Carcinoma Stomach
Radiation Oncology Perspective

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Max SuperSpecialty Hospital, Mohali
Nine tenths of education is encouragement.

-Anatole France
Outline

- Indications of Adjuvant Radiation
- CT Anatomy
- Target Delineation
- Plan Evaluation
Resectable Ca Stomach
Upfront Surgery
Pre-op Chemo/Chemorad
D1 vs D2 Resection

Patient survival after D₁ and D₂ resections for gastric cancer: long-term results of the MRC randomized surgical trial

No difference in 5yr OS
Panc & Spleen removal a/w poor survival

Summary Controversy still exists on the optimal surgical resection for potentially curable gastric cancer. Much better long-term survival has been reported in retrospective/non-randomized studies with D₂ resections that involve a radical extended regional lymphadenectomy than with the standard D₁ resections. In this paper we report the long-term survival of patients entered into a randomized study, with follow-up to death or 3 years in 96% of patients and a median follow-up of 6.5 years. In this prospective trial D₁ resection (removal of regional perigastric nodes) was compared with D₂ resection (extended lymphadenectomy to include level 1 and 2 regional nodes). Central randomization followed a staging laparotomy.

Out of 737 patients with histologically proven gastric adenocarcinoma registered, 337 patients were ineligible by staging laparotomy because of advanced disease and 400 were randomized. The 5-year survival rates were 35% for D₁ resection and 33% for D₂ resection (difference -2%, 95% CI = -12%–8%). There was no difference in the overall 5-year survival between the two arms (HR = 1.10, 95% CI 0.87–1.39, where HR > 1 implies a survival benefit to D₁ surgery). Survival based on death from gastric cancer as the event was similar in the D₁ and D₂ groups (HR = 1.05, 95% CI 0.79–1.39) as was recurrence-free survival (HR = 1.03, 95% CI 0.82–1.29). In a multivariate analysis, clinical stages II and III, old age, male sex and removal of spleen and pancreas were independently associated with poor survival. These findings indicate that the classical Japanese D₂ resection offers no survival advantage over D₁ surgery. However, the possibility that D₂ resection without pancreateico-splenectomy may be better than standard D₂ resection cannot be dismissed by the results of this trial.
D2 a/w:
• Lower LRR & gastric cancer related death
• Higher post-op mortality/morbidity/re-op rates

Background

Historical data and recent studies show that standardised extended (D2) lymphadenectomy leads to better results than standardised limited (D1) lymphadenectomy. Based on these findings, the Dutch D1D2 trial, a nationwide prospectively randomised clinical trial, was undertaken to compare D2 with D1 lymphadenectomy in patients with resectable primary adenocarcinoma of the stomach. The aim of the study was to assess the effect of D2 compared with D1 surgery on disease recurrence and survival in patients treated with curative intent.

Methods

Between August, 1989, and July, 1993, patients were entered and randomised at 80 participating hospitals by means of a telephone call to the central data centre of the trial. The sequence of randomisation was in blocks of six with stratification for the participating centre. Eligibility criteria were a histologically proven adenocarcinoma of the stomach with no evidence of distant metastasis, no radiotherapy or chemotherapy, adequate physical condition for D1 or D2 resection, and no co-existing condition that would limit the chance of cure with either operation. A total of 711 patients underwent one or other of the procedures (355 in the D1 group and 356 in the D2 group). The median follow-up of the 711 patients treated with curative intent was 15·2 years (range 6·9–17·9 years). Analyses were done for the 711 patients treated with curative intent and were according to the allocated treatment group. Of the 711 patients, 174 (25%) were alive, but all one without recurrence. Overall 15-year survival was 21% (82 patients) for the D1 group and 29% (92 patients) for the D2 group (p=0·34). Gastric-cancer-related death rates were significantly higher in the D1 group (48%, 182 patients) compared with the D2 group (37%, 123 patients), whereas death due to other causes was similar in both groups. Local recurrence was 22% (82 patients) in the D1 group versus 12% (40 patients) in D2, and regional recurrence was 19% (73 patients) in D1 versus 13% (43 patients) in D2. Patients who had the D2 procedure had a significantly higher operative mortality rate than those who had D1 (n=32 [10%] vs n=15 [4%]; 95% CI for the difference 2–9; p=0·004), higher complication rate (n=142 [43%] vs n=94 [25%]; 11–25; p=0·0001), and higher reoperation rate (n=59 [18%] vs n=30 [8%]; 5–15; p=0·0001).

Interpretation

After a median follow-up of 15 years, D2 lymphadenectomy is associated with lower locoregional recurrence and gastric-cancer-related death rates than D1 surgery. The D2 procedure was also associated with significantly higher postoperative mortality, morbidity, and reoperation rates. Because a safer, spleen-preserving D2 resection technique is currently available in high-volume centres, D2 lymphadenectomy is the recommended surgical approach for patients with resectable (curable) gastric cancer.
CHEMORADIOThERAPY AFTER SURGERY COMPARED WITH SURGERY ALONE FOR ADENOCARCINOMA OF THE STOMACH OR GASTROESOPHAGEAL JUNCTION

JOHN S. Macdonald, M.D., STEPHEN R. Smalley, M.D., JACQUELINE Benedetti, Ph.D., SCOTT A. Hundahl, M.D., NORMAN C. Estes, M.D., GRANT N. Stemmermann, M.D., DANIEL G. Haller, M.D., JAFFER A. Ajani, M.D., LEONARD L. Gunderson, M.D., J. MILBURN Jessup, M.D., AND JAMES A. Martenson, M.D.

Abstract

Background Surgical resection of adenocarcinoma of the stomach is curative in less than 40 percent of cases. We investigated the effect of surgery plus postoperative (adjuvant) chemoradiotherapy on the survival of patients with resectable adenocarcinoma of the stomach or gastroesophageal junction.

