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Optimal imaging sequence for staging in colorectal liver metastases: Analysis of three hypothetical imaging strategies

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Abstract ***Background:*** Computed tomography (CT), positron emission tomography CT (PET-CT) and magnetic resonance imaging (MRI) all play a role in the management of colorectal liver metastases (CRLM), but inappropriate over investigation can lead to delays in treatment and additional cost. This study aimed to determine the optimal sequence for preoperative imaging pathway to minimise delays to treatment and healthcare costs.

Methods: All patients with colorectal liver metastases referred to a single tertiary liver specialist multidisciplinary team (MDT) between 2008 and 2011 were examined. Primary data of clinical and radiological outcomes of all patients were analysed. These data were used to construct and test 3 hypothetical imaging strategies – 'Upfront', 'Sequential' and 'Hybrid' models.

Results: Six hundred and forty four consecutive patients were included. One hundred and sixty five patients were excluded for curative resection following the initial CT review. Subsequently 167/433 patients did not proceed to hepatectomies. Eighty (47.9%) of these patients had extra-hepatic disease identified on PET-CT, and 29 were due to the exclusion by MRI liver. A resectable pattern of liver disease on initial CT did not exclude patients with occult disease on PET-CT.

Based on cost analysis, assessment of initial CT, followed by MDT with subsequent PET-CT and MRI imaging thereafter (Hybrid model), was associated with the shortest time-to-decision and lowest cost.

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Conclusions: Resectable pattern of liver metastases should not solely be used to determine the application of PET-CT for staging. Hybrid model is associated with the lowest cost and shortest time-to-treatment.

1. Introduction

The determination of an optimal sequence of pre-operative imaging in colorectal liver metastases (CRLM) has been highlighted as one of the five key research recommendations by the National Institute of Health and Clinical Excellence (NICE) of the United Kingdom [1]. Computed tomography (CT), magnetic resonance imaging (MRI) which is liver specific and 18-fuorodeoxyglucose (FDG) positron emission tomography CT (PET-CT) which is patient specific are the imaging modalities most frequently used for detection, staging and determining resectability of CRLM [2,3]. The use of all three imaging modalities as a triple liver assessment is associated with low futile laparotomy rates, and is considered routinely in all patients being considered for hepatectomy at the study institution [4]. It has also been shown that management of these patients outside of a specialist multidisciplinary team (MDT), or tumour board is associated with lower resection rates, and patients being inappropriately denied curative treatment [5,6]. Consequently in the United Kingdom it is now seen as the standard of care that a specialist liver surgeon should assess all patients with liver limited metastases from colorectal cancer [7].

Performing and reviewing imaging in MDT's are time-consuming as well as economically costly. Furthermore, increasing the numbers of radiological staging investigation is a major contributor to delays in instigating appropriate treatment [8]. For many patients multiple imaging modalities may offer little benefit, whilst incurring significant cost, and prolonging uncertainty at what is already a challenging time.

This study aims to define the optimal imaging, and MDT assessment strategy for patients diagnosed with CRLM, in terms of time-to-decision and the healthcare costs.

2. Patients and methods

All patients with CRLM referred to the MDT between January 2008 and November 2011 were recruited into this study. In addition to the radiological reports from the referral centres, all imaging at each MDT were independently reviewed by our specialist liver radiologists prior to MDT discussion; Whenever PET-CT imaging was available for MDT discussion, it was reviewed by a dedicated nuclear radiologist (HW). Patient radiological and clinical data and outcomes were determined following the MDT discussion. These data were prospectively recorded into an electronic cancer registry at each MDT [9]. All outcomes were analysed retrospectively. A model of practice over this period was collated to inform a subsequent decision model. This model was used to answer the research question.

2.1. Standard practice

Since 2002, national United Kingdom guidelines have stipulated that all patients with CRLM are required to be referred to tertiary hepatobiliary unit with specialist MDT for further assessment [7]. The initial pattern of imaging sequences from non-tertiary centres was variable, depending on local policy at the referring hospitals. For those patients referred with solely CT imaging, PET-CT and/or MRI are arranged if the initial imaging suggests resectable diseases or no disseminated metastases.

Standard imaging protocol was applied for staging using PET-CT [10]. The routine MRI imaging protocol included T2 Fat saturated (SPIR), T1 In and out Phase, and gadolinium contrast T1 dynamic thrive study (immediate, arterial, portal venous and equilibrium phase). In indeterminate liver lesions, Primovist-contrast MRI liver was performed for further characterisation. To avoid false positive cases detected by PET-CT, all imaging modalities were reviewed in our MDT, in conjunction with every attempt to establish histological diagnosis for distant metastases on a case-by-case basis.

Initial clinic appointment and pre-operative assessment are arranged after all imaging has been completed and a specialist MDT decision suggesting potentially operable disease has been established. It is our policy that neoadjuvant chemotherapy is commenced without the recommendation from the specialist MDT.

2.2. Data categorisation

Each patient record was analysed to establish their management pathway. The numbers and timing/sequencing of CT, MRI and PET-CT imaging from initial diagnosis to the final management outcome for each patient were recorded for both the resected and non-resected groups.

The reasons for patients not undergoing any further radiological assessment beyond CT were categorised as '*no evidence of liver metastases*', '*extensive liver replacement with bi-lobar metastases*', '*overt extrahepatic metastases*' and '*co-morbidities precluding surgery*'. For those patients who underwent further imaging