Accuracy of preoperative CT for local staging in colorectal carcinomas

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ABSTRACT

Introduction: This study aimed to determine the accuracy of computed tomography (CT) in the evaluation of local tumour invasion and regional lymphadenopathy in colorectal carcinomas.

Methods: A total of 99 consecutive patients who had undergone a contrast-enhanced CT within two weeks prior to surgery with histopathological confirmation of colorectal carcinoma were selected. Intravenous contrast-enhanced CT was performed with a 5–7 mm collimation. Axial images were retrospectively and independently reviewed by two radiologists (R1 and R2) who were blinded to the surgical findings and histopathology. The readers assessed the primary tumour according to modified CT staging criteria. The radiological assessment was then compared with the surgical findings and histopathology for accuracy and inter-observer agreement.

Results: At histopathology, the T-stage of the tumours was T2 in five, T3 in 62 and T4 in 32 patients, and the N-stage was N0 in 36, N1 in 28 and N2 in 35 patients. The accuracy of CT for T-stage and N-stage for the two readers was 45.5 percent and 60.6 percent (κ is 0.30) and 33.3 percent and 45.4 percent (κ is 0.23), respectively. The understaging and overstaging by R1 and R2 was 40.4 percent, 21.2 percent and 14.1 percent, 17.2 percent for T-stage and 22.2 percent, 37.4 percent and 32.3 percent, 28.3 percent for N-stage. The accuracy of serosal invasion for R1 and R2 (tumour perforates the visceral peritoneum or directly involves the adjacent organs) was 63.6 percent and 66.7 percent (κ is 0.51), respectively. The understaging and overstaging by R1 and R2 for serosal invasion was 24.1 percent, 12.1 percent and 20.1 percent, 12.1 percent, respectively.

Conclusion: Our study results show that the accuracy for CT staging of colorectal carcinomas

for T-stage and in particular, serosal invasion, is moderate, but it is relatively low for N-stage.

Keywords: colorectal cancer, computed tomography, local staging, regional lymphadenopathy, serosal invasion

INTRODUCTION

Colorectal carcinoma is a common malignancy associated with significant morbidity and mortality. It is the third commonest cancer in Western countries,[1] the second commonest cause of death due to cancer in developed countries,[2] and is currently the most common cancer in Singapore, taking into account both the genders combined.[3]

Surgery remains the mainstay of treatment and is potentially curative if detected early, whereas chemotherapy and radiotherapy take on adjuvant roles.[2-6] At our institution, computed tomography (CT) imaging has become a routine part of the staging of colorectal carcinomas prior to surgery. CT is an excellent modality for the detection of distant metastases; however, its value for the use of local staging has been controversial. Accurate local staging preoperatively may allow for the prediction of clinical outcome and exploration into the use of neo-adjuvant therapy.[6] Burton et al have demonstrated that poor prognostic features identified on CT, including the presence of extramural invasion and involvement of the retroperitoneal surgical margin, are useful in the treatment stratification of patients preoperatively.[4] Similarly, Smith et al have found CT to be a robust method for stratifying patients preoperatively, with comparable accuracy to that of histopathology for predicting clinical outcomes.[6] Previous studies have revealed a wide range of accuracy in relation to local invasion. The accuracy of CT staging in the literature is 41%–82%[2,6-10] for T-staging and 22%–96%[6-11] for N-staging.

The advent of positron emission tomography (PET)/CT has provided an added dimension, taking into consideration both anatomical and functional aspects, but its strength lies primarily in the detection of distant metastases[8,12] as opposed to local spread and staging. The use of magnetic resonance (MR) imaging,

Table I. Computed tomography staging criteria for tumour staging.*

Stage	Computed tomography criteria
T1	Intraluminal projection of a colonic lesion without any visible distortion of the wall layers.
T2	Asymmetrical thickening projecting intra-luminally. Smooth preservation of muscle coat and clear adjacent pericolic fat.
T3	Smooth or nodular extension of a discrete mass and disruption of the muscle coat with extension into pericolic fat.
T4	Nodular penetration through the peritonealised areas of the muscle coat. Advancing edge of tumour penetrating the adjacent organs.

