New techniques in diagnostic imaging - PET-CT for the imaging of cardiovascular disease

The paper presents clinical abilities of PET/CT technique in the diagnostics of coronary heart disease. Clinical value and limitations of SPECT, PET and CT methods, performed separately were discussed. Fusion systems technique was presented and its value as a method used for diagnostics and assessment of prognosis in ischaemic heart disease was also discussed.

Cardiovascular imaging has undergone rapid growth in recent years. Several techniques compete for use in the diagnostic and prognostic workup of patients with proven or suspected coronary artery disease (CAD). Among these, myocardial perfusion imaging (MPI) has become the most important noninvasive diagnostic test and is most often applied in diagnostic wards. Its success is based on the functional characterization of CAD. Gould et al. first described the importance of coronary flow reserve measurements in the clinical evaluation of CAD in the 1970s. Demonstrating that measurement of coronary artery stenosis diameters did not predict the functional severity of CAD [9]. Adding functional parameters such as blood flow reserve enables the stratification of coronary artery stenosis into hemodynamically significant or insignificant lesions.

With the introduction of tomographic imaging approaches such as SPECT, it became possible to quantitatively assess the extent and severity of perfusion abnormalities [23]. The success of MPI has been further enhanced by demonstrating not only the diagnostic but also the prognostic value of functional parameters. However, despite this clinical success, certain significant limitations of SPECT perfusion imaging remain. First, the radiotracers currently used for perfusion imaging do not exhibit ideal physiological characteristics.

The extraction fraction of 99mTc-labeled flow markers by myocardium is relatively low and continues to decrease at higher flow rates [19]. Second, the lack of accurate attenuation correction leads to artifacts reducing the specificity of SPECT in defining regional perfusion abnormalities [7, 18]. Along with SPECT, PET has been developed as a clinical imaging tool for the quantitative assessment of myocardial perfusion and for the characterization of tissue viability in patients with advanced CAD. However, because of its high cost, PET has never reached the same level of clinical acceptance as SPECT.

CT was introduced primarily to measure regional coronary calcification as an early marker of CAD. The introduction of spiral CT in 1989 represented a major technical breakthrough, offering for the first time continuous-volume CT and hence opening up the field of CT angiography [14]. To increase the imaging volume and hence temporal resolution, multislice spiral CT was introduced in 1998. Currently, multislice CT systems with 16 or 64 slices are recommended for cardiac imaging. Townsend and Cherry were the first to combine PET and CT in 2001 [26]. This development was paralleled by the dramatic improvement of CT technology, yielding multislice data acquisition to support whole-body PET [15, 8]. Combining coronary calcification, noninvasive coronary angiography, and structural definition of cardiac and vascular tissues with PET data will provide a new comprehensive imaging procedure in cardiology.

Diagnosis of CAD

Given the changing pathophysiologic understanding of CAD, it is becoming increasingly difficult to define the gold standard for disease detection. Conventionally, the presence of 50%-75% coronary stenosis is considered indicative of obstructive CAD. However, there is increasing evidence that although the degree of stenosis may be related to the presence or absence of symptoms, the prognoses of patients cannot be predicted purely on the basis of angiographic criteria [11]. A study has shown that coronary culprit lesions with less than 50% narrowing can be found in a large subset of patients with acute myocardial infarction, limiting the use of the degree of steno-
s enjoyment as a predictor for acute ischemic syndromes [17]. A consensus exists that indica-
tions for revascularization in patients with stable
coronary disease should be based on evidence of myocardial ischemia [25], in symptomatic and asymptomatic patients with CAD, a large body of data indicates that the prognosis depends on the extent and severity of perfusion abnormalities during
stress [11,13]. The combination ofangiography, PET/CT and perfusion imaging in patients with CAD is a powerful tool for early detection of myocardial ischemia [5,6]. A single recent study comparing CTA with intravascular ultrasound revealed a 19% incidence of noncalcified lesions. Becker et al. recently characterized various plaque subtypes using density measurements [Hounsfield units] [2]. With the advent of molecular imag-
ing, there may be an opportunity to enhance contrast in plaque imaging by combining
scintigraphic data with CT characterization of individual plaques.

There is relatively little information available demonstrating the accuracy of CT angiography in patients with impaired left ven-
tricular function. The quality of the contrast bolus in patients with low cardiac output may impair image quality. However, because of the reduced cardiac function, motion artifacts may be less prevalent in this population. PET has been validated extensively in the assessment of tissue viability using a combination of metabolic imaging with 18F-FDG and evaluation of myocardial blood flow. The extent of tissue viability predicts the outcome of myocardial revascularization [4]. Based on coronary angiographic data provided by CT angiography and assessment of tissue viability, a noninvasive diagnostic workup may be possible. This may be especially important for patients being considered for cardiac trans-
plants, where information about the viabil-
y of the myocardium is critical to the decision to perform CAD, as defined by PET, is necessary.

In addition to its usefulness for the clini-
ical characterization of patients with left ven-
tricular dysfunction, PET/CT may be attractive for clinical research. This imaging mo-
dality provides surrogate endpoints for
interventional studies, especially in the ap-
plication of gene or cell therapy, which re-
quires regional delineation of therapeutic interventions. Studies using reporter gene imaging have shown that the regional effects of gene therapy can be measured with tracer techniques such as PET/CT [27]. The ability to characterize coronary lesion severity at a level of diagnostic accu-

racy similar to that of invasive coronary an-

giography may enable the close correlation of plausible myocardial perfusion and functional mea-
surements such as myocardial perfusion. Furthermore, the early detection of CAD will be improved by the use of detailed struc-
tural and molecular information provided by PET/CT. For example, coronary calci-
fication measurements combined with specific tracer techniques for the characterization of inflammatory processes may help to iden-
tify patients who are at high risk of developing acute ischemic syndromes. Several studies have indicated that the presence of metabolic activity segments with severe dysfunction is associated with higher risk if these segments are not revascularized [5,6]. One study has also shown that residual viability in dysfunctional myocardium is as-

sociated with a lower perioperative risk from revascularization [10]. Thus the combination of PET/CT in pa-

tients with severe left ventricular dysfunction may improve the diagnostic process and help avoid unnecessary invasive proce-
dures. Such comprehensive cardiac evalua-
tion with PET/CT includes not only CT an-
giography data and myocardial tissue char-

acterization but also assessment of regional function through left ventricular ejection frac-
tion [12]. Therefore, with a single noninvasive imaging procedure, the extent and severity of left ventricular dysfunction, the extent of tissue viability, and the overall extent of CAD can be characterized and used to risk-stratify the patient [24].

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