

## Retrospective Study

## Surgical care quality and oncologic outcome after D2 gastrectomy for gastric cancer

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### Abstract

**AIM:** To examine the quality of surgical care and long-term oncologic outcome after D2 gastrectomy for gastric cancer.

**METHODS:** From 1999 to 2008, a total of 109 consecutive patients underwent D2 gastrectomy without routine pancreateosplenectomy in a multimodal setting at our institution. Oncologic outcomes together with clinical and histopathologic data were analyzed in relation to the type of surgery performed. Staging was carried out according to the Union for International Cancer Control criteria of 2002. Patients were followed-up for five years at the outpatient clinic. The primary measure of outcome was long-term survival with the quality of surgery as a secondary outcome measure. Clinical data were retrospectively collected from the patient records, and causes of death were obtained from national registries.

**RESULTS:** A total of 109 patients (58 men) with a mean age of  $67.4 \pm 11.2$  years underwent total

gastrectomy or gastric resection with D2 lymph node dissection. The tumor stage distribution was as follows: stage I, (27/109) 24.8%; stage II, (31/109) 28.4%; stage III, (41/109) 37.6%; and stage IV, (10/109) 9.2%. Forty patients (36.7%) received chemotherapy or chemoradiotherapy. The five-year overall survival rate for all 109 patients was 45.0%, and was 47.1% for the 104 patients treated with curative R0 resection. The five-year disease-specific survival rates were 53.0% and 55.8%, respectively. In a multivariate analysis, body mass index and tumor stage were independent prognostic factors for overall survival (both  $P < 0.01$ ), whereas body mass index, tumor stage, tumor site, Lauren classification, and lymph node invasion were prognostic factors for cancer-specific survival (all  $P < 0.05$ ). Postoperative 30-d mortality was 1.8% and 30-d, surgical (including three anastomotic leaks, two of which were treated conservatively), and general morbidities were 26.6%, 12.8%, and 14.7%, respectively.

**CONCLUSION:** D2 dissection is a safe surgical option for gastric cancer, providing quality surgical care and long-term oncologic outcomes that are in line with current Western standards.

**Key words:** Gastric cancer; Quality of care; Survival; Gastric surgery; Clinical practice

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**Core tip:** Gastric cancer remains one of the most lethal malignancies worldwide. Although radical surgery with adequate lymphadenectomy is the cornerstone of curative treatment, whether D2 lymphadenectomy is applicable in Western hospitals is not clear, despite the low reported morbidity and mortality rates and survival benefit. This single-center study of 109 patients demonstrates that D2 lymphadenectomy can be performed with relatively low mortality (1.8%) and morbidity (26.6%). Five-year survival rates were 45.0% (overall) and 53.0% (disease-specific). Therefore, D2 gastrectomy can be considered as a safe surgical option for gastric cancer.

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## INTRODUCTION

Gastric cancer is the sixth most common cancer and the third leading cause of cancer-related death worldwide<sup>[1,2]</sup>. The cornerstone of treatment involves adequate surgery, though it is not curative, as most

patients present with advanced disease. As nodal involvement is indicative of a poor prognosis, more aggressive surgical approaches with lymph node removal have gained popularity<sup>[3]</sup>. D2 lymph node dissection is currently the gold standard in gastric cancer surgery in Asia with regard to long-term survival and local recurrence<sup>[4]</sup>. In the Western world, however, the role of D2 lymphadenectomy for the treatment of gastric cancer is controversial<sup>[5,6]</sup>.

Large European randomized studies report higher mortality and morbidity with no survival benefit from D2 dissection with splenic and/or pancreatic resection compared to D1 dissection<sup>[7,8]</sup>. However, an Italian study found similar rates of postoperative complications (18% vs 12%) and mortality (2% vs 3%) when comparing D2 (with preservation of the spleen and pancreas) and D1 dissections<sup>[9]</sup>. Another small single-center randomized trial comparing D1 and D3 (current D2) dissections showed a better overall survival after D2/3 dissection, but no significant difference in disease-specific survival<sup>[10]</sup>. Finally, a Japanese randomized trial showed that extended D2 dissection with removal of para-aortic lymph nodes did not improve survival compared with standard D2 dissection<sup>[11]</sup>.