* Modified from Burton et al[4] and Smith et al.[6]

Table II. Computed tomography staging criteria for nodal staging.*

Stage	Computed tomography criteria
N0	No lymph node >1 cm and no abnormal clustering.
N1	1–3 lymph nodes > 1 cm, or abnormal clustering of 3 or more normal-sized lymph nodes.
N2	More than 3 lymph nodes > 1 cm.

* Modified from Burton et al[4] and Smith et al.[6]

on the other hand, is primarily confined to the staging of rectal carcinomas. Its use in other parts of the colon is unreliable due to motion artifact secondary to peristalsis.[13] With the use of MR imaging, accuracy rates of 54%–87% for T-staging of rectal carcinomas have been reported.[14] Currently, CT is the main modality of choice for the preoperative staging of colorectal carcinomas at our institution. Therefore, the aim of this study was to determine the accuracy of standard protocol CT in the evaluation of local staging and regional lymphadenopathy in colorectal carcinomas.

METHODS

Approval was obtained from the Institutional Review Board for this study. Written informed consent was not required for this retrospective analysis, and a waiver of consent was obtained from the Institutional Review Board. Data was collected for a two-year time frame from 1 January, 2006 to 31 December, 2007. The medical records of 220 consecutive patients who underwent surgical intervention for a presumed diagnosis of colorectal carcinoma at our institution were reviewed.

The criteria for inclusion into this study were a preoperative CT of the abdomen and pelvis, surgery performed within two weeks of the CT imaging, a segment of the large bowel having been resected for pathological evaluation and the presence of primary colorectal malignancy confirmed on histopathology. Of the 220 patients recruited, only 99 met the inclusion criteria; 57 did not have a preoperative imaging done within two weeks of the surgery, 47 had CT imaging performed more than two weeks prior to the operation, seven had inadequate imaging (i.e. CT performed included only the abdomen) and ten did not have primary colorectal cancer.

The CT studies of the 99 patients were reviewed, of which there were 56 male and 43 female patients with a median age of 62 (range 29–94) years. 66 scans were performed on a multidetector-row CT (MDCT) scanner (4-slice and 64-slice CT, Siemens, Forchheim, Germany), and the remaining 33 were done using a single slice helical CT scanner (Picker PQ5000, Marconi Medical, Cleveland, OH, USA).

Intravenous, oral and rectal contrasts were used in all patients. Scans were performed from the diaphragmatic dome to the pubic symphysis. A total volume of 100 ml non-ionic iodinated contrast was injected into a peripheral vein of the patients at a rate of 1.5–2 ml/sec. Scans were acquired with a collimation of 5 mm and 7 mm on MDCT and single-slice CT, respectively. Images were obtained either as one acquisition on the MDCT scanner or as two acquisitions on single-slice CT. Axial slices of 5 mm were reconstructed and sent to the Picture Archiving and Communication System (PACS).

Axial CT sections of the 99 patients were then independently reviewed by two consultant radiologists (R1 and R2) who were blinded to the surgical findings and histopathology. Both readers had a specialist interest in body imaging and were experienced in reading CT studies of colonic tumours. R1 and R2 have had six years and five years experience post specialist qualifications, respectively. Modified CT criteria were adapted from Burton et al[4] and Smith et al.[6] The readers identified the location of the tumour, the extent of local invasion, nodal spread (the short axis was measured) and adjacent organ involvement. Tables I and II define the CT staging criteria used for local tumour spread and lymph node involvement, respectively.[4,6]

A training session was conducted with both the readers prior to the individual assessment to verify that the interpretation of the criteria specified was accurate. 15 cases that had already been excluded from the analysis were used for the training session. The radiological assessment was then compared with the surgical findings and histopathology for accuracy and inter-observer agreement. Carcinomas were staged pathologically

Table III. Summary of the accuracy, overstaging and understaging of T-staging, N-staging and serosal invasion for R1 and R2.

