

## Hybrid imaging and publishing

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According to Webster dictionary, the word hybrid was first used between 1595 and 1605 and has its origin from the Latin word *hybrida*. *Hybrida* is used to “describe a crossbred animal (the offspring of two animals); plants of different breeds, varieties, species; a person or group of persons produced by the interaction or crossbreeding of two unlike cultures or traditions; anything composed of elements of different kinds such as a hybrid of the academic and business worlds; a word composed of different languages or something that is powered by more than one source of power such as hybrid cars”.

In our field, hybrid has been applied to imaging; a PubMed search on April 11, 2018 revealed 32,979 hits using the term hybrid imaging! The topic has been addressed on the pages of the Journal.<sup>1,2</sup>

Broadly speaking, hybrid imaging could be defined as either using the same imaging modality or two different imaging modalities. A good example (when technetium-labeled tracers were introduced and when multi-crystal gamma cameras were available) was the combination of first-pass radionuclide ventriculography (using the multi-crystal camera) and the SPECT perfusion imaging (using the Anger gamma camera). Elegant studies showed that the combination of exercise (true peak exercise) EF and perfusion pattern enhanced the diagnostic and prognostic information compared to each modality alone.

Other examples for a single imaging modality include stress echocardiography plus measurement of

coronary flow reserve (CFR); stress perfusion imaging by cardiac magnetic resonance imaging (CMRI) plus MR angiography, myocardial perfusion by positron emission tomography (PET) plus CFR, and hybrid stress testing using treadmill exercise combined with pharmacological vasodilation.

The more widely accepted definition of hybrid imaging, however, involves the use of two different imaging modalities with the implication, again, that the combination adds value above and beyond a single imaging modality for the diagnosis and risk assessment. There is a good reason to believe that this is true because each modality has strengths and weaknesses. CTA could define plaque burden, composition and characteristics that are not detected by SPECT but yet have impact on patient outcome in patients with stable CAD and those with acute coronary syndromes. There are many examples of such hybrid imaging such as SPECT/coronary calcium score, SPECT plus CTA, PET plus CT and PET plus CMRI. Defining the anatomic CAD by invasive coronary angiography or by CTA plus assessment of the coronary physiology (such as by fractional flow reserve) is meant to improve the precision in defining the hemodynamic relevance of coronary stenosis. Hybrid imaging (PET and CT) is well accepted in oncology and neurology.

An argument has been made that appropriate use of hybrid imaging in its self requires a change in the training of the new generation of cardiac imagers.<sup>1</sup>

The most common forms of hybrid imaging involve the use of SPECT or PET with coronary calcium score (CCS) or PET combined with CTA or MR. On the horizon are other combinations such as echocardiography plus CCS/CTA and MR plus CCS/CTA. Hybrid imaging with SPECT and CCS implies that both tests are done on the same patient though the sequence might differ and hence is not the same as using CCS as a screening test for which there are plenty of supporting data.<sup>3</sup>

Hybrid imaging could be done on two different imaging systems or on the same imaging system. There

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are sophisticated softwares that could merge CTA with perfusion data or PET with CMRI data although for precision and convenience the use of a single integrated system offers an advantage. The hybrid PET and MR imaging system is such an example and is uniquely suited for imaging a moving organ such as the heart but the system is expensive and the imaging protocols are demanding and therefore are likely to have appeal in only major academic institutions for cardiac applications.<sup>4</sup>

The current data indicate that SPECT plus CCS or SPECT plus CTA provide incremental diagnostic and prognostic value in both asymptomatic and symptomatic patients. The hybrid use of PET plus MR or PET plus CT has been very useful in non-CAD patients to detect endocarditis especially in difficult cases involving prosthetic valves, pace-maker (pocket and lead) infections, septic emboli, cardiac sarcoidosis and amyloid heart disease. Emerging data show the value of hybrid imaging in acute coronary syndromes and myocarditis and is essential for molecular imaging to track biological phenomenon and localization.

