Diagnostic Performance of Multidetector Computed Tomography (MDCT) in Evaluation for Peritoneal Metastasis in Gastric Cancer

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Objective: *Determine the characteristic imaging findings and accuracy for diagnosis of peritoneal metastasis in gastric cancer by 64-slice multidetector computed tomography (MDCT).*

Material and Method: *A retrospective study was performed in 50 patients with gastric cancer who underwent 64-slice MDCT. The patients were enrolled between January 2006 and March 2011. The MDCT scan of abdomen from patients with gastric cancer was retrospectively evaluated by two gastrointestinal radiologists without knowledge of each patient's history, clinical data, and final diagnosis. Readers recorded the presence or absence of ascites, increased peritoneal fat density, peritoneal thickening or enhancement, and peritoneal nodule or mass. Sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of CT scan were calculated.*

Results: *Twenty-five patients from 50 patients indicated presence of peritoneal metastasis. The accuracies of 64-sliced MDCT of ascites, increased peritoneal fat density, peritoneal thickening/enhancement, and peritoneal nodule are 80.00, 80.00, 68.00, and 84.00%, respectively.*

Conclusion: *The 64-slice MDCT is a non-invasive imaging method that can be used for diagnosing staging gastric cancer with carcinomatosis peritoneii. It is an important tool for further investigation and proper treatment. Peritoneal nodules, increased peritoneal fat density, ascites, and peritoneal thickening/enhancement are ancillary signs suggestive of peritoneal carcinomatosis. However, in equivocal cases of imaging study, further investigation with laparoscopy is suggested to rule out small or miliary peritoneal metastasis.*

Keyword: *Gastric cancer, Stomach neoplasm, Peritoneal metastasis, Peritoneal carcinomatosis, Peritoneal spreading*

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Nowadays, cancer is the third common cause of death following cardiovascular disease and infectious disease[1]. Gastric cancer is one of the common cancers both in the world and in Thailand[2]. Adenocarcinoma is most common histologic type, with about 95% of total cases. This cancer has a higher incidence in elderly men than women, in whom advance of the disease usually was discovered at the first visit. The 5-year survival rate is about 20%[3]. At present, complete tumor resection is the only treatment of choice that offers a chance of curative treatment. Treatment of gastric cancer depends on accurate staging, which results in greater chance of complete curative treatment. Preoperative staging is fundamental of an optimal therapeutic approach.

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Preoperative imaging, which evaluates mural invasion, adjacent organ involvement, nodal involvement, and distant metastasis, is an important tool of the surgeon before further treatment. Furthermore, it decreases unnecessary surgery. Endoscopic ultrasound has high sensitivity and high specificity for T staging gastric cancer compared to CT imaging[4]. However, CT has advantages for evaluating distant metastasis and gives evidence of carcinomatosis, which is limited in endoscopic ultrasound. It is also a non-invasive method. Carcinomatosis peritoneii in gastric cancer is a poor prognosis and is found in about 10 to 20% of cases[5]. The recent study of peritonectomy and perioperative intraperitoneal chemotherapy has improved the survival rate in this group of patients. Then, it is important to identify these patients for proper treatment.

Previous study revealed limited accuracy of CT in evaluation of peritoneal metastasis. The overall sensitivity of these researches is about 50 to 79%[4,6,7].

However, in most of these studies, the slice thickness was too thick (10 mm slice thickness) to be used in current practice.

Nowadays, due to advanced technical development, fast scan and multiplanar reformation, increasing used of thin slice technique and multidetector computed tomography (MDCT) imaging is allowing more clinical practice observations to detect small lesions. With these potential advantages, it is hoped that 64-slice multidetector computed tomography (MDCT) can improve detection of early peritoneal metastasis in patients with gastric cancer.

The aim of our retrospective study was to evaluate the diagnostic performance of 64-slice MDCT in the detection of peritoneal metastasis in patients with gastric cancer.