D2 lymphadenectomy with preservation of the spleen and pancreas is now regarded as the standard surgical technique for locally advanced gastric cancer. Patient outcome has been further improved by the centralization of procedures to experienced high-volume units and the use multimodal treatments<sup>[12]</sup>, such as chemotherapy and/or radiotherapy. An American study using postoperative chemoradiation<sup>[13]</sup> and European studies using pre- and postoperative chemotherapy<sup>[14,15]</sup> have shown improved survival with adjuvant therapies. Furthermore, a recent meta-analysis showed that adjuvant chemotherapy based on 5-fluorouracil (FU) regimens was associated with improved survival compared to surgery alone<sup>[16]</sup>. However, whether to use pre- and postoperative chemotherapy, postoperative chemoradiotherapy, or adjuvant chemotherapy remains unclear.

Due to the availability of multiple individually tailored treatment options, it is important to monitor the quality of care, which also affects outcomes. In Finland, for example, there is no national quality audit for gastric cancer. Therefore, the aim of this study was to assess the long-term oncologic outcome and quality of surgical care for patients who underwent D2 gastrectomy at our institution between 1998 and 2008.

## MATERIALS AND METHODS

### Patients

This study examined 109 consecutive patients with histologically proven gastric adenocarcinoma that underwent D2 gastrectomy with curative intent at the Central Hospital of Central Finland in Jyväskylä

**Table 1** Baseline characteristics (*n* = 109)

Characteristic	<i>n</i> (%)
Male gender	51 (46.8)
Body mass index (kg/m <sup>2</sup> ), mean (SD)	25.6 (4.9)
ASA score III-IV	67 (61.5)
Tumor site	
Upper	21 (19.3)
Middle	43 (39.4)
Lower	38 (34.9)
All levels	7 (6.4)
UICC tumor stage	
I	27 (24.8)
II	31 (28.4)
III	41 (37.6)
IV	10 (9.2)
Tumor type	
Intestinal	50 (45.9)
Diffuse	56 (51.4)
Mixed	3 (2.8)
Lymph node invasion	
No	45 (41.2)
Yes	64 (58.7)
Type of surgery	
Total gastrectomy	103 (94.5)
Subtotal gastric resection	6 (5.5)
D2-lymph node dissection	109 (100)
Splenectomy	48 (44.0)
Cholecystectomy	19 (17.4)
Additional organ resection due to cancer invasion	10 (9.2)
Radicality	
R0	104 (95.4)
Neoadjuvant/adjvant treatment	
No	69 (63.3)
Neoadjuvant chemoradiotherapy	2 (1.8)
Adjuvant chemotherapy	26 (23.9)
Adjuvant chemoradiotherapy	12 (11.0)

ASA: American Society of Anesthesiologists; UICC: Union for International Cancer Control.

between January 1998 and December 2008. Pre-operative diagnosis and staging was performed *via* endoscopy and thoracoabdominal CT; laparoscopic staging was not routinely conducted during the study period. Clinical and follow-up patient data were collected retrospectively. Patients who underwent other surgical procedures (D1 dissection or palliative resections) were excluded. The study was approved by the ethics committee of the Central Hospital of Central Finland.

### Surgical treatment

D2 lymph node dissections were conducted by senior upper gastrointestinal surgeons who also performed hepatobiliary and pancreatic surgeries. Resection of the pancreas was performed only when invasion by the gastric cancer was suspected. Indications for splenectomy were gastric carcinomas of the greater curvature in the upper and middle part of the stomach. Cholecystectomy was performed routinely, and additional organ resections were performed when deemed appropriate. The nodal dissection of the removed surgical specimen was performed by

surgeons on the bench in the operating room in a standardized fashion following the JRS GC classification system<sup>[17]</sup>. R0 gastric resection was defined by the following parameters: negative resection margins, en bloc resection of adherent organs, and en bloc resection of the greater and lesser omentum.

Perioperative care during the study period included the assessment and optimization of medical risk factors, thromboprophylaxis with low-molecular-weight heparin and elastic stockings, prophylactic antibiotics, standard anesthesia with epidural analgesia, avoidance of hypothermia, and increased oxygen concentrations. Nasogastric tubes were removed in the operation theatre.