Methods A total of 556 patients with resected adenocarcinoma of the stomach or gastroesophageal junction were randomly assigned to surgery plus postoperative chemoradiotherapy or surgery alone. The adjuvant treatment consisted of 425 mg of fluorouracil (20 mg per square meter per day) plus leucovorin (20 mg per square meter per day) were given one month apart.

Results The median overall survival in the surgery-only group was 27 months, as compared with 36 months in the chemoradiotherapy group; the hazard ratio for death was 1.35 (95 percent confidence interval, 1.09 to 1.66; P=0.003). The hazard ratio for relapse was 1.52 (95 percent confidence interval, 1.23 to 1.86; P<0.001). Three patients (1 percent) died from toxic effects of the chemoradiotherapy; grade 3 toxic effects occurred in 41 percent of the patients in the chemoradiotherapy group, and grade 4 toxic effects occurred in 32 percent.

Conclusions Postoperative chemoradiotherapy should be considered for all patients at high risk for recurrence of adenocarcinoma of the stomach or gastroesophageal junction who have undergone curative resection.

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>10 yr median f/u –

• Sig. improvement in RFS & OS
• Similar distant relapse rates
• 9.6% D2 dissection, 36% D1
• Lower OS rates in diffuse histology (40% pts)
Phase III Trial Comparing Capecitabine Plus Cisplatin Versus Capecitabine Plus Cisplatin With Concurrent Capecitabine Radiotherapy in Completely Resected Gastric Cancer With D2 Lymph Node Dissection: The ARTIST Trial

Jeeyun Lee, Do Hoon Lim, Sung Kim, Se Hoon Park, Joon Oh Park, Young Suk Park, Ho Yeong Lim, Min Gew Choi, Tae Sung Sohn, Jae Hyung Noh, Jae Moon Bae, Yong Chan Ahn, Insuk Sohn, Sin Ho Jung, Cheol Keun Park, Kyoung-Mee Kim, and Won Ki Kang

• D2 dissection
• XP arm vs XP/XPRT/XP arm
• Remnant stomach not routinely included in fields
• No 3DCRT or IMRT

Results:
No sig difference in DFS
Sig better DFS in pN+

The addition of XP chemotherapy did not significantly reduce recurrence after curative resection and D2 lymph node dissection in gastric cancer. A subsequent trial (ARTIST-II) in patients with lymph node–positive gastric cancer is planned.

Phase III Trial to Compare Adjuvant Chemotherapy With Capcitabine and Cisplatin Versus Concurrent Chemoradiotherapy in Gastric Cancer: Final Report of the Adjuvant Chemoradiotherapy in Stomach Tumors Trial, Including Survival and Subset Analyses

• 7 yrs f/u, similar OS & DFS
• Similar distant relapse rates
• LRR more in XP arm, 13% vs 7%, p=0.003

Patients and Methods
Between November 2004 and April 2008, 458 patients with GC who received gastrectomy with D2 lymph node dissection were randomly assigned to either six cycles of adjuvant chemotherapy with capcitabine and cisplatin (XP) or to two cycles of XP followed by chemoradiotherapy and then two additional cycles of XP (XPRT). This final update contains the first publication of overall survival (OS), together with updated DFS and subset analyses.

Results
With 7 years of follow-up, DFS remained similar between treatment arms (hazard ratio [HR], 0.740; 95% CI, 0.520 to 1.050; P = .0922). OS also was similar (HR, 1.130; 95% CI, 0.775 to 1.647; P = .5272). The effect of the addition of radiotherapy on DFS and OS differed by Lauren classification (interaction P = .04 for DFS; interaction P = .03 for OS) and lymph node ratio (interaction P < .01 for DFS; interaction P < .01 for OS). Subgroup analyses also showed that chemoradiotherapy significantly improved DFS in patients with node-positive disease and with intestinal-type GC. There was a similar trend for DFS and OS by stage of disease.

Conclusion
In D2-resected GC, both adjuvant chemotherapy and chemoradiotherapy are tolerated and equally beneficial in preventing relapse. Because results suggest a significant DFS effect of chemoradiotherapy in subsets of patients, the ARTIST 2 trial evaluating adjuvant chemotherapy and chemoradiotherapy in patients with node-positive, D2-resected GC is under way.
ARTIST Trial
Critical Analysis!!
ARTIST Trial

High proportion of early stage & diffuse type gastric cancer
- 60% in stage Ib/II (15% node negative)
- 60% diffuse type

Subgroup Analysis

Chemoradiotherapy beneficial in –
- Node positive disease
- Intestinal type GC
- Higher lymph node ratio

HRs for DFS
Regional nodes and/or Tumor Bed within RT fields

Remnant stomach not routinely encompassed

Duodenal stump/Anastomotic site included if margins<3cm

Group 2 LNs - common hepatic, celiac, splenic, hepatoduodenal

Group 3 LNs – Posterior panc head, sup.mesentric, paraaortic

Dose – 45Gy/5 weeks

No 3DCRT or IMRT
• 22 pts, 11 in each arm

• Common in >pT1
  PNI +
  Signet ring/P.D. adeno

• 9.7% vs 2.3% LR in pts. with all 3 factors

• 25/28 rec.in XP arm

• Most rec.in group 3 LNs
Chemoradiotherapy beneficial in node positive, intestinal type, high nodal ratio.
Effects of adjuvant radiotherapy on completely resected gastric cancer: A radiation oncologist's view of the ARTIST randomized phase III trial