Final stage (Histopathology)	Accuracy (%)		Overstaging (%)		Understaging (%)	
	R1	R2	R1	R2	R1	R2
T2	60.0	0.0	40.0	100.0	0.0	0.0
T3	54.8	77.4	19.4	19.4	25.8	0.0
T4	25.0	37.5	0.0	0.0	75.0	62.5
All T-stages	45.5	60.6	14.1	17.2	40.4	21.2
N0	44.4	33.3	55.6	63.9	0.0	0.0
N1	17.9	39.3	42.6	17.9	39.3	42.9
N2	68.6	28.6	0.0	0.0	31.4	71.4
All N-stages	33.3	45.4	32.3	28.3	22.2	37.4
Serosal invasion	63.6	66.7	12.1	12.1	24.1	20.1

R1: radiologist 1; R2: radiologist 2

according to conventional TNM criteria.[5] Accuracies for individual readers were evaluated for T-staging, N-staging, serosal invasion and the presence or absence of metastases. Inter-observer agreement was assessed using the kappa test.

RESULTS
With regard to tumour location, nearly half were found to involve the rectosigmoid region (44.4%). The distribution of tumours in the remaining colon was as follows: caecum (6.1%), ascending colon (12.1%), hepatic flexure (2.0%), transverse colon (9.1%), splenic flexure (16.2%) and descending colon (10.1%). At histopathology, the T-stage was T2 in five (5.1%), T3 in 62 (62.6%) and T4 in 32 (32.3%) patients. The nodal stage was fairly evenly distributed with N0 in 36 (36.4%), N1 in 28 (28.3%) and N2 in 35 (35.4%) patients. A summary of the accuracy, overstaging and understaging of T-staging, N-staging and serosal invasion for R1 and R2 is depicted in Table III.

The overall accuracy for T-stage assessment was 45.5% and 60.6% (inter-observer agreement, $\kappa = 0.30$) for R1 and R2, respectively. Figs. 1 and 2 demonstrate examples of tumours staged accurately by both readers. On the whole, overstaging of tumours for T-stage was moderate, with R1 overstaging in 14.1% and R2 overstaging in 17.2%. Overstaging of T2 tumours was relatively high (40.0% for R1 and 100.0% for R2) as compared to 19.4% for T3-stage tumours for both readers. Fig. 3 shows an example of overstaging, where both readers interpreted the tumour as T4 when there appeared to be an involvement of the adjacent bowel. It was, however, found to be of T3-stage on histopathology. In terms of understaging of tumours for T-stage, R1 understaged in 40.4% and R2 in 21.2% of the cases. For T3-stage, R1 understaged in 25.8%, but no T3 tumours were understaged by R2. A relatively large proportion of

T4 tumours were understaged (R1: 75.0%, R2: 62.5%). The CT image in Fig. 4 demonstrates a tumour that was interpreted as T3 by both readers, but was found to be of T4-stage on histopathology.

Adjacent organ involvement was observed in 12 (12.1%) patients. The accuracy for serosal involvement (tumour perforates the visceral peritoneum or directly involves the adjacent organs) was relatively good, at 63.6% and 66.7% (inter-observer agreement, $\kappa = 0.51$) for R1 and R2, respectively. The understaging and overstaging by R1 and R2 for serosal invasion was 24.1%, 12.1% and 20.1%, 12.1%, respectively. Fig. 5 shows an example where both readers interpreted evidence of serosal invasion, but the tumour was found to be of T3-stage on histopathology.

The overall accuracy for N-stage assessment was relatively poor, at 33.3% and 45.4% (inter-observer agreement, $\kappa = 0.23$) for R1 and R2, respectively. N0-staged tumours were overstaged in 55.6% and 63.9%, and N1-stage tumours were overstaged in 42.6% and 17.9% of cases by R1 and R2, respectively. In terms of understaging, 39.3% and 42.9% of N1 tumours as well as 31.4% and 71.4% of N2-staged tumours were understaged by R1 and R2, respectively. Figs. 6 and 7 depict images portraying tumours in which both readers overstaged the N-stage.

