Accuracy of Spiral CT in Preoperative Staging of Gastric Carcinoma: Correlation with Surgical and Pathological Findings

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Objective: *To assess the accuracy of spiral CT scan in the preoperative staging of gastric carcinoma by comparing it with surgical/pathological staging.*
Material and Method: *Twenty-eight patients with gastric carcinoma who underwent both preoperative CT scan and surgery were retrospectively studied for TNM classification. All CT scans were reviewed for tumor location, gastric wall thickness, tumor extension, N1 and N2 nodal involvement, and metastases to the liver, peritoneum and lung.*
Results: *Spiral CT staging was correct in 20 of 28 patients (71.4%). The preoperative CT scan had 96.1% sensitivity, 100% specificity and 96.4% accuracy for evaluating serosal invasion. The sensitivity, specificity and accuracy for assessing pathologic lymph node involvement were 73.1, 50.0 and 84.2 percent, respectively. In the present study, peritoneal metastasis could not be identified by CT, but CT had 100% sensitivity for evaluating hepatic metastases.*
Conclusion: *Spiral CT is a useful modality for preoperative staging of gastric carcinoma with high accuracy for evaluating serosal invasion and hepatic metastases.*

Keywords: *Gastric carcinoma, Staging, Spiral CT*

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Although the incidence of gastric carcinoma is decreasing worldwide, it remains a deadly disease and the second most common cancer after lung cancer[1]. Most patients present late with an advanced stage of disease; hence, 5-year survival is ~20% (5-35%) (Table 1). At present, surgery is the best therapeutic option offering a chance of cure. Between 15 and 30 percent of patients have unresectable disease and undergo no procedure, other than open biopsy due to extensive metastasis of the disease at the time of diagnosis[2].

Computed tomography (CT) is an imaging modality used for preoperative staging, treatment planning, assessment of therapy response, and estimation of patient prognosis. It would be of great benefit for patients with unresectable disease if they could be spared unnecessary laparotomy. Preoperative knowledge of adjacent organ invasion and distant metastases is important in planning the operative procedure, allowing the surgeon to decide whether surgery is potentially curative or palliative in nature and whether additional organs may have to be resected[2,13,15]. In the past, preoperative CT offered limited ability to identify lymph node metastases, adjacent organs invasion, hepatic and peritoneal metastases; however, spiral CT technology, which can give more and better imaging details, has been developed.

The objective of the present study was to evaluate the accuracy of spiral CT in preoperative staging of gastric carcinoma by comparing the imaging findings with surgical/pathological findings used in TNM classification.

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Table 1. Staging and 5-years-survival

Stage	TNM stage	5-year-survival
I	T1N0M0, T1N1M0, T2N0M0	88%
II	T1N2M0, T2N1M0, T3N0M0	65%
IIIa	T2N2M0, T3N1M0, T4N0M0	35%
IIIb	T3N2M0	35%
IV	T4N1-3M0, TxN3M0, TxNxM1*	5%

* Tx = any T stage
* Nx = any N stage
Source: Reference 10

Material and Method

Between February 2001 and May 2004, the authors retrospectively studied 64 patients admitted to Srinagarind Hospital Khon Kaen University, who underwent both preoperative CT of the upper abdomen and operative assessment. Each patient had a preoperative histological diagnosis of gastric carcinoma, based upon an upper gastrointestinal endoscopic biopsy. Thirty-six patients were excluded because operative data, pathologic data or CT images were not available. Ultimately, the present study comprised the remaining 28 patients (15 men; 13 women) between 21 and 82 years of age (mean, 54).

The CT examinations were performed using a multi-slice CT scanner (Siemens, Somatome Volume Zoom). All patients were kept NPO for at least 6 hours before the examination. Water (800 to 1,000 mL) was given as the oral contrast material to distend the stomach and better visualize the gastric wall[11,12]. The abdomen was scanned in the supine position with 8-mm thick, continuous slices, from the dome of the diaphragm to the end of the lower pole of the kidney. Non-ionic, iodinated contrast material (300 mgI,100 mL) was administered intravenously with a power injector at 2.5-3 mL/sec. Contrastenhanced CT images were obtained at 30 sec for the arterial phase and 70 sec for the portal venous phase.

All studies were reviewed by an experienced radiologist without prior knowledge of the operative and/or histopathological findings.