In conclusion, adjuvant XPRT significantly prolonged LRRFS in completely D2 resected gastric cancer patients, and adjuvant XPRT had a large effect on LRRFS in patients with LN metastasis. The regional area (LNs in groups 2 and 3 including the para-aortic, retropancreatic, aortocaval, retrocaval region) might be the most important RT target, and local area could be considered when determining RT targets in strictly limited patients. The combination of RT and chemotherapy was well tolerated without an increased risk of complications. The ARTIST-II trial is ongoing.
Gastrectomy with D2 lymph node dissection is the standard treatment for curable gastric cancer in eastern Asia. In Western countries, extended dissection of distant lymph nodes contributes to accurate staging of the disease; however, its contribution to the prolongation of survival is unclear.\textsuperscript{71,110,113} Initial results from two large randomized trials performed in northern Europe and Japan failed to show any survival benefit associated with extended nodal dissection.\textsuperscript{116,120,121}

For patients with localized resectable gastric cancer, the NCCN Guidelines recommend gastrectomy with a D1 or a modified D2 lymph node dissection, with a goal of examining $\geq 15$ lymph nodes.\textsuperscript{110,116,120,121} The guidelines emphasize that D2 lymph node dissection should be performed by experienced surgeons in high-volume centers. Routine or prophylactic pancreatectomy is not recommended with D2 lymph node dissection,\textsuperscript{106,125} and splenectomy is acceptable only when the spleen or hilum is involved.
Patients who have not received pre-op chemotherapy

The benefit of postoperative chemoradiation for patients who have not received preoperative therapy has been established in randomized studies. Therefore, postoperative chemoradiation is recommended for all patients following an R1 or R2 resection, patients with pT3-pT4, any N or any pT, N+ tumors who received less than a D2 dissection (category 1); and select high-risk patients with pT2, N0 tumors following an R0 resection. High-risk features include poorly differentiated or higher grade cancer, LVI, neural invasion, age <50 years, and not undergoing D2 lymph node dissection. Palliative management, as clinically indicated, is an alternate option for patients with R2 resection.

Patients with pT3-pT4, any N or any pT, N+ tumors who have undergone primary D2 lymph node dissection may alternatively receive chemotherapy (category 1).

Perioperative Chemotherapy

Patients who have received preoperative chemoradiation should be observed until disease progression following R0 resection, regardless of tumor stage or nodal status. However, patients who have received preoperative chemotherapy could receive postoperative chemotherapy following R0 resection (category 1). In the absence of distant metastases, chemoradiation is recommended for patients with R1 or R2 resection, only...
Risk stratification is the key
ARTIST II Trial ongoing
RADIOTHERAPY PLANNING IN CARCINOMA STOMACH
Gross

- Relations
- Arterial/Lymphatic supply
Lymphatic Drainage

Figure 1. Diagram of stomach with primary vasculature. The nodal chains are generally defined in relationship to the vasculature. The location of the nodes defined in the Japanese system are shown by number. Published with permission.

1/2 - Paracardia
3/4 - Lesser and Greater curvature
5 - Rt Gastric A
6 - Infrapyloric
7 - Lt Gastric A
8 - Common Hepatic A
9 - Celiac axis
10/11 - Splenic A/Hilum
12 - Hepatoduodenal ligament
13-20 & 110-112 - others (distant nodes)

Japanese Classification of Gastric Carcinoma, 3rd Edn: Gastric Cancer 2011
**N1 lymph nodes:**
perigastric, along lesser and greater curvatures

**N2 lymph nodes:**
along celiac and its three branches (left gastric, common hepatic, and splenic)

**More distal nodes:**
N3 (hepatoduodenal, peripancreatic, root of mesentery) and N4 (periaortie, middle colic)

*Splenic & Lt Cardia – N3 for antral lesions
*Infra/Supra Pyloric – N3 for cardial lesions

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Radiological Anatomy

- Portal V
- IVC
- Aorta
- Celiac A
- Splenic V
- Stomach
- Pancreas

T10-L1 level
Proper Hepatic A
Portal V
Post Surgery CT Anatomy
Patterns of Spread

- **Direct through wall** –
  All adhesions regarded as malignant

- **Lymphatic** –
  Submucosal and subserosal
  At least 5cm cut margins
  All LN groups are at some risk irrespective of site of tumor

- **Hematogenous** – portal vein, liver in 30%

- **Peritoneum**
<table>
<thead>
<tr>
<th>LN at risk</th>
<th>Low risk</th>
<th>Direct Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal/Cardia</td>
<td>Mediastinal, Paracardial</td>
<td>Esophageal anastamosis, Tumor bed</td>
</tr>
<tr>
<td></td>
<td>Gastric antrum, Periduodenal, Porta hepatic</td>
<td>Pancreas, Gastric resection margin</td>
</tr>
<tr>
<td>Body</td>
<td>ALL nodal sites esp perigastric</td>
<td>Cardia, Periesophageal, Mediastinal, Splenic hilum</td>
</tr>
<tr>
<td>Distal 1/3rd/Antrum</td>
<td>Periduodenal, Peripancreatic, Porta hepatis</td>
<td>Duodenum</td>
</tr>
</tbody>
</table>
Preplanning

- Pre-op CT scan
- Operative notes
- Histopathology
- Determine treatment volume
- Planning - 2D/3DCRT/IMRT
Simulation

- Patient education/Fasting
- Consent
- Positioning - patient supine, hands over head
- Immobilization
- IV/oral contrast
<table>
<thead>
<tr>
<th>Movement</th>
<th>Mean Maximal Movement (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranio – Caudal</td>
<td>2.4 +/- 1.6</td>
</tr>
<tr>
<td>Left – Right</td>
<td>1.2 +/- 0.9</td>
</tr>
<tr>
<td>Ant – Post</td>
<td>0.6 +/- 0.3</td>
</tr>
</tbody>
</table>

Respiration-induced movement of the upper abdominal organs: a pitfall for the 3DCRT treatment of pancreatic cancer: *Bussels B et al, Radiotherapy and Oncology 2003*
Margin to account diaphragm movement
Guidelines for Treatment Volume
INTEROBSERVER VARIATION OF CLINICAL TARGET VOLUME DELINEATION IN GASTRIC CANCER

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*Department of Radiotherapy, The Netherlands Cancer Institute/Antoni van Leeuwenhoek Hospital, Amsterdam, The Netherlands; and †Department of Oncology, Karolinska Institute, Stockholm, Sweden

Purpose: To evaluate interobserver variability in clinical target volume (CTV) delineation in gastric cancer performed with the help of a delineation guide.