Material and Method

The retrospective review of the database containing the patients' records at Siriraj Hospital was approved by the Institutional Review Board without acquiring signed informed consent from each patient. The patients were enrolled between January 2006 and March 2011. Fifty consecutive patients (17 men and 33 women; age range, 36-85 years; mean age, 59.8 years) had a preoperative histological diagnosis of gastric adenocarcinoma established on the basis of upper gastrointestinal endoscopic biopsy. Interval between CT of abdomen and surgery or pathological proof should be within 45 days. Patients were excluded if (a) they had cancer of a histologic type other than adenocarcinoma, (b) a thin-section MDCT data set was unavailable, (c) they had a history of previous gastric cancer treatment, including neoadjuvant chemotherapy or surgery, and (d) they had a history of another malignancy.

CT studies were performed using 64-slice MDCT (LightSpeed 64 scanners, GE Healthcare or Somatom Sensation 64, Siemens Medical Solutions) included non-contrast material-enhanced images and contrast material-enhanced images. All patients received 100 ml iodinated contrast material (non-ionic water-soluble contrast medium) administered intravenously with power injection at rate 3 ml/second followed by water 20 ml, 2 ml/second. Three glasses (250 ml/glass) of contrast (33 patients) or water (17 patients) were administered orally, one glass every 15 minutes and the last glass just before entering the CT room. All scans included acquisition of porto-venous phase images with 1.25 mm collimation at 80 seconds after initial intravenous contrast injection. Images were obtained from the dome of the liver to the inferior margin of kidneys in 20 patients and from liver dome to pubic symphysis in 30 patients, during a single breath-hold. Images were reconstructed at 1.25-mm intervals with soft-tissue algorithm. Coronal and sagittal reformations from original axial images at the workstation were performed for evaluating findings in each case.

Two attending radiologists with sub-specialist expertise in abdominal imaging who were unaware of the clinical or pathologic findings reviewed the CT scans by consensus. The radiologists were aware that the purpose of the CT study was the preoperative staging of gastric cancer. Readers recorded the presence or absence of ascites, increased peritoneal fat density, peritoneal thickening or enhancement, and peritoneal nodule or mass since these have been described as ancillary signs of peritoneal metastasis. Amount of abdominal fat was also recorded in the present study (minimal, moderate, and large amount) because we believe that it determined difficulty in detection of peritoneal pathology.

The presence or absence of peritoneal metastases was established with staging laparotomy, peritoneal washing cytology, or biopsy. From these CT findings, we rated the likelihood of peritoneal metastases on a five CT grading as follows, in Table 1. Then, diagnostic values of MDCT in different cuff off point (Table 2) were calculated. Reader interpretations were compared with the surgical and histopathologic standard of reference. Statistical data were analyzed by SPSS version 15. Positive predictive value (PPV), negative predictive value (NPV), sensitivity, specificity with 95% CI and accuracy of CT scan were calculated.

Table 1. CT grading for peritoneal carcinomatosis in gastric cancer

Grade	CT finding
0	Absence of ascites, normal peritoneal fat and no peritoneal thickening/enhancement/implant
1	Absence of ascites but increased density of peritoneal fat and/or peritoneal thickening and enhancement
2	Absence of ascites but presence of peritoneal nodule
3	Presence of ascites and/or increased density of peritoneal fat and/or peritoneal thickening and enhancement
4	Presence of ascites and peritoneal nodule/mass

Table 2. Criteria for diagnostic value of different cut off point in peritoneal carcinomatosis in gastric cancer

Category	Peritoneal metastasis	
	Absent (number of patients)	Present (number of patients)
A	Grade 0	Grade 1-4
B	Grade 0-1	Grade 2-4
C	Grade 0-2	Grade 3-4
D	Grade 0-3	Grade 4

Results

The 50 consecutive patients with diagnosis of gastric cancer (17 men and 33 women; age range 36-85 years; (mean [± SD] age, 58.9±13.60 years) were evaluated. The tumor staging was as follow, T1, two patients (4%), T2, one patients (2%), T3, 22 patients (44%), T4, four patients (8%), and unknown, 21 patients (42%). Location of stomach cancer are diffuse (7 patients, 14%), body (7 patients, 14%), antrum (10 patients, 20%), cardia (2 patients, 4%), fundus (1 patient, 2%), pylorus and antrum (9 patients, 18%), body and antrum (4 patients, 8%), cardia and fundus (2 patients, 4.00%), body and fundus (1 patient, 2%), and other for seven patients (14%).