For all CT findings, the following data were recorded:

Primary tumor characteristics, including the site of the primary lesion, gastric wall thickness and the extent of the tumor;

The stomach was anatomically divided into the proximal portion (fundus), the middle portion (body), the distal portion (antrum) and the most distal portion (pylorus). The gastric wall was normally < 5 mm in a fully distended stomach[3]. Any area of localized or diffuse wall thickness >5 mm was considered abnormal.

Gastric abnormalities depicted with CT were graded according to the TNM staging of the American Joint Committee on Cancer (AJCC), namely[3-5]:

T1: Mucosal invasion - focal thickening of the inner layer of the gastric wall with an intact gastric serosal layer and smooth perigastric fat plane.

T2: Muscular or subserosal invasion - transmural involvement with an intact serosal layer or partially obscured or irregular perigastric fat plane covering < 1 cm distance.

T3: Penetration of the serosa - transmural tumor with an obscured perigastric fat plane covering a 1-2 cm distance.

T4: Invasion of an adjacent structure - obscuration of the perigastric fat plane extending > 2 cm distance or that the adjacent organs were inseparable from the tumor mass.

Lymph node involvement;

The lymph nodes were considered involved by metastasis if they were > 8 mm in their short-axis diameter and/or according to the shape and pattern of enhancement:

N1: enlarged, perigastric lymph nodes closer than 3 cm to the primary lesion; and,

N2: enlarged, distant (> 3 cm) paragastric lymph nodes and nodes along the main arteries supplying the stomach.

Metastases to the liver, lungs, ovaries and peritoneal cavity and presence of ascites;

All data were compared and correlated with the surgical/pathological staging according to the AJCC TNM classification (Table 2).

Twenty-five patients underwent partial or total gastrectomy. Of the 25, four were treated with a D1-lymphadenectomy and 21 with a D2-lymphadenectomy. The remaining three patients underwent an open-close exploratory with omentectomy. Five patients had distal pancreatectomy. There was one patient who underwent distal esophagogastrectomy, distal pancreatectomy, splenectomy, left lower lobe lobectomy, diaphragmatic and left adrenal gland resection.

Results

All told, 28, patients were included. The time between the CT scan and surgical assessment was between 2 and 98 days (mean, 22.4). The lesions

Table 2. Surgical and pathologic staging of gastric carcinoma (AJCC TNM classification)

T stage: Primary tumor - extent of penetration through gastric wall
Tis - Carcinoma in situ, intraepithelial tumor
T1 - Tumor invades submucosa
T2 - Tumor invades muscularis propria or subserosa
T3 - Tumor penetrates serosa
T4 - Tumor invades adjacent organs
N stage: Lymph node involvement - number and site of draining lymph nodes involved
N0 - No lymph node involved
N1 - Metastases in 1-6 regional lymph nodes
N2 - Metastases in 7-15 regional lymph nodes
N3 - Metastases in > 15 regional lymph nodes
M stage: Presence of metastases
M0 - No distant metastases
M1 - Distant metastases

Source: Reference 5

occurred in the: antrum (14 or 50.0%), pylorus (7 or 25.0%), fundus (3 or 10.7%), body (2 or 7.1%), pylorus and antrum (1 or 3.6%) and diffuse (1 or 3.6%). The CT images correctly identified the location of the primary tumor in 21 of the 28 cases (75%).

Gastric wall thickness and tumor extent

One patient (3.5%) *who had a normal wall thickness < 5 mm on CT* had pathologic subserosal invasion; however, surgery was performed 3 months after the CT study. Twelve patients (42.9%) had a gastric wall thickness <2 cm; 10 (83.3%) of whom had serosal involvement. The remaining two had a respective gastric wall thickness of 0.5 and 1.0 cm. Sixteen (57.1%) patients had a gastric wall thickness $\geq$ 2 cm; all of whom (100.0%) had serosal involvement.

Based on CT findings in T staging, 21 (75.0%) of the 28 patients were correctly staged (Table 3). However, two T2 and T3 tumors each were over-staged as T4s, while one T3 was under-staged as a T2 (Fig. 1) and two T4s were under-staged as T3s. The sensitivity and specificity for detection of T3 vs. T4 tumors were 57.1 and 90.5 vs. 89.5 and 77.8 percent, respectively.