Patients and Methods: Ten radiotherapy centers that participate in the CRITICS Phase III trial were provided with a delineation atlas, preoperative CT scans, a postoperative planning CT scan, and clinical information for a gastric cancer case and were asked to construct a CTV and create a dosimetric plan according to departmental policy.

Results: The volumes of the CTVs and planning target volumes (PTVs) differed greatly, with a mean (SD) CTV volume of 392 (176) cm³ (range, 240–821 cm³) and PTV volume of 915 (312) cm³ (range, 634–1677 cm³). The overlapping volume was 376 cm³ for the CTV and 890 cm³ for the PTV. The greatest differences in the CTV were seen at the cranial and caudal parts. After planning, dose coverage of the overlapping PTV volume showed less variability than the CTV.

Conclusion: In this series of 10 plans, variability of the CTV in postoperative chemoradiotherapy for gastric cancer is large. Strict and clear delineation guidelines should be provided, especially in Phase III multicenter studies. Adaptations of these guidelines should be evaluated in clinical studies.
Radiation Treatment Parameters in the Adjuvant Postoperative Therapy of Gastric Cancer

Joel E. Tepper and Leonard L. Gunderson

Table 2. General Guidelines of Impact of T and N Stage on Inclusion of Remaining Stomach, Tumor Bed, Nodal Sites Within Irradiation Fields

<table>
<thead>
<tr>
<th>TN Stage</th>
<th>Remaining Stomach**</th>
<th>Tumor Bed</th>
<th>Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-2 (not into subserosa) N0</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>T2N0 (into subserosa)*</td>
<td>Variable</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>T3N0</td>
<td>Variable</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>T4N0</td>
<td>Variable</td>
<td>Y</td>
<td>Variable</td>
</tr>
<tr>
<td>T1-2N+</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>T3-4N+</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

*Posterior wall T2N0 lesions, or those that extend beyond muscularis propria, especially tumors located in the proximal or distal stomach, are at risk for local relapse. In addition, patients with low-stage disease with close or positive surgical margins should be considered for treatment to the tumor bed.

**Inclusion of the remaining stomach is preferable in most patients if two thirds of one kidney can be excluded. This is dependent on the extent of surgical resection and uninvolved margins (in centimeters).
## Table 3. Impact of Site of Primary Lesion and TN Stage on Irradiation Treatment Volumes—EG Junction (General Guidelines)

<table>
<thead>
<tr>
<th>Site of Primary and TN Stage</th>
<th>Remaining Stomach</th>
<th>Tumor Bed Volume**</th>
<th>Nodal Volumes</th>
<th>Tolerance Organ Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) EG junction</td>
<td>If allows exclusion of 2/3 R kidney</td>
<td>T-stage dependent</td>
<td>N-stage dependent</td>
<td>Heart, lung, spinal cord, kidneys,</td>
</tr>
<tr>
<td>T2N0 with invasion of subserosa</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>Medial left hemidiaphragm; adjacent body of pancreas</td>
<td>None or perigastric, periesophageal***</td>
<td></td>
</tr>
<tr>
<td>T3N0</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>Medial left hemidiaphragm; adjacent body of pancreas</td>
<td>None or perigastric, periesophageal mediastinal, celiac***</td>
<td></td>
</tr>
<tr>
<td>T4N0</td>
<td>Preferable but dependent on surgical-pathologic findings*</td>
<td>As for T3N0 plus site(s) of adherence with 3-5 cm margin</td>
<td>Nodes related to site of adherence, +/− perigastric, periesophageal mediastinal, celiac</td>
<td></td>
</tr>
<tr>
<td>T1-2 N+</td>
<td>Preferable</td>
<td>Not indicated for T1, as above for T2 into subserosa</td>
<td>Periesophageal mediastinal, prox perigastric, celiac</td>
<td></td>
</tr>
<tr>
<td>T3-4 N+</td>
<td>Preferable</td>
<td>As for T3, T4N0</td>
<td>As for T1-2N+ and T4N0</td>
<td></td>
</tr>
</tbody>
</table>

*For tumors with wide (>5 cm) surgical margins confirmed pathologically, treatment of residual stomach optional, especially if this would result in substantial increase in normal tissue morbidity.

**Use preop imaging (CT, barium swallow), surgical clips and postop imaging (CT, barium swallow).

***Optional node inclusion for T2-3N0 lesions if there has been an adequate surgical node dissection (D2 dissection) and at least 10-15 nodes have been examined pathologically.