The presence or absence of peritoneal metastases was established with staging laparotomy (16 patients, 32%), peritoneal washing cytology (22 patients, 44%), peritoneal biopsy (10 patients, 20%), peritoneal washing cytology, and biopsy (2 patients, 4%).

CT finding

Diagnostic performance measurements for the ancillary signs of peritoneal metastases were shown in Table 3, which peritoneal thickening/enhancement had the highest sensitivity among four ancillary signs (90.90%), followed by presence of ascites (82.61%), increased peritoneal fat density (75.86%), and peritoneal nodule/mass (70.83%). Conversely, peritoneal nodule/mass was the most specific and accurate sign for detection of peritoneal metastasis. The specificity and accuracy were 96.15% (95% CI 81% to 99%) and 84% (95% CI 71% to 92%), respectively. Increased peritoneal fat density had the lowest specificity (61.54% with 95% CI 52% to 86%).

Ascites was found in 23 patients (46%), 19 of 23 patients and four of 23 patients with and without peritoneal metastasis, respectively. Most of them have only a minimal amount, both with and without peritoneal metastasis. Four patients had ascites but no evidence of peritoneal metastasis, three patients had a small amount, and one patient has a moderate amount. Average density of malignant and non malignant ascites is 11.75 and 13.58 HU, respectively. Locations of malignant and non-malignant ascites were either upper abdomen or pelvic cavity, or at both locations.

Increased peritoneal fat density (as shown in Fig. 1) was found in 29 patients (58%), 23 in 25 patients and four in 25 patients with and without peritoneal metastasis, respectively. Most common sites of increased peritoneal fat density were visible at peritumoral region.

Peritoneal thickening/enhancement was found in 11 patients (22%), 10 patients and one patient with and without peritoneal metastasis, respectively.

The peritoneal nodules were found in 17 patients of 25 patients (68%) with peritoneal metastasis group. The other eight patients (32%) in this group were not detected peritoneal nodule from CT images. The most common location of peritoneal nodules was at the greater omentum (8 patients, 32%; Fig. 2). Other location were right paracollic gutter

Table 3. Diagnostic performance measurements for the ancillary signs of peritoneal metastases, the value of 95% CI is in parentheses

Ancillary sign	Sensitivity	Specificity	PPV	NPV	Accuracy
Ascites	76.00% (57%-89%)	84.00% (65%-94%)	82.61% (63%-93%)	77.78% (59%-89%)	80.00% (67%-89%)
Increased peritoneal fat density	88.00% (70%-96%)	70.04% (52%-86%)	75.86% (58%-88%)	85.71% (65%-95%)	80.00% (66%-89%)
Peritoneal thickening/enhancement	40.00% (23%-59%)	96.00% (80%-99%)	90.90% (62%-98%)	61.53% (46%-75%)	68.00% (54%-79%)
Peritoneal nodule/mass	70.83% (51%-85%)	96.15% (81%-99%)	94.44% (74%-99%)	78.13% (61%-89%)	84.00% (71%-92%)

PPV = positive predictive value; NPV = negative predictive value

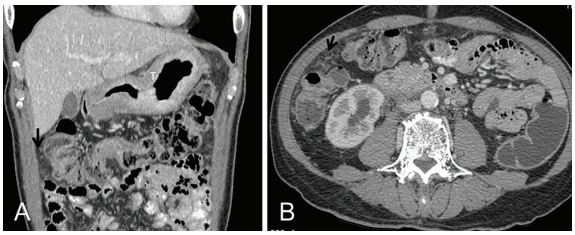

Fig. 1 A) Coronal CT scan post contrast study shows diffuse thickening of gastric wall with abnormal transmural enhancement by infiltrative gastric tumor (T) at stomach, linitis plastica pattern. Focal increased peritoneal fat density at right side of omentum (arrow) is compatible with carcinomatosis peritoneii. B) Axial CT post contrast study is also demonstrating the same peritoneal metastasis in right side abdomen. Note mild hydronephrosis of right kidney due to reteroperitoneal metastasis.

