space is negligible in comparison to myocardial cells in the healthy myocardium, it increases significantly in the ischemic myocardium and is a probable major player in the well-described overestimation of infarct size by contrast-enhanced cardiac magnetic resonance at the acute phase of myocardial infarction. This is so true that early gadolinium enhancement has recently been compared in *iJACC* to T_2w imaging with acceptable levels of correlation and proposed as a new method to measure the AAR (5).

Like many others, we believe that T_2w imaging has a lot to offer for the assessment of acute myocardial infarction patients, but we have to stay close to pathophysiology and not only look at pretty pictures if we want to get closer to truth.

Nathan Mewton, MD, PhD,* Franck Thuny, MD, PhD, Pierre Croisille, MD, PhD

*Hôpital Cardiovasculaire Louis Pradel, Cardiology, 28 Avenue Doyen Lépine, Bron, Rhône 69500, France.
E-mail: nmewton@gmail.com

doi:10.1016/j.jcmg.2011.11.010

REFERENCES

1. Raman SV, Ambrosio G. T_2-cardiac magnetic resonance: has Elvis left the building? Circ Cardiovasc Imaging 2011;4:198–200.
2. Fuernau G, Eitel I, Franke V, et al. Myocardium at risk in ST-segment elevation myocardial infarction comparison of T_2-weighted edema imaging with the MR-assessed endocardial surface area and validation against angiographic scoring. J Am Coll Cardiol Img 2011;4:967–76.
3. Mewton N, Rapacchi S, Augeul L, et al. Determination of the myocardial area at risk with pre- versus post-reperfusion imaging techniques in the pig model. Basic Res Cardiol 2011;106:1247–57.
4. Friedrich MG, Kim HW, Kim RJ. T_2-weighted imaging to assess post-infarct myocardium at risk. J Am Coll Cardiol Img 2011;4:1014–21.
5. Matsumoto H, Matsuda T, Miyamoto K, Shimada T, Mikuri M, Hiraoka Y. Peri-infarct zone on early contrast-enhanced CMR imaging in patients with acute myocardial infarction. J Am Coll Cardiol Img 2011;4:610–8.

REPLY

We thank Dr. Mewton and colleagues for their interest in our paper (1) and applaud them for raising an important point concerning the validity of current T2-weighted CMR imaging to visualize the area at risk in reperfused myocardial infarction (MI).

While technical issues with CMR imaging will be resolved by improved T2-weighted imaging protocols or novel T2 mapping techniques, the relationship of myocardial edema to the underlying pathophysiology deserves attention.

Recent animal data have confirmed an excellent agreement of findings in T2-weighted images with pathology in early reperfused MI (2). The amount of peri-infarct edema in clinical studies, however, varies significantly (3) and thus needs to be further studied. Specifically, there is a lack of validation data on the impact of potential confounders related to reperfusion. It is very likely that reperfusion injury with associated peri-infarct inflammation and microvascular dysfunction will modify the extent of myocardial edema. A recent study by Mewton et al. (4) indicates that reperfusion after a 40-min period of coronary occlusion may increase the extent of edema and thus apparent "myocardial salvage" within the first 90 min. Regarding late reperfusion, previous clinical studies showing edema adjacent to the necrotic