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## Table 4. Impact of Site of Primary Gastric Lesion and TN Stage on Irradiation Treatment Volumes—Cardia/Proximal One Third of Stomach (General Guidelines)

<table>
<thead>
<tr>
<th>Site of Primary and TN Stage</th>
<th>Remaining Stomach</th>
<th>Tumor Bed Volume**</th>
<th>Nodal Volumes</th>
<th>Tolerance Organ Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Cardia/prox 1/3 of stomach</td>
<td>Preferred, but spare 2/3 of one kidney (usually R)</td>
<td>T-stage dependent</td>
<td>N-stage dependent</td>
<td>kidneys, spinal cord, liver, heart, lung</td>
</tr>
<tr>
<td>T2N0 with invasion of subserosa</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>Medial L hemidiaphragm, adjacent body of pancreas (+/− tail)</td>
<td>None or perigastric†</td>
<td></td>
</tr>
<tr>
<td>T3N0</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>Medial L hemidiaphragm, adjacent body of pancreas (+/− tail)</td>
<td>None or perigastric: optional: periesophageal, mediastinal, celiac†</td>
<td></td>
</tr>
<tr>
<td>T4N0</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>As for T3N0 plus site(s) of adherence with 3-5 cm margin</td>
<td>Nodes related to site of adherence, +/− perigastric, periesophageal, mediastinal, celiac</td>
<td></td>
</tr>
<tr>
<td>T1-2N+</td>
<td>Preferable</td>
<td>Not indicated for T1, as above for T2 into subserosa</td>
<td>Perigastric, celiac, splenic, supra-pancreatic, +/− periesophageal, mediastinal, pancreatic, porta hepatitis***</td>
<td></td>
</tr>
<tr>
<td>T3-4 N+</td>
<td>Preferable</td>
<td>As for T3, T4N0</td>
<td>As for T1-2N+ and T4N0</td>
<td></td>
</tr>
</tbody>
</table>

*For tumors with wide (>5 cm) surgical margins confirmed pathologically, treatment of residual stomach not necessary, especially if this would result in substantial increase in normal tissue morbidity.

†Use preop imaging (CT, barium swallow), surgical clips and postop imaging (CT, barium swallow).

***Pancreaticoduodenal and portahepatic nodes are at low risk if nodal positivity is minimal (ie, 1-2 pos nodes with 10-15 nodes examined), and this region does not need to be irradiated. Periesophageal and mediastinal nodes are at risk if there is esophageal extension.

†Optional node inclusion for T2-3N0 lesions if there has been an adequate surgical node dissection (D2 dissection) and at least 10-15 nodes have been examined pathologically.
To identify Diaphragm

Lung window:
Abdominal cavity & Lung interface

Diaphragm
Proximal Stomach Tumor
Inclusion of medial $\frac{2}{3}$rd of Lt Hemidiaphragm in CTV
### Table 5. Impact of Site of Primary Gastric Lesion and TN Stage on Irradiation Treatment Volumes—Body/Middle One Third of Stomach (General Guidelines)

<table>
<thead>
<tr>
<th>Site of Primary and TN Stage</th>
<th>Remaining Stomach</th>
<th>Tumor Bed Volumes*</th>
<th>Nodal Volumes</th>
<th>Tolerance Organ Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>3) Body/mid-1/3 of stomach</td>
<td>Yes, but spare 2/3</td>
<td>T-stage dependent</td>
<td>N-stage dependent, spare 2/3</td>
<td>Kidneys, spinal cord, liver</td>
</tr>
<tr>
<td>T2N0 with invasion of submucosa—esp. post wall</td>
<td>of one kidney</td>
<td>Body of pancreas (+/- tail)</td>
<td>of one kidney</td>
<td></td>
</tr>
<tr>
<td>T3N0</td>
<td>Yes</td>
<td>Body of pancreas (+/- tail)</td>
<td>None or perigastric; optional; celiac, splenic, supra-pancreatic, pancreatic-duodenal, portahepatis**</td>
<td></td>
</tr>
<tr>
<td>T4N0</td>
<td>Yes</td>
<td>As for T3N0 plus site(s) of adherence with 3-5 cm margin</td>
<td>Nodes related to site of adherence +/- perigastric, celiac, splenic, supra-pancreatic, pancreatic-duodenal, portahepatis++</td>
<td></td>
</tr>
<tr>
<td>T1-2 N+</td>
<td>Yes</td>
<td>Not indicated for T1</td>
<td>Perigastric, celiac, splenic, supra-pancreatic, pancreatic-duodenal, portahepatis</td>
<td></td>
</tr>
<tr>
<td>T3-4N+</td>
<td>Yes</td>
<td>As for T3, T4N0</td>
<td>As for T1-2N+ and T4N0</td>
<td></td>
</tr>
</tbody>
</table>

*Use preop imaging (CT, barium swallow), surgical clips, and postop imaging (CT, barium swallow).
**Optional node inclusion for T2-3N0 lesions if there has been adequate surgical node dissection (D2 dissection) and at least 10-15 nodes have been examined pathologically.

### Table 6. Impact of Site of Primary Gastric Lesion and TN Stage on Irradiation Treatment Volumes—Antrum/Pyloric/Distal One Third of Stomach (General Guidelines)

