行政院國家科學委員會補助專題研究計畫成果報告

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※ 氟-18/鎝-99m 雙同位素同時單一光子電腦斷層顯影以預 ※
※ 測局部左心室功能之復原 ※
※ F-18 Fluorodeoxyglucose/Tc-99m Sestamibi Dual-Isotope Simultaneous- ※
※ Acquisition SPECT in Predicting Recovery of Regional Left Ventricular ※
※ Function after Revascularization ※
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計畫主持人：黃博昭

執行單位：國立台灣大學醫學院內科

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行政院國家科學委員會專題研究計畫成果報告

計畫名稱：氟-18/鍀-99m 雙同位素同時單一光子電腦斷層顯影以預測局部左心室功能之復原
F-18 Fluorodeoxyglucose/Tc-99m Sestamibi Dual-Isotope Simultaneous-Acquisition SPECT in Predicting Recovery of Regional Left Ventricular Function after Revascularization

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一、中英文摘要

^{18}氟-去氧葡萄糖(簡稱 ^{18}F-FDG)/^{99m}鍀-密比(^{99m}Tc-sestamibi)雙同位數同時於單一光子電腦斷層顯影(簡稱 DISA SPECT)，新近被証實可正確地偵測心肌缺氧。然而，利用此一技術以評估心肌之存活，迄今無這方面之資料。本研究之目的，乃測定並比較此一技術與以鉈-201 電腦斷層造影來評估心肌存活之準確度。

研究對象包括 36 名慢性冠心病者，經心導管證實其冠狀動脈管腔阻塞 ≥ 70%且左心室功能有異常。所有病人均於一週內接受冠狀動脈攝影、鉈-201 以及 DISA SPECT 等檢查。

靜態雙同位素 DISA SPECT 檢查，以 GE Hawkeye 掃描儀掃描之。此掃描儀配有雙偵測頭及超高能準直儀，具 ^{18}F-FDG 及 ^{99m}Tc-sestamibi 同時造影功能。每人之左心室心肌圖像以 17 個心肌節段分析之。當 ^{99m}鍀-sestamibi 及 ^{18}F-FDG 之顯現均≤ 50%，則該心肌為壞死。鉈-201 之顯現於壓力相以及於再分布相或再注射相均依舊≤ 50%時，該節段之心肌亦為壞死。

結果顯示：全部 612 個心肌節段中，以 FDG/mibi 雙同位素造影偵測出壞死心肌有 104 個，以鉈-201 偵測出之壞死節段有 138 個。二者認定心肌存活之一致性為 72.9%。結論：FDG/mibi 雙同位素 SPECT 造影簡易可行，對心肌存活之偵測，可媲美昂貴之 FDG/^{13}N ammonia PET 造影。

Abstract

^{99m}Tc-sestamibi/^{18}F-fluorodeoxyglucose (FDG) dual-isotope simultaneous acquisition (DISA) SPECT has recently been found to be effective in identifying myocardial ischemia. However, to date there has been no study regarding the ability of this technique in assessing myocardial viability. Accordingly, the aim of this study is to compare the value of ^{18}F-FDG/^{99m}Tc-sestamibi DISA and thallium-201 SPECT in the assessment of myocardial viability.

The study population consists of 36 patients with angiographically significant CAD (≥ 70% diameter stenosis) and left ventricular dysfunction. Each patient underwent stress thallium-201 reinjection SPECT and ^{18}F-FDG/^{99m}Tc-sestamibi DISA SPECT, within 1 week.

DISA SPECT was performed with a GE Hawkeye system. This system consists of a Millennium VG dual-head scintillation camera equipped with ultra-high energy collimators, capable of imaging 511 keV photons. The nondiabetics received 50 g of oral glucose and diabetic patients received intravenous insulin to adjust blood glucose levels before DISA imaging.

All DISA and thallium images were interpreted qualitatively using a 17-segment model. For thallium SPECT, a segment with a severe (≤ 50% of peak uptake), fixed

perfusion defect was considered nonviable. For DISA SPECT, concordantly marked reduction of both sestamibi uptake (≤ 50%) and FDG uptake (≤ 50%) was considered scar tissue.

A total of 612 segments were analyzed. DISA revealed myocardial scar in 104 segments and thallium SPECT detected nonviability in 138 segments. Among the 140 segments with nonviability, complete agreement of the two tests was obtained in 102 segments (72.9%). We conclude that the application of ^{18}F-FDG/^{99m}Tc-sestamibi DISA SPECT is feasible. This technique is a cost-effective alternative to ^{18}F-FDG/^{13}N-ammonia PET for assessing myocardial viability.

二、緣由與目的

In patients with coronary artery disease (CAD), dyssynergic myocardium may arise from either viable or necrotic myocardium [1, 2]. Improvement of regional contractile dysfunction after revascularization often occur in viable myocardium, whereas necrotic myocardium will not improve in function [3-5]. In patients with poor left ventricular function, revascularization is associated with high mortality [6, 7]. Therefore, accurate identification of reversible, viable myocardium has important clinical implications.

Positron emission tomography (PET) using ^{18}F-fluorodeoxyglucose (^{18}F-FDG) has been proved to be the most accurate method of differentiating reversible ischemic myocardium from irreversible scar tissue [2, 8-12]. Nevertheless, this technique is currently hampered by the limited availability because of high costs of PET [13]. Recently, single-photon emission computed tomography (SPECT) with 511 keV collimators has been found useful in imaging myocardial FDG uptake [14-17].