A preoperative CT scan suggested 11 patients had pancreatic invasion because of stranding or haziness of the fat plane between the primary gastric tumor and pancreas. Five patients had pathologic pancreatic invasion (Fig. 2). The sensitivity, specificity and accuracy of the CT in evaluating for pancreatic invasion were 100.0, 73.9 and 78.6 percent, respectively.

Twenty-six patients had pathologic-proven serosal or adjacent organ invasion (Fig. 3). Spiral CT thus achieved a sensitivity, specificity and accuracy of 96.2 100 and 96.4 percent for evaluating serosal involvement with/without adjacent organ invasion (Table 4).

Lymph nodes involvement

In two of 28 patients, the pathologic findings showed no perigastric (N1) or paragastric (N2) lymph node involvement. Eight patients had N1 node involvement and 18 N2 node involvement (Fig. 4). In total, the nodal involvement was correctly assessed with CT in 17 (60.7%) of 28 patients (Table 5). Four N1 and three N2 nodes were under-staged as N0 by CT.

Table 3. Comparison of T staging between spiral CT and pathology

Pathologic staging	Spiral CT staging				Total (n = 28)
	T1	T2	T3	T4	
T2	2	0	0	0	2
T3	0	1	4	2	7
T4	0	0	2	17	19

Table 4. Comparison of evidence of serosal with/without adjacent organs invasion between spiral CT and pathology

Pathologic findings	Spiral CT findings		Total (n = 28)
	+	-	
+	25	1	26
-	0	2	2
Total	25	3	28

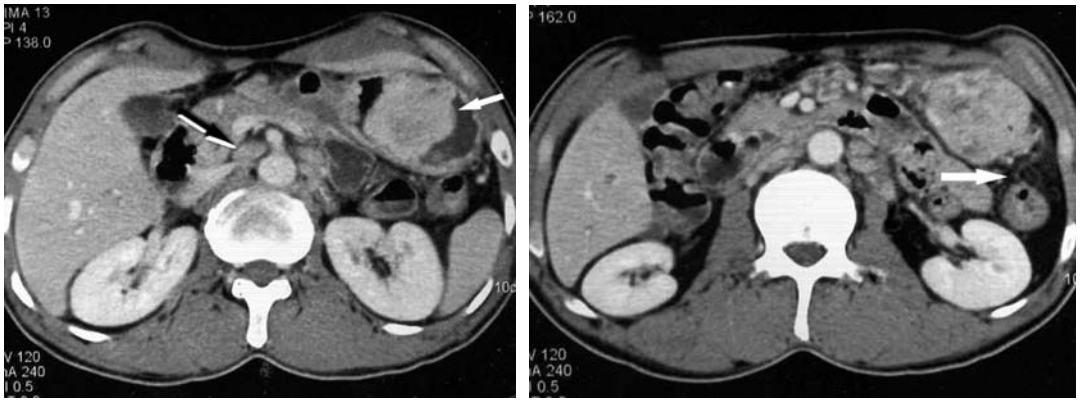
Sensitivity = (25/26) x 100 = 96.2%
Specificity = (2/2) x 100 = 100.0%
Accuracy = (27/28) x 100 = 96.4%
Positive predictive value = (25/25) x 100 = 100.0%
Negative predictive value = (2/3) x 100 = 66.7%

Table 5. Comparison of N staging between spiral CT and pathology

Pathologic staging	Spiral CT staging			Total (n = 28)
	N0	N1	N2	
N0	1	1	0	2
N1	4	2	2	8
N2	3	1	14	18

Fig. 1 Understaging; circumferential antral tumor (white arrow) without perigastric fat stranding (T2). Pathologically, serosal invasion was proven (T3)

Fig. 2 Circumferential antral tumor (white arrow) with pancreatic invasion, no ascites. Surgical findings show mesenteric and small bowel seeding



3A **3B**

Fig. 3 Axial CT images of a 50-year-old man with fungating tumor at gastric body (white arrow in 3A), celiac nodal involvement (shadow arrow in 3A) and serosal invasion (white arrow in 3B). This patient was correctly staged as T3N2M0

The CT evaluation yielded a sensitivity for detecting pathologic lymph nodes (*i.e.*, N1 and N2) of 73.1% while achieving a specificity of 50.0% (Table 6). The sensitivity and specificity for identified involvement of N1 vs. N2 nodes were 25.0 and 90.0 vs. 77.8 and 80.0 percent, respectively.