<table>
<thead>
<tr>
<th>Site of Primary and TN Stage</th>
<th>Remaining Stomach</th>
<th>Tumor Bed Volumes**</th>
<th>Nodal Volumes</th>
<th>Tolerance Organ Structures</th>
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<tbody>
<tr>
<td>4) Pylorus/distal 1/3 stomach</td>
<td>Yes, but spare 2/3</td>
<td>T-stage dependent</td>
<td>N-stage dependent</td>
<td>Kidneys, liver, spinal cord</td>
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<tr>
<td>T2N0 with invasion of submucosa</td>
<td>of one kidney (usually L)</td>
<td>Head of pancreas, (+/- body), 1st and 2nd duodenum</td>
<td>None or perigastric; optional; pancreatic-duodenal, porta hepatitis, celiac, supra-pancreatic***</td>
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<tr>
<td>T3N0</td>
<td>Variable dependent on surgical-pathologic findings*</td>
<td>Head of pancreas, (+/- body), 1st and 2nd duodenum</td>
<td>None or perigastric; optional; pancreatic-duodenal, porta hepatitis, celiac, supra-pancreatic***</td>
<td></td>
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<tr>
<td>T4N0</td>
<td>Preferable but dependent on surgical-pathologic findings*</td>
<td>As for T3N0 plus site(s) of adherence with 3-5 cm margin</td>
<td>Nodes related to site(s) of adherence +/- perigastric, pancreatic-duodenal, portahepatis, celiac, supra-pancreatic***</td>
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<tr>
<td>T1-2N+</td>
<td>Preferable</td>
<td>Not indicated for T1</td>
<td>Perigastric, pancreatic-duodenal, portahepatis, celiac, supra-pancreatic; Optional splenic hilum***</td>
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<tr>
<td>T3-4N+</td>
<td>Preferable</td>
<td>As for T3, T4N0</td>
<td>As for T1-2N+ and T4N0</td>
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*For tumors with wide (>5 cm) surgical margins confirmed pathologically, treatment of residual stomach is optional if this would result in substantial increase in normal tissue morbidity.
**Use preop imaging (CT, barium swallow), surgical clips, and postop imaging (CT, barium swallow).
***Optional node inclusion for T2-3N0 lesions if there has been an adequate surgical node dissection (D2 dissection) and at least 10-15 nodes have been examined pathologically.
Guidelines

EORTC-ROG expert opinion: Radiotherapy volume and treatment guidelines for neoadjuvant radiation of adenocarcinomas of the gastroesophageal junction and the stomach

Oscar Matzinger\textsuperscript{a,b}, Erich Gerber\textsuperscript{c}, Zvi Bernstein\textsuperscript{d}, Philippe Maingon\textsuperscript{e}, Karin Haustermans\textsuperscript{f}, Jean François Bosset\textsuperscript{g}, Akos Gulyban\textsuperscript{a}, Philip Poortmans\textsuperscript{h}, Laurence Collette\textsuperscript{a}, Abraham Kuten\textsuperscript{d}

\textsuperscript{a}EORTC Headquarters, Brussels, Belgium

Fig. 7. Corresponding elective lymph node stations for GC tumours of the proximal third with their tumour centre outside of the gastroesophageal junction: 1, right paracardial LN; 2, left paracardial LN; 3, LN along the lesser curvature; 4a, LN along the short gastric vessels; 4b, LN along the left gastroepiploic vessels; 7, LN along the left gastric artery; 9, LN around the celiac artery; 10, LN at the splenic hilum; 11p, LN along the proximal splenic artery; 11d, LN along the distal splenic artery; 19, infradiaphragmatic LN.

Ca Proximal Stomach
Mid 1/3rd Stomach

Fig. 8. Corresponding elective lymph node stations for GC tumors of the middle third: 1, right paracardial LN; 2, left paracardial LN; 3, LN along the lesser curvature; 4sa, LN along the short gastric vessels; 4b, LN along the left gastroepiploic vessels; 4d, LN along the right gastroepiploic vessels; 5, suprapyloric LN; 6, infrapyloric LN; 7, LN along the left gastric artery; 8a, LN along the common hepatic artery (anterosuperior group); 8b, LN along the common hepatic artery (posterior group); 9, LN around the celiac artery; 10, LN at the splenic hilum; 11p, LN along the proximal splenic artery; 11d, LN along the distal splenic artery; 18, LN along the inferior margin of the pancreas; 19, infraduodenal LN.

Distal 1/3rd Stomach

Fig. 9. Corresponding elective lymph node stations for GC tumors of the distal third: 3, LN along the lesser curvature; 4d, LN along the right gastroepiploic vessels; 5, suprapyloric LN; 6, infrapyloric LN; 7, LN along the left gastric artery; 8a, LN along the common hepatic artery (anterosuperior group); 8b, LN along the common hepatic artery (posterior group); 9, LN around the celiac artery; 11p, LN along the proximal splenic artery; 12a, LN in the hepatoduodenal ligament (along the hepatic artery); 12b, LN in the hepatoduodenal ligament (along the bile duct); 13p, LN in the hepatoduodenal ligament (behind the portal vein); 13, LN on the posterior surface of the pancreatic head; 14, LN on the anterior surface of the pancreas.
Original Report

Gastric lymph node contouring atlas: A tool to aid in clinical target volume definition in 3-dimensional treatment planning for gastric cancer

Jennifer Y. Wo MD a,*, Sam S. Yoon MD b, Alexander R. Guimaraes MD, PhD c, John Wolfgang PhD a, Harvey J. Mamon MD, PhD d, Theodore S. Hong MD a
encountered are the left paracardial LNs (Fig 1A). The left paracardial LNs are anatomically defined medially by the gastric fundus, anterolaterally by the visceral peritoneum, posteriorly by the spleen, superiorly by the hemidiaphragm, and inferiorly by the greater curvature LNs. Generally, the region anterior to the gastric body is devoid of any nodal tissue.