Hybrid imaging was cited in the 2014 European Society of Cardiology (ESC) guidelines as class IIA recommendation in intermediate risk patients with suspected CAD and in the 2015 guidelines for diagnosis of endocarditis. The differences in payment methods and the need for pre-authorization might have delayed the hybrid approach in the United States compared to Europe based on American College of cardiology guidelines.<sup>5</sup>

Some may suggest that hybrid imaging is one way to increase volume and revenues. The decline in revenues is a real thing as imaging centers have changed from being revenue centers to being cost centers.<sup>5</sup> One of our associate editors shared with me the magnitude of the decline in reimbursements in his institution, which has a large volume; in 2012, the professional revenues were ~ \$800,000 for ~ 3800 studies performed while in 2016 they were \$480,000 for ~ 6200 studies performed (a 63% decrease!). The cycle of revenue vs volume is akin to the chicken and egg scenario, is the volume increase a response to compensate for the decrease in reimbursement or the decrease in reimbursement is the remedy for the increase in volume? I believe these are associations rather than cause and effect because the vast majority of physicians place patient care as a top priority above financial gains.

The question is not whether multi-modality imaging could be done but rather when, how and why? In select patients, a combination of SPECT plus CTA for example could improve the diagnosis and management. This raises the question of what endpoint should be used to justify such a use as it is not enough to show that one test

is positive and the second is negative. Many studies have shown that a hybrid approach using MPI plus CTA improves the diagnostic performance when compared to invasive coronary angiography with or without fractional flow reserve measurements.<sup>6</sup> Hard endpoints are hard to come by as they require large studies and long follow-up. Softer endpoints such as referral to invasive coronary angiography and coronary revascularization could be challenged as being test driven and may not alter patient outcome.<sup>7</sup>

There is a reason to believe that fusion display of MPI and CTA or PET and CTA is better than side-by-side display in assigning perfusion defects to the correct coronary artery or reclassification of defects as artefacts in the absence of stenosis by CTA. Recent studies have attempted to automate and quantify such measurements.<sup>8</sup> As Slomka pointed out hybrid imaging has not received wide acceptance due to a number of reasons such as complexity, expense, reimbursement, radiation exposure and the lack of automated methods of interpretation.<sup>6</sup>

It is clear to develop unequivocal recommendations such as combining SPECT with CTA or PET with CTA, more studies are needed as we strive to balance idealism with pragmatism and concerns for escalating costs due to downstream resource utilization. The experience to date is strong for the need and usefulness of hybrid imaging in inflammatory and infiltrative cardiac disorders. The paper by Nudi et al. in this issue makes a great argument for its use in CAD.<sup>9</sup> Schwaiger et al. argued “the technology ‘Hybrid PET and MR’ holds great promise for providing unique information especially in the area of plaque imaging as well as in molecular characterization of inflammatory processes. Future research will tell if these applications will have the necessary clinical impact on management of patients with cardiovascular diseases”.<sup>4</sup> This cautious optimism could apply for other types of hybrid imaging modalities. The field of imaging has to adopt to the fact that CAD burden is changing as reflected by the decline in the number of the patients with abnormal imaging results and the low event rates in medically treated patients with CAD. Thus, data of 2 decades ago may not be useful today.<sup>10,11</sup> Even the scores used to assess pre-test probability of CAD may not be valid today! These changes emphasize the need for individualized algorithms, which puts the burden on the treating physician to choose wisely.

Finally, Our Journal like many others is a hybrid one; in that accepted papers appear first online (and could be cited on average of 2 to 3 weeks after acceptance) and then they appear in printed form. Lately, there has been a plethora of online-only journals; many with familiar and catchy names that may confuse the

readers with the traditional journals. I receive on the average six messages per day (every day) inviting me to be on the editorial board, to submit a paper (any paper) or review a paper. These messages come from “virtual” offices that could be anywhere within and outside the United States. Each message often starts with a complimentary note about one of the late papers which could be as simple as an announcement from the editor! This is one more reason we continue to provide a hybrid approach.

## Disclosures

*Nothing to disclose.*

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