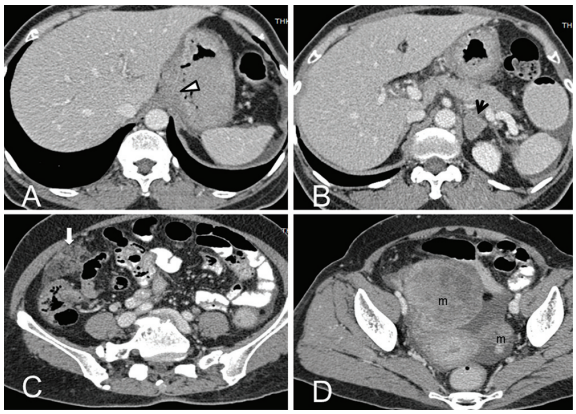

Fig. 2 Axial CT scan of malignant cancer of stomach at cardia (white arrow head in A) shows left adrenal metastasis (black arrow in B), omental mass at right side abdomen (white arrow in C) and bilateral ovarian metastasis (m in D). Minimal ascites is observed at perisplenic, left paracollic gutter and pelvic cavity.

(4 patients, 16%), left paracollic gutter (3 patients, 12%), serosal of cecum and rectosigmoid colon (1 patient, 4%), and retroperitoneum (1 patient, 4%).

According to Table 4, the majority of patients were in grade 0 and 4 (17 and 16 patients). There was only one patient whose CT findings were compatible with grade 2. It can be seen from Table 4 that 60% of those with positive peritoneal carcinomatosis belong to grade 4, and the same percentage of those with negative peritoneal carcinomatosis belong to grade 0.

Four CT categories were created from routine practice of CT interpretation, which was estimated that the probability of peritoneal metastasis should be increased if many positive CT findings were present (Table 5). When the category A was used, the carcinomatosis peritoneii was diagnosed with high sensitivity (92%), but only 60% of specificity. By contrast, category D has a 60% sensitivity, but the highest specificity (96%). Category B and C have roughly equal sensitivity, specific, PPV and NPV. Nevertheless, all four categories have roughly equal accuracies, category A 76% (95% CI 63% to 86%), category B 80% (95% CI 67% to 89%), category C 78% (95% CI 65% to 87%), and category D 78% (95% CI 65% to 87%).

Table 4. Number of patients with and without carcinomatosis peritoneii from CT grading

Grade	Positive for carcinomatosis (patients)	Negative for carcinomatosis (patients)	Total (patients)
0	2	15	17
1	3	5	8
2	1	0	1
3	4	4	8
4	15	1	16

Discussion

Gastric cancer with peritoneal metastasis is poor prognosis. Preoperative staging is important in planning of treatment. Nowadays, MDCT has an increasing role and greater accuracy for peritoneal seeding. The presence of peritoneal nodules is most specific (96.15%) and most accurate (84%). It is an ancillary sign that is suggestive of peritoneal metastasis in the present study followed by increased peritoneal

Table 5. Sensitivity, specificity, PPV, NPV, accuracy and 95% CI of each category, the value of 95% CI is in parentheses

Category	Sensitivity	Specificity	PPV	NPV	Accuracy
A	92.00% (75%-98%)	60.00% (40%-77%)	69.69% (53%-83%)	88.24% (66%-97%)	76.00% (63%-86%)
B	80.00% (61%-91%)	80.00% (69%-91%)	80.00% (61%-91%)	80.00% (61%-91%)	80.00% (67%-89%)
C	76.00% (57%-89%)	80.00% (1%-91%)	79.17% (60%-91%)	76.92% (58%-89%)	78.00% (65%-87%)
D	60.00% (41%-77%)	96.00% (80%-99%)	93.75% (72%-99%)	70.59% (54%-83%)	78.00% (65%-87%)