greater curvature LNs, splenic hilum LNs, and right paracardial LNs (Fig 1B). Once the greater curvature is encountered, the nodal tissue on the left lateral perigastric region is termed the greater curvature LNs. The greater curvature LNs run along the short gastric vessels and both right and left gastroepiploic vessels, and they are bordered medially by the gastric body, anterolaterally by the ribs, and posteriorly by the spleen and splenic hilum LNs. Lying posterior to the greater curvature LNs, the splenic hilum LNs represent the nodal basin lying between the spleen and gastric body, bordered posterolaterally by the spleen, medially by the kidneys, extending inferiorly to cover all of the splenic hilum vasculature. In Fig 1B, the right paracardial LNs can also be identified, representing the narrow anatomic space that lies between gastric cardia
Figure 1C depicts the lesser curvature and splenic artery LNs in relation to greater curvature and splenic hilum LNs. The lesser curvature LNs are defined superiorly by the right paracardial LNs, anteromedially by the liver, inferomedially by the suprapyloric LNs, laterally by the gastric body, and posteriorly by the kidney. The splenic artery LN basin surrounds the splenic artery. It is bordered anteriorly by the posterior aspect of the gastric body, posteriorly by the left kidney, laterally by the splenic hilum LNs, and medially by the celiac axis LNs. Figure 1D illustrates the location of the left gastric LNs in the context of other previously described LN stations. The left gastric LN station is defined as regional tissue surrounding the left gastric artery, starting inferiorly from its origin of the celiac axis to superiorly, running along the superior portion of the lesser curvature, where these LNs merge with the lesser curvature LNs. The left gastric LN station is bordered medially by the liver, superolaterally by the splenic artery LN basin, and inferolaterally by the celiac LNs.
Continuing inferiorly, Figure 1E illustrates the location of hepatoduodenal and paraaortic LN stations. The hepatoduodenal LNs lie along the proper hepatic artery, common bile duct, and the portal vein, extending superiorly from the under surface of the liver to the superior portion of the duodenum inferiorly. The paraaortic LNs are located within the region between and immediately adjacent to the aorta and inferior vena cava. Through consensus discussion, the superior border of the paraaortic LNs was designated as 5-mm below the origin of the celiac axis. This LN basin extends inferiorly to the duodenal sweep, medially to the vertebral body, and laterally extending to 2-mm left of the aorta.

As named, the common hepatic LNs (Fig 1F) can best be identified by first identifying the common hepatic artery, which terminates to form the proper hepatic artery and gastroduodenal artery. This LN basin is bordered posteriorly by the paraaortic LNs, posteromedial by the celiac LNs, anteriorly by the liver, anteroinferiorly by the suprapyloric LNs, and laterally by the hepatoduodenal LNs. Similarly, the celiac LNs are defined by the celiac artery, starting from its origin from the aorta to its termination where it branches and gives off the common hepatic artery, left gastric artery, and splenic artery.
Figure 1G illustrates the suprapyloric LN(s), which lie directly superior to the gastric pylorus. The common hepatic LN(s) flow into the suprapyloric LN(s), then flow leftward to join up with the lesser curvature LN(s). The suprapyloric LN(s) are bordered anteriorly by the left lobe of the liver, posteriorly by the pancreatic body, and to the left by the inferior portion of the lesser curvature LN(s).

Lastly, the infrapyloric LN(s), posterior pancreatic LN(s), and the superior mesenteric LN(s) can be appreciated. The infrapyloric LN(s) lie immediately inferior to the gastric pylorus and anterior to the pancreatic head and superior mesenteric vessels. The posterior pancreatic LN(s) lie immediately posterior to the pancreatic head and anterior to the paraortic LN(s). The superior mesenteric LN(s) reside anteriorly along the surface of the pancreatic head and neck, from the junction of the superior mesenteric artery and vein superiorly to the duodenal sweep inferiorly.
Phase II trial

A new approach to delineating lymph node target volumes for post-operative radiotherapy in gastric cancer: A phase II trial