Distant metastases

The CT images visualized liver metastases in 6 patients (Table 7) with surgical-pathologic evidence for five (Fig. 5). Twelve patients had surgical-pathologic evidence of peritoneal involvement but these persons were not evaluated by CT. All four patients with ascites visualized by CT also had pathologic peritoneal metastases (Fig. 6).

The time between the CT study and surgery was between 3 and 27 days. One of these patients (1/12) had bilateral metastases to the ovaries (*i.e.*, a Krukenberg tumor) and one patient had pulmonary metastasis depicted by CT.

Staging

Two patients (7.2%) were stage II, three (10.7%) stage III and twenty-three (82.1%) stage IV.

The agreement in cancer-staging by CT and surgicalpathologic evidence was 20 of 28 patients (71.4%). Tumors were under-staged in seven (25.0%) patients and over-staged in one (3.6%) (Table 8). Three of the 7 under-staged patients had peritoneal seeding, 3 were under-staged as N0 and one patient was T2

Table 6. Comparison of pathologic lymph nodes between spiral CT and pathology

Pathologic findings	Spiral CT findings		Total (n = 28)
	+	-	
+	19	7	26
-	1	1	2
Total	20	8	28

Sensitivity = (19/26) x 100 = 73.1%
Specificity = (1/2) x 100 = 50.0%
Accuracy = (20/28) x 100 = 71.4%
Positive predictive value = (19/20) x 100 = 95.0%
Negative predictive value = (1/2) x 100 = 50.0%

Table 7. Comparison of M staging between spiral CT and pathology

Pathologic staging	Spiral CT staging		Total (n = 28)
	M0	M1	
M0	10	1	11
M1	11	6	17

Table 8. Comparison of TNM staging between spiral CT and pathology

Pathologic staging	Spiral CT staging				Total (n = 28)
	I	II	III	IV	
II	1	0	1	0	2
III	0	2	1	0	3
IV	0	2	2	19	23

despite being labeled T3. The one over-staged patient had reactive lymph nodes identified as pathologic lymph nodes (Fig. 7).

Discussion

The curative treatment of patients with gastric carcinoma was predicated on total removal of all cancerous tissue. The prognosis was based on the extent of gastric wall penetration, lymph nodes involvement and distant metastases. One of the greatest benefits of undergoing a preoperative CT scan is a positive study for advanced disease which can prevent the morbidity/mortality related to an "open-close" surgical exploration and decrease the costs of surgery and hospital

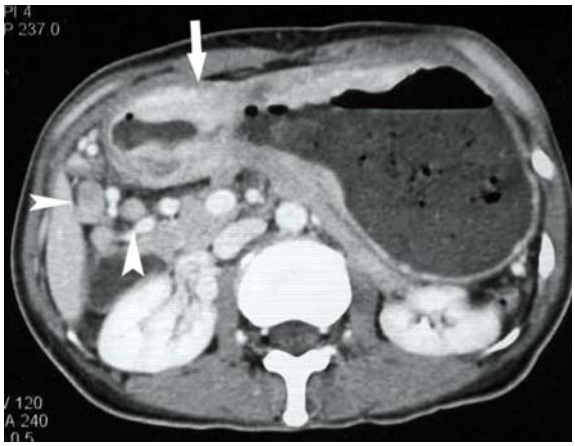


Fig. 4 Axial CT image shows antral tumor (arrow) multiple enlarged paragastric lymph nodes (N2) (arrow heads) that proved to be N2 involvement from pathology

Fig. 5 Gastric carcinoma with hepatic metastases at segment 6 (arrow)

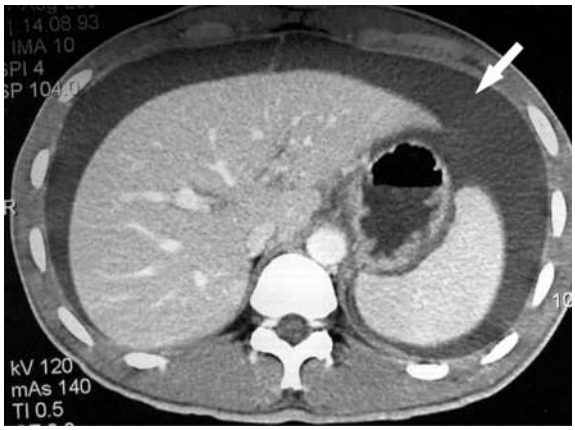


Fig. 6 Carcinoma of gastric body associated with ascites (arrow). No peritoneal metastases was identified, but surgical findings show peritoneal nodules in the pelvic cavity

stay. Recently, clinical trials indicate that new oncological treatment in some cases enables follow-up surgery of previously inoperable gastric carcinoma[6].

