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Positron emission tomography and colorectal cancer

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Contents

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Abstract

Colorectal cancer (CRC) is a major cause of cancer-related morbidity and mortality. Molecular imaging using positron emission tomography (PET) is now an integral part of multidisciplinary cancer care. In this review, we discuss the role of PET in CRC including well established indications in the assessment of recurrent disease and emerging applications such as initial staging, monitoring therapy efficacy and using PET for radiotherapy planning. With rapid advancement in imaging technology, we also discuss the future potential of combining PET and magnetic resonance imaging and the use of novel radiotracers.

Keywords: Positron emission tomography; PET; FDG; Colorectal cancer; Oncology; Therapy response

1. Introduction

Colorectal cancer (CRC) is a major cause of cancer-related morbidity and mortality in developed countries. In 2006 there were 412,900 new cases of CRC in Europe and responsible for 217,400 deaths [1]. In the United States, CRC is the third most common cause of cancer mortality estimated in 2009 [2]. Over the last two decades, there has been an enormous growth in the literature demonstrating the benefits of positron emission tomography (PET) in many malignancies [3] and is now an integral part of multidisciplinary cancer care. The initial results from the United States National Oncologic PET Registry of 22,975 studies in 21,419 patients from 1178 centres showed that physicians changed their intended management in more than a third of cases in light of PET findings [4]. Since the basic principles and various oncologic applications of PET were reviewed in this *Journal* recently [5], the general principles of PET scanning will only be discussed in brief. In this review, we shall focus on the role of PET in CRC.

2. Positron emission tomography

2.1. PET and PET-CT

PET detects pairs of photons emitted in opposite directions following the annihilation of positron emitting radioisotopes. PET cameras record data in three dimensions and allow the localisation of this process *in vivo*. The advent of combined PET and computed tomography (CT) scanners (PET-CT) allows the fusion of functional and anatomical information in a single scan with an improvement in diagnostic confidence and accuracy compared to PET and CT data viewed side by side, PET alone or CT alone [6–8]. As a result, PET-CT has now largely replaced PET-only systems.

[Fluorine-18]-2-fluoro-2-deoxy-D-glucose (FDG) is a radiolabelled glucose analogue and is by far the most widely used positron emitting radiopharmaceutical for PET. Because cancer cells exhibit enhanced glycolytic metabolism, this molecular process is depicted by mapping FDG uptake using PET cameras. The degree of metabolic activity or FDG uptake by tissue, expressed as a standardised uptake value (SUV), can also be quantitatively assessed and compared between studies (e.g. pre- and post-treatment). PET allows a unique insight into tumour biology and the correlation of FDG metabolism and tumour proliferative rates may in turn be useful in determining prognosis in CRC [9].

2.2. PET-CT colonography

There has been recent interest in combining PET-CT and virtual colonography as an "all-in-one" staging modality. By using pharmacologic bowel relaxation, rectal water enema to maintain bowel distension and PET imaging in the prone position, Veit-Haibach and colleagues demonstrated a slight improvement in the accuracy of staging using PET-CT colonography compared with PET and CT [10]. In 47 patients with 50 lesions, the overall TNM stage was correctly assigned in 74% of the patients using FDG PET-CT colonography and 64% using CT and PET. Patients with incomplete conventional colonoscopy due to obstructing lesions may also benefit from PET-CT colonography. In a small number of patients with CRC ($n = 13$) that could not be traversed by optical colonoscopy, PET-CT colonography detected 2 synchronous CRC proximal to the stenosis [11]. The major advantage of the procedure is that it could be performed without bowel preparation. Despite limited data showing its feasibility and potential utility, the precise role of PET-CT colonography is not well defined at this point in time and should not be adopted as standard protocol.

3. Clinical applications

3.1. Initial staging

The role of FDG PET in staging CRC is not well established and is currently not recommended as a routine investigation [1]. While there is emerging evidence of incremental benefit in addition to conventional modalities in rectal cancer, its role in colon cancer remains controversial. Furthermore, the studies often comprised both colon and rectal cancers from which subgroup analyses were not always carried out.

3.1.1. Rectal cancer

Tumour stage is the strongest predictor of recurrence in rectal cancer [12]. Accurate staging determines different therapeutic options such as the type of surgery and the need for