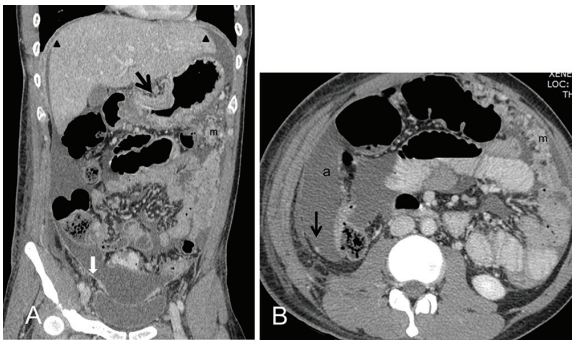

Fig. 3 Malignant gastric cancer with peritoneal carcinomatosis grade 4. A) CT scan coronal post contrast study reveals focal circumferential thickening with abnormal transmural enhancement at gastric antrum (black arrow), compatible with primary gastric cancer. Diffuse thickening of peritoneum at bilateral subphrenic spaces (black arrow head), omental mass in left side abdomen (m), large amount of ascites and nodular thickening peritoneum in lower abdomen (white arrow) represent peritoneal metastasis. B) CT scan axial view post contrast study of the same patient shows small peritoneal nodule at right paracollic gutter (black arrow), large amount of ascites and omental mass (m).

fat density, ascites, and peritoneal thickening, respectively. Density of ascites is not a helpful finding for discriminating this condition in contrast to the amount of ascites. A large amount of ascites with peritoneal nodules is also more specific findings than one finding separately. Finding only ascites from CT without the other finding should be confirmed by diagnostic laparoscopy[8]. There are many conditions that may found with ascites, such as physiologic condition, cirrhosis, chronic renal disease, congestive heart failure, and malnutrition. Until now, diagnostic significance of ascites detected by CT has remained obscure. However, the specificity of ascites from the present study is slightly higher (84%).

Weedward et al[9] have suggested that the small peritoneal implants (10 mm or smaller) have a sensitivity of 25 to 50% and are underdetermined by single row detector helical CT scanners (5-10 mm slice thickness). The study of Kim et al[10] suggested that equivocal CT case should receive further laparoscopy to rule out miliary peritoneal carcinomatosis, especially of greater tumor size and the T stage. Laparoscopy is the gold standard procedure in preoperative staging of gastric cancer to compensate for the limited sensitivity of CT images for peritoneal metastasis.

According to Table 4, multidetector CT can detect carinomatosis peritoneii precisely when all ancillary CT findings are present. However, it can be seen that only a small number of the patients have CT findings which are compatible with grade 1, 2, and 3 which results in inevitable selection bias. In addition, the equivocal CT findings of these patients are actually problems of diagnosis in real situations whereas grade 0 and 4 findings (Fig. 2) are usually diagnosed accurately. Hence, further imaging study to solve this problem should be beneficial.

Surprisingly, as shown in Table 5, all four categories have roughly equal accuracies, although of different sensitivities, specificities, PPVs and NPVs. No matter how different is each CT category, the accuracy is still the same. Thus, it can be argued that the ability of imaging modality in detection of peritoneal metastasis should be emphasized more than the CT findings.

Peritoneal surfaces that are involved at early stage of peritoneal carcinomatosis contain the lymphatic orifices. These orifices are lymphatic stomata, connect with sub-peritoneal lymphatic channel and milky spots. Milky spots are found mainly at greater omentum, small bowel mesentery, and pelvic peritoneum. Intraperitoneal free cancer cells deposit in this lymphatic stomata. The early stage of peritoneal seeding nodules is more frequently found within these areas. As opposed to liver capsule, splenic surface, and serosal surface of small bowel and stomach, there are no lymphatic stomata in which serosal seeding of these organs are involved, only at the late stage of peritoneal carcinomatosis in gastric cancer[11].