Yu Haijun¹, Wu Qiuji¹, Fu Zhenming, Huang Yong, Liao Zhengkai, Xie Conghua, Zhou Yunfeng, Zhong Yahua *
<table>
<thead>
<tr>
<th>Lymph node station</th>
<th>Target volume delineation</th>
<th>Radiation indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6 Perigastric LNs</td>
<td>Residual stomach and 0.5-1 cm expansion</td>
<td>Any perigastric LNs involved</td>
</tr>
<tr>
<td>7 LNs along the left gastric artery</td>
<td>The interspace between the liver and the stomach Caudal-lower border of the cardia Cranial-lower border of the celiac trunk Anterior-anterior border of the lesser gastric curvature Posterior-anterior border of the abdominal aorta Right-left border of the liver Left-right border of the stomach</td>
<td>Lesions occur in the lesser curvature, involve the lower esophagus, or involve the station 1 or 3a LNs</td>
</tr>
<tr>
<td>8 LNs along the common hepatic artery</td>
<td>The common hepatic artery and 0.5-1 cm expansion</td>
<td>Lesions located in the lesser curvature near the pylorus or in the lower portion of the greater curvature, or involvement to the station 3b, 5, 6, and 4d lymph nodes</td>
</tr>
<tr>
<td>9 LNs around the celiac artery</td>
<td>The celiac trunk and 0.5-1 cm expansion</td>
<td>Any LNs involved</td>
</tr>
<tr>
<td>10 LNs at the splenic hilum</td>
<td>The splenic artery distal to the pancreatic tail and the vessels at the splenic hilum, with an additional 0.5-1 cm margin</td>
<td>Lesions at the fundus or the left gastroepiploic artery-supplying area, or involvement of the 4a or 4b LNs</td>
</tr>
<tr>
<td>11p Proximal splenic LNs</td>
<td>The splenic artery from its origin to halfway between its origin and the pancreatic tail end, then with an additional 0.5-1 cm margin</td>
<td>Lesions at the left gastroepiploic artery-supplying area or station 6 LNs involved</td>
</tr>
<tr>
<td>11d Distal splenic artery LNs</td>
<td>The splenic artery from halfway between its origin and the pancreatic tail end to the end of the pancreatic tail, then with an additional 0.5-1 cm margin</td>
<td>Lesions at the fundus or the left gastroepiploic artery-supplying area</td>
</tr>
<tr>
<td>12a Hepatoduodenal ligament LNs along the proper hepatic artery</td>
<td>The proper hepatic artery from its gives rise to the left and right hepatic artery to the common hepatic artery</td>
<td>Lesions at the lesser curvature near the pylorus or at the lower portion of the greater curvature, or involvement of the station 3b, 5, 6, 4d, and 8 LNs</td>
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<tr>
<td>12p Hepatoduodenal ligament LNs along the portal vein</td>
<td>The portal vein from the right hepatic vein joins the portal vein to the right border of the pancreas</td>
<td>Lesions at the lesser curvature</td>
</tr>
<tr>
<td>13 LNs on the posterior surface of the pancreatic head</td>
<td>Cranial—the upper border of pancreatic head Caudal—the lower border of the pancreatic head Right—the duodenum Left—the abdominal aorta Anterior-posterior border of the pancreas Posterior-anterior border of the inferior vena cava</td>
<td>Signet-ring cell carcinoma or mucinous adenocarcinoma at the gastric antrum, or the pancreas involved</td>
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<tr>
<td>14v LNs along the superior mesenteric vein</td>
<td>The superior mesenteric vein from the lower border of the pancreas to the level of bifurcation of celiac vein, then with an additional 0.5-1 cm margin</td>
<td>Station 6 LNs involved</td>
</tr>
<tr>
<td>14a LNs along the superior mesenteric artery</td>
<td>The proximal 2.5 cm to 3.0 cm of the superior mesenteric artery and 1 cm expansion</td>
<td>Lesions invading into the adjacent tissues or organs such as the pancreas or the transverse colon</td>
</tr>
<tr>
<td>15 LNs along the middle colic vessels</td>
<td>The region from the involved transverse colon to the root of the superior mesenteric vessels</td>
<td>Lesions at the greater curvature and invading into the transverse colon or its mesentery</td>
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<tr>
<td>16a1 LNs around the abdominal aorta</td>
<td>Para-aortic LNs in the diaphragmatic aortic hiatus Cranial: the upper margin of the origin of the celiac artery Caudal: the lower border of the left renal vein</td>
<td>Lesions at gastroesophageal junction</td>
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<tr>
<td>16a2 LNs around the abdominal aorta</td>
<td>Any LNs involved</td>
<td>Lesions at gastroesophageal junction</td>
</tr>
<tr>
<td>16b1 LNs around the abdominal aorta</td>
<td>Cranial: the lower border of the left renal vein Caudal: the upper border of the origin of the inferior mesenteric artery</td>
<td>Any LNs involved, excluding lesions at gastroesophageal junction</td>
</tr>
<tr>
<td>16b2 LNs around the abdominal aorta</td>
<td>Cranial: the upper border of the origin of the inferior mesenteric artery Caudal: the aortic bifurcation</td>
<td>Station 16b2 is generally not included in the CTV</td>
</tr>
</tbody>
</table>

Left: left border of abdominal aorta with an additional 1-1.5 cm margin; Right: right border of abdominal aorta with an additional 2 cm margin; Anterior: anterior border of abdominal aorta with an additional 1.5-2 cm margin; Posterior: posterior border of abdominal aorta with an additional 0.3-0.5 cm margin.

*16a1, 16a2, 16b1, and 16b2 have same left, right, anterior and posterior border.
Nodal Contours

Celiac Nodes
Hepatoduodenal Nodes
Paraaortic Nodes
Suprapyloric Nodes
Posterior Pancreatic Nodes
Greater Curvature Nodes
Right Paracardial Nodes
Lesser Curvature Nodes
Splenic Hilar Nodes
Splenic Arterial Nodes
Splenic Arterial Nodes
Regional Lymphatics of Stomach
Lymphatics Contour vs CTV
Post-operative Radiotherapy

**Dose –**
- R0 resection - 45-50.4Gy @1.8Gy/fr
- R+ resection – 55-60Gy (to smaller volume)

**OAR constraints –**
- Spinal Cord: D_{max} \leq 45Gy
- Lungs: V_{20Gy} < 20-30%; D_{mean} < 20Gy
- Bowel: V_{45Gy} < 195cc
- Heart: V_{30Gy} < 30% (closer to 20% preferred)  
  D_{mean} < 30Gy
- Kidneys (evaluate each separately):  
  D_{mean} < 18Gy; V_{20Gy} < 33%
- Liver: D_{mean} < 25Gy; V_{30Gy} < 33%

BEAM ARRANGEMENT

- AP/PA portals

- Anteriorly weighted beams to reduce spinal cord doses

- Reduced fields with obliques or laterals used after 45 Gy

- AP/PA +LATERAL/ oblique port can be used from beginning to decrease spinal cord dose till 20 Gy. Lateral port to be removed thereafter to decrease liver dose
3DCRT

- Beam arrangement – AP, PA, Obliques
- Fields may be weighted to maximize sparing of kidneys
- MLCs
AP/PA beam portals

Full doses to cord, bowel
AP/PA/LAT portals
Oblique beams
Relative sparing of cord, bowel
AP/PA beams
Liver & B/L Kidneys 90-100% isodose
**Oblique beams**

Kidneys 70-80% isodose
54/F,

Carcinoma Pyloric Antrum (s/p Distal Gastrectomy, pT2pN3M0)

Adjuvant RT – 45Gy/25#

3DCRT vs VMAT plans
DVH

Left Kidney

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<tr>
<th></th>
<th>3DCRT</th>
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Supportive Care

- Nutrition, review weekly
- Prophylactic antiemetics
- B12, Fe, Folate, Vitamins as indicated
- CBC weekly during treatment, then monthly
Let us not cast aside
What belongs to the past,
for,
It is only with the Past
That we can weave the fabric of the Future

....Anatole France
Thank You