DISCUSSION
Our study results show low to moderate accuracy of CT in local staging of the colonic tumours and low accuracy for nodal staging. Colorectal carcinoma is a common malignancy, and the ability to accurately predict the extent of local invasion is important and relevant in patient management. The potential advantage of neoadjuvant therapy lies in the early institution of treatment for micrometastases, greater

Fig. I Preoperative CT image shows a tumour of the ascending colon extending into the lumen (arrows). Both readers correctly interpreted this as T3, which was confirmed on histopathology.
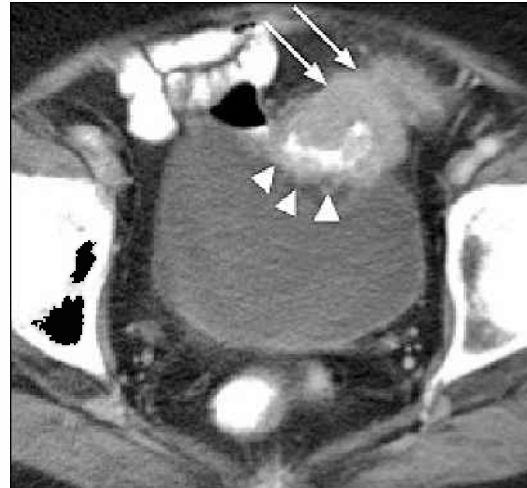
Fig. 2 Preoperative CT image shows a sigmoid colonic tumour (arrows) with invasion of the adjacent bladder wall (arrowheads). Both readers correctly interpreted this as T4, which was confirmed on histopathology.
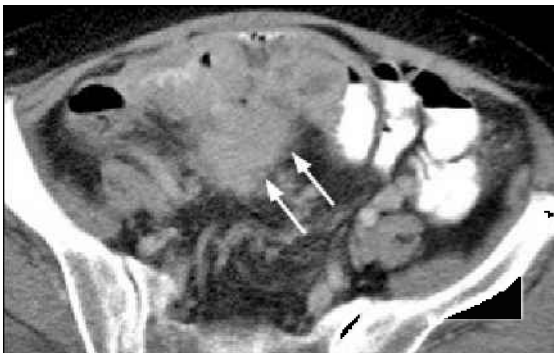
Fig. 3 Both readers interpreted this sigmoid colonic tumour (arrows) to be of T4-stage with an apparent invasion of the adjacent small bowel. However, it was proven to be T3 on histopathology.
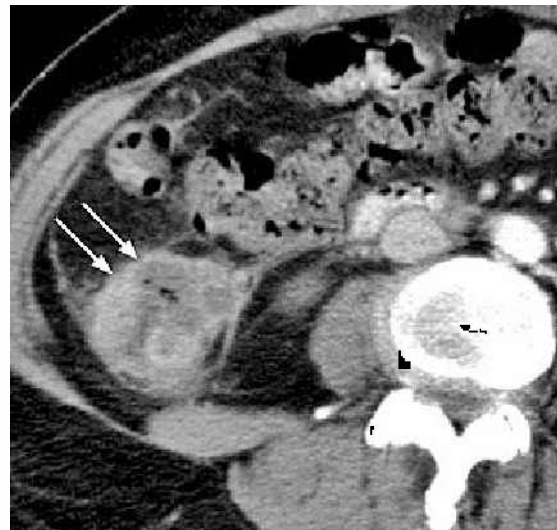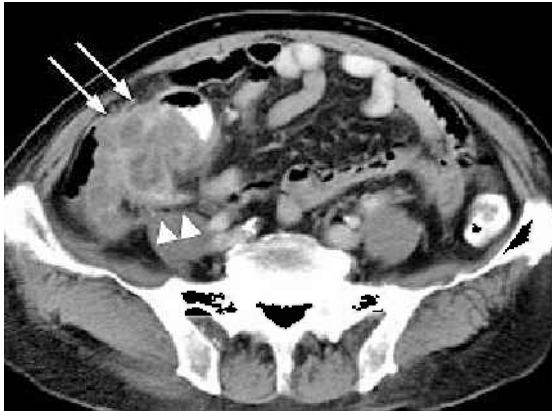

Fig. 4 Both readers interpreted this ascending colonic tumour (arrows) to be of T3-stage, but it was found to be T4 at histopathology, as the tumour had invaded into the adjacent greater omentum.

patient compliance rates and a significant downstaging of tumours to allow for potential curative resection.[15]