In the present study, the authors used water as an oral contrast material and performed spiral CT by injecting a bolus of IV contrast. The authors found that the thickness of the gastric wall correlated with serosal invasion ($p < 0.001$) and there was high sensitivity (96.1%), specificity (100%) and accuracy (96.4%) for detection of serosal invasion (for both T3 and T4 staging).

The present study achieved 100% sensitivity, 73.9% specificity and 78.6% accuracy for a preoperative CT evaluation of pancreatic invasion, a better sensitivity than both Weijun et al[3] (75.0%) and Davies et al[2](50.0%). The authors had six patients for whom the CT suggested pancreatic invasion because of a loss of the fat plane between the tumor and pancreas, but the pathologic findings indicated only an inflammatory reaction. This finding might occur in cachectic patients whose loss of a fat plane simulates direct organ invasion (Fig. 8).

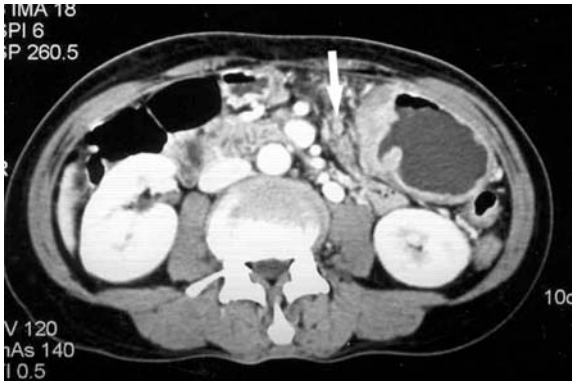


Fig. 7 CT image considered N1 due to enlarged perigastric lymph nodes (arrow). Pathologic findings show follicular hyperplasia, no metastatic lymph node (N0)

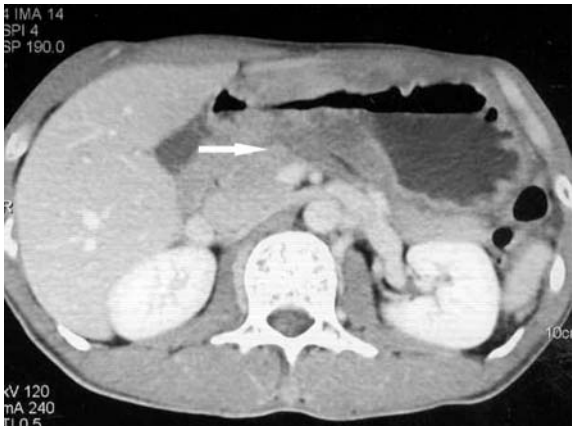


Fig. 8 Carcinoma of gastric antrum (arrow) with suspected pancreatic invasion by evidence of obscured fat plane between tumor and pancreas (T4). Pathologic findings show serosal invasion with perigastric inflammation, no pancreatic involvement (T3)

In the past, CT scan was limited to identifying lymph node metastases with an overall accuracy of 22-73% as reported by Paramo et al[7] and a sensitivity of 24-43% as reported by Davies et al[2] Fukuya et al reported the incidence of pathologic lymph nodes varied according to size (5% for nodes < 5 mm, 23% for nodes between 10-14 mm and 84% for nodes > 14 mm)[8]. CT images identified involvement of N2 nodes better than N1 nodes[2]. When spiral CT was used, better visualization of pathologic lymph nodes (both N1 and N2) was achieved (*i.e.*, 73.1 and 83.3 percent sensitivity in the present study, respectively, and the present study by Weijun)[3]. The specificity of pathologic lymph node involvement was rather low (50.0%), possibly because small nodes may contain metastatic tumors or large nodes may be inflamed. Since extended nodal dissection (D2-lymphadenectomy) tends to be performed in the majority of surgical centers nowadays, incorrect nodal staging probably would not change surgical protocol.