Because an onsite cyclotron for production of short-life PET perfusion tracers is cost-intensive and not widely available, alternatives are of interest when combining metabolic imaging using FDG with perfusion imaging using ^{99m}Tc-sestamibi. In 1995, Delbeke et al. [18] demonstrated that simultaneous evaluation of myocardial perfusion/metabolism with a SPECT camera equipped with an ultrahigh-energy collimator is possible using ^{99m}Tc-sestamibi/^{18}F-FDG with a dual-isotope simultaneous acquisition (DISA) protocol. This ^{18}F-FDG/^{99m}Tc-sestamibi DISA SPECT is effective in identifying myocardial ischemia [19]. However, to date there has been no study regarding the ability of this DISA technique in assessing myocardial viability. In addition, stress thallium-201 SPECT has been proposed effectively for the identification of dysfunctional but viable myocardium [20-25]. Nevertheless, a direct comparison between ^{18}F-FDG/^{99m}Tc-sestamibi and thallium-201 SPECT is lacking. Accordingly, the aim of this study was to compare the value of ^{18}F-FDG/^{99m}Tc-sestamibi DISA and thallium-201 SPECT in the assessment of myocardial viability.

三、方法

Thirty-six patients (33 men, 3 women, aged 34-85 years) with angiographically significant CAD (≥ 70% diameter stenosis) and left ventricular dysfunction (ejection fraction ≤ 40%) were studied. Each patient underwent stress thallium-201 reinjection SPECT [25] and rest ^{18}F-FDG/^{99m}Tc-sestamibi DISA SPECT, within 1 week.

DISA SPECT was performed with a GE Hawkeye system. This system consists of a Millennium VG dual-head scintillation camera equipped with ultra-high energy collimators capable of imaging 511 keV photons. In 28 nondiabetics, each received 50 g of oral glucose before the SPECT imaging after 4-hour fast. Sixty min after oral glucose, 6-8 mCi of ^{18}F-FDG and 20-25 mCi of ^{99m}Tc-sestamibi were administered intravenously. DISA data were acquired 60 min after injection. In 8 diabetic patients, regular insulin was administered intravenously to adjust blood glucose levels before DISA imaging [26].

All DISA and thallium images were interpreted qualitatively using a 17-segment model [27]. For thallium SPECT, a segment

with a severe (≤ 50% of peak uptake), fixed perfusion defect was considered nonviable [25]. For DISA SPECT images, criteria of viability were (1) normal perfusion and FDG uptake, (2) concordantly mildly-moderately reduced perfusion and FDG uptake, or (3) reduced perfusion with preserved or increased FDG uptake (mismatch). Concordantly marked reduction of both sestamibi uptake (≤ 50%) and FDG uptake (≤ 50%) was considered scar tissue.

Student's *t* test and chi-square or Fisher's exact test, when appropriate, were used to determine the significant differences between the groups.

四、結果

Baseline plasma glucose levels averaged 100 ± 12 mg/dl (range 72 to 120 mg/dl) in nondiabetic patients, and 215 ± 41 mg/dl (range 167 to 303) in diabetics. In diabetic patients, the glucose levels before DISA imaging averaged 144 ± 9 mg/dl (range 128 to 159) and the insulin injected was 7 ± 3 IU.

The mibi images were of good quality for analysis in all patients. However, good FDG SPECT images were obtained in only 32 (89%) of 36 patients. Two diabetics and 2 nondiabetics had marginal FDG images.

A total of 612 segments (17 per patient) were analyzed. DISA revealed myocardial scar in 104 segments. On stress thallium SPECT, nonviability was detected in 138 segments. Thirty-six (26%) of 138 segments with nonviability on thallium SPECT were found viable on DISA images, while only 2 (2%) of 104 segments with scar on DISA were classified as fixed defect on thallium SPECT ($p < 0.001$). Among the 140 segments with nonviability based on either DISA or thallium SPECT, complete agreement of the two tests was obtained in 102 segments (72.9%).

五、討論

Sandler et al. [19] have demonstrated that ^{18}F-FDG/^{99m}Tc-sestamibi dual-isotope images obtained with a SPECT camera equipped with an ultra-high energy collimator may provide information regarding myocardial ischemia. In this study, we provided more data regarding myocardial viability using this DISA technique.

So far, only limited data are available on the comparison between FDG SPECT and other imaging modalities. Bax et al. [28] comparing FDG SPECT with thallium reinjection SPECT revealed that both FDG and thallium SPECT had a high sensitivity (≥ 89%) in predicting improvement of regional function. However, the specificity of thallium imaging was significantly lower compared with FDG SPECT (43% for thallium and 77% for FDG, $p < 0.05$). The agreement for the detection of viable and nonviable segments between the two techniques was 70%. In the present study, we also found a modest agreement between ^{18}F-FDG/^{99m}Tc-sestamibi SPECT and thallium imaging. The agreement between the two imaging modalities in identifying nonviable segments is 72.9%.

六、結論與成果自評

This study demonstrates a modest agreement between ^{18}F-FDG/^{99m}Tc-sestamibi DISA SPECT and stress thallium reinjection SPECT in the identification of nonviable myocardium. The use of rest ^{18}F-FDG/^{99m}Tc-sestamibi dual-isotope SPECT may provide a cost-effective alternative to ^{18}F-FDG/^{13}N-ammonia PET to assess myocardial viability. The limitation of the present study is the lack of an independent measurement of viability, that is, functional outcome after revascularization. Recovery of regional dysfunction in this study was available in only 4 patients who underwent revascularization. Further study with a larger number of patients with revascularization is needed to explore this issue.

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