The accuracy rate for CT staging in our study was within the range reported in the literature: 41%–83% for T-staging[2,6-10,16] and 22%–80% for N-staging.[6-11,16] The wide range of accuracies is partly attributed to the use of different CT scanners by different investigators. MDCT generally offers thinner collimations and superior spatial resolution, which may improve accuracy. Evaluation of axial in combination with multiplanar reformations also help to enhance accuracy.[16] Colonic preparation and distension with air attribute to the improvement in results obtained, as exemplified by Balthazar et al.[9] Preoperative CT in general has been found to be more relevant for the presence of metastatic disease, providing a baseline for comparison postoperatively,[17] or for neoadjuvant therapy.[8] However, Burton et al[4] and Smith et al[6] have shown the use of preoperative CT for local staging.

Our results revealed poor to satisfactory inter-observer agreement for T-staging. There was a good agreement between the readers with regard to serosal invasion. This is important with respect to surgical implications and may perhaps, be of use in terms of possible neo-adjuvant therapy. However, there was poor agreement in terms of lymph node involvement, in keeping with the results found in the majority of previous studies conducted.[7,8,10] The difference in the CT criterion used, e.g. enlarged lymph nodes defined as greater than 1 cm[4,9] or 1.5 cm[7] in diameter, contributed to the range of accuracies reported in the literature.
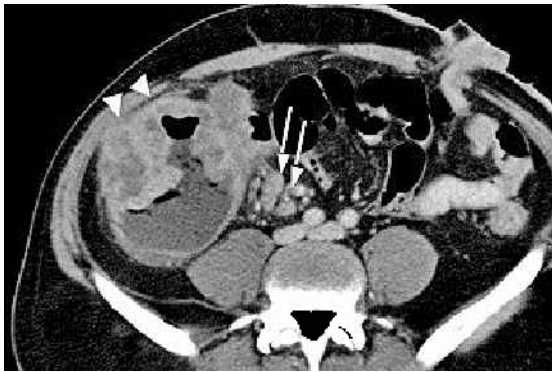
Our study results are also consistent with the reported overstaging of the tumours on CT[4] owing to the inability

Fig. 5 Both readers interpreted this ascending colonic tumour (arrows) to be associated with serosal invasion with apparent involvement of the adjacent psoas muscle (arrowheads). It was, however, found to be T3 on histopathology.

Fig. 7 This is a florid example in which both readers interpreted the nodal stage (arrows) for this ascending colonic tumour (arrowheads) to be of N2-stage, but it was found to be N0 on histopathology.

Fig. 6 Both readers interpreted the ileocolic nodes (arrows) associated with the ascending colonic tumour (arrowheads) to be of N1-stage, but it was found to be N0 on histopathology.

to obtain a true perpendicular plane to the wall; however, the use of multiplanar reconstructions may help overcome this limitation. Tumour understaging can also occur because of the obliquity of the tumours in the sections obtained. Microscopic invasion into different layers is difficult to detect on CT, even with thin collimation. The number of tumours under- or over-staged in our study was higher than those in the study conducted by Burton et al,[4] and this may be due to the thick collimation used in our study.

In all, our results revealed low to moderate accuracy for CT staging, as it is difficult to differentiate inflammatory or desmoplastic reaction from true transmural spread, as well as reactive lymph nodes from tumour involvement. This is predominantly the case for N-staging in which lymph nodes of more than 1 cm in short axis diameter are considered pathological.[2] However, not all enlarged nodes contain a tumour; on the contrary, normal-sized lymph nodes may have microscopic tumour involvement.

There were some limitations to our study. First, it was a retrospective study, and different scanners with different collimations were used. Second, we did not evaluate the multiplanar reconstructions (i.e. coronal and sagittal reconstructions), which may have improved the accuracy of the study. However, this was not possible owing to the retrospective nature of the study and the non-availability of CT raw data for reconstruction. Third, no specific bowel preparation was used prior to the study; only oral and rectal contrast mediums were used. Without bowel preparation, the presence of faecal matter may interfere with the interpretation of the wall thickening.

In conclusion, our study shows that the accuracy for CT staging of colorectal carcinomas is moderate for T-stage, particularly for serosal invasion, but low for nodal involvement. In the future, the evaluation of multiplanar reconstructions and bowel preparation prior to CT may help improve accuracy.

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