The present study had multiple limitations. First, the basis of a retrospective study may be a cause of bias case selection. Second, the small population included in the study may affect sensitivity, specificity, and accuracy. Third, increased peritoneal fat density or peritoneal thickening may be allowed underestimating, in some cases especially are who has paucity of body fat composition.

Conclusion

The 64-slice MDCT is non-invasive imaging method that can stage gastric cancer with carcinomatosis peritoneii, and is an important tool for further investigation and proper treatment. Peritoneal nodules, increased peritoneal fat density, ascites, and peritoneal thickening/enhancement are ancillary signs suggestive of peritoneal carcinomatosis. However, in equivocal

cases from imaging study, further investigation with laparoscopy is suggested to rule out small or miliary peritoneal metastasis.

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Potential conflicts of interest

None.

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การวินิจฉัยมะเร็งกระเพาะอาหารที่กระจายไปในช่องท้องโดยใช้การตรวจเอกซเรย์คอมพิวเตอร์ 64 สไลด์

โสภา พงศ์พรทรัพย์, พิรา เนื่องตัน, สมชาย ชัยรุ่งเรือง, ปิยาภรณ์ อภิสารธนรักษ์

วัตถุประสงค์: *เพื่อศึกษาความถูกต้องของการตรวจหาภาวะมะเร็งกระเพาะอาหารที่กระจายไปในช่องท้องโดยใช้การตรวจเอกซเรย์คอมพิวเตอร์ 64 สไลด์ เพื่อการรักษาโรคต่อไปได้อย่างเหมาะสม*

วัสดุและวิธีการ: *ศึกษาย้อนหลังจากผู้ป่วยที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์ 64 สไลด์ จากผู้ป่วยจำนวน 50 ราย ที่ได้รับการวินิจฉัยว่าเป็นมะเร็งกระเพาะอาหารในโรงพยาบาลศิริราช ตั้งแต่เดือนมกราคม พ.ศ. 2549 ถึง เดือนมีนาคม พ.ศ. 2554 โดยรังสีแพทย์ 2 คน ซึ่งจะประเมินภาวะการกระจายของมะเร็งในช่องท้องอันได้แก่ น้ำในช่องท้อง การบวมของไขมันในช่องท้อง ภาวะการหนาตัวของเยื่อบุช่องท้อง และก้อนในเยื่อบุช่องท้อง นำมาหาค่าความไว ความจำเพาะ ความแม่นยำของการตรวจ*

ผลการศึกษา: *ผู้ป่วย 25 ราย ได้รับการวินิจฉัยว่าพบภาวะมะเร็งกระจายในช่องท้องจากทั้งหมด 50 ราย ค่าความแม่นยำของภาวะน้ำในช่องท้อง การบวมของไขมันในช่องท้อง ภาวะการหนาตัวของเยื่อบุช่องท้อง และก้อนในเยื่อบุช่องท้องในการประเมินภาวะกระจายของมะเร็งเท่ากับร้อยละ 80.00, 80.00, 68.00 และ 84.00 ตามลำดับ*

สรุป: *การตรวจวินิจฉัยมะเร็งกระเพาะอาหารที่มีการกระจายสู่ช่องท้องโดยใช้การตรวจเอกซเรย์คอมพิวเตอร์ 64 สไลด์ โดยการประเมินก้อนในเยื่อบุช่องท้อง การบวมของไขมันในช่องท้อง ภาวะหนาตัวของเยื่อบุช่องท้อง และน้ำในช่องท้อง ทำให้ผู้ป่วยได้รับการรักษาที่ถูกต้องมากขึ้น อย่างไรก็ตามในกรณีที่ไม่พบลักษณะสงสัยดังกล่าว ผู้ป่วยควรได้รับการตรวจค้นต่อโดยการเจาะส่องกล้องดูภายในช่องท้องเพื่อประเมินในกรณีที่มีการกระจายของมะเร็งในช่องท้องขนาดเล็ก*