For distant metastases, laparotomy was of little benefit in patients with hepatic or peritoneal metastases, because they had a median survival of 3 to 9 months[7]. Davies et al and Weijun et al reported 57 and 71.4 percent sensitivity for identifying hepatic metastases, whereas in the present study sensitivity was 100%. Twelve patients had peritoneal metastases that were later seen during surgery. The authors could not identify evidence of peritoneal metastases or carcinomatosis peritoneii perhaps because CT was performed only in the upper part of the abdomen. All patients with ascites had peritoneal metastases, so ascites might be related to peritoneal metastases. It was also difficult to detect tiny peritoneal or omental metastatic nodules particularly in the absence of ascites. One patient had bilateral ovarian metastases (Krukenburg tumor) that were under-evaluated on the preoperative CT. This patient underwent CT of the upper abdomen which showed evidence of ascites and limited pelvic pathology assessment.

As for the overall staging of gastric carcinoma, most of the presented patients had advanced disease, three were stage III and 23 stage IV. Seven cases were

under-staged by the preoperative CT, perhaps due to: (1) small nodules in the peritoneal cavity and omentum not identified by CT (three cases), (2) no demonstrated pathologic lymph nodes (three cases) and (3) being defined as T2 despite really being T3 (one case). The 71.4% accuracy for staging gastric carcinoma in the present study correlated favorably with the 76.7 and 83.3 percent accuracy reported by Feng et al[9] and Weijun et al[3], respectively.

Recently, endoluminal ultrasound (EUS) has been developed and superior to CT in the assessment of the depth of tumor invasion through the gastric wall (T-stage) and of N1 and N2 lymph nodes involvement (N-stage). However, EUS is only available in specialized centers and requires experienced persons to perform and interpret it[2,14]. Evaluation of hepatic and peritoneal metastases was also limited. However, CT scan is superior to any other single staging technique and can be used to assess the entire peritoneal cavity, retroperitoneum and other solid organs during a single exam. If any imaging technique is considered in the preoperative work-up, CT scan should be regarded as the modality of choice.

Conclusion

Spiral CT scan is a useful modality for preoperative staging of gastric carcinoma with a high accuracy for evaluating serosal invasion and hepatic metastases.

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ความแม่นยำของเอกซเรย์คอมพิวเตอร์แบบหมุนเกลียวในการบอกระยะของมะเร็งกระเพาะอาหาร เมื่อเทียบกับผลการผ่าตัดและผลทางพยาธิวิทยา

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มะเร็งกระเพาะอาหารเป็นสาเหตุของการเสียชีวิตที่สำคัญอย่างหนึ่งของมะเร็งในระบบทางเดินอาหาร การผ่าตัดเป็นการรักษาที่ถือเป็นมาตรฐานของโรคนี้ การตรวจบอกระยะก่อนเลือกวิธีการผ่าตัดจะมีความสำคัญร่วมการตรวจอื่น ๆ

ในปัจจุบันมีการใช้เอกซเรย์คอมพิวเตอร์แบบหมุนเกลียวในการตรวจทางระบบทางเดินอาหารมากขึ้นโดยสามารถจะแสดงรายละเอียดของส่วนที่เป็นทั้งด้านผนังภายในและการลุกลามออกจากผนังด้านนอกเข้าสู่ช่องท้อง การกระจายไปทางต่อมน้ำเหลืองหรืออวัยวะอื่นได้ จึงให้ข้อมูลที่สมบูรณ์มากขึ้น เมื่อเทียบกับการตรวจด้วยการกลืนสารทึบแสงหรือการตรวจด้วยการส่องกล้องเท่านั้น

การศึกษานี้ได้ทำการศึกษาย้อนหลังในจำนวนผู้ป่วย 28 ราย ซึ่งได้รับการวินิจฉัยว่าเป็นมะเร็งกระเพาะอาหารในโรงพยาบาลศรีนครินทร์ในช่วงเวลา ตั้งแต่ กุมภาพันธ์ พ.ศ. 2542 ถึง พฤษภาคม พ.ศ. 2547 ซึ่งสามารถค้นข้อมูลของเอกซเรย์คอมพิวเตอร์ได้และได้รับการผ่าตัด โดยศึกษาเปรียบเทียบ กับผลการผ่าตัด และผลการตรวจทางพยาธิวิทยาและพบว่าเอกซเรย์คอมพิวเตอร์มีความไวและความแม่นยำอยู่ในระดับสูง ในการบอกระยะของโรค และสรุปว่าเอกซเรย์คอมพิวเตอร์เป็นวิธีการตรวจที่จะบอกระยะของโรคได้ดี