### Pathology

Tumors were staged by pathologists according to the 2002 Union for International Cancer Control/Tumor-node-metastasis categories<sup>[18]</sup>. Lymph node ratios were defined as the proportion of metastatic lymph nodes from the total number studied, and classified as follows: ratio, 0%, 1%-9%, 10%-25%, and > 25%<sup>[19]</sup>. The histopathologic tumor type was evaluated according to Lauren classification<sup>[20]</sup>.

### Neoadjuvant treatment and adjuvant chemotherapy

A selective approach for neoadjuvant and adjuvant oncologic treatments was used. Adjuvant postoperative chemotherapy consisted of FU-based regimens combined with epirubicin and cisplatin or oxaliplatin. Chemoradiotherapy (40-45 Gy and FU or capecitabine) was generally used in the postoperative setting, but two patients received preoperative chemoradiation (Table 1). None of the patients had perioperative chemotherapy<sup>[14,15]</sup>.

### Follow-up

Patients were followed at the surgical outpatient clinic every six months for two years, and then once a year for up to five years from the operation. Tumor recurrence was defined as a recurrent tumor in the tumor bed or distant organs and diagnosed by CT, magnetic resonance imaging, or endoscopy. Histopathologic confirmation was not mandatory. The end of follow-up was June 30, 2014. The causes of death were obtained from the National Cause of Death Registry.

### Statistical analysis

Statistical analyses were conducted using SPSS (version 15.0 for Windows; SPSS Inc., Chicago, IL, United States) and STATA (version 11; StatCorp LP, College Station, TX, United States) software. Results are given as mean  $\pm$  SD or median (interquartile range). Pearson's  $\chi^2$  or Fisher's exact tests were used to compare frequencies, and Student's *t* and Mann-Whitney *U* tests were used for continuous variables. The Kaplan-Meier method was used to calculate the

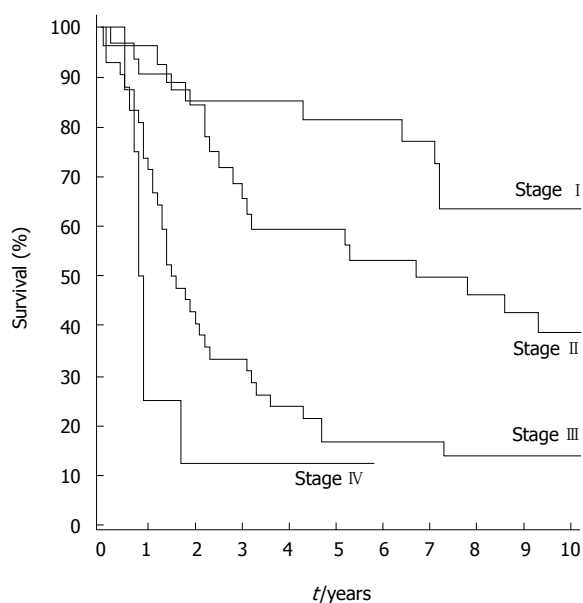


Figure 1 Overall survival rates by tumor stage.

survival, and the differences between groups were compared with the log-rank test. Survival times were calculated from the date of surgery until the time of death or the end of follow-up. Factors affecting survival were analyzed with univariate and multivariate Cox proportional hazards regression models; only variables with  $P < 0.20$  were entered in the multivariate analysis. All statistical tests were two-sided, with a  $P < 0.05$  considered as statistically significant.

## RESULTS

### Baseline characteristics

Baseline patient and tumor characteristics are shown in Table 1. A total of 109 patients with a mean age of  $67.4 \pm 11.2$  years (median, 69 years; range: 59-77 years) underwent total gastrectomy or subtotal gastric resection with D2 lymph node dissection; 5/109 (4.6%) patients had residual microscopic disease upon histopathologic examination. Ten patients received multivisceral resections for locally invasive or metastatic disease, including resection of the colon ( $n = 2$ ), pancreas ( $n = 1$ ), liver ( $n = 1$ ), esophagus ( $n = 2$ ), kidney ( $n = 2$ ), and ovaries ( $n = 2$ ).

### Survival

The overall median follow-up time was 3.3 (1.5-5.1) years, and 9.1 (7.9-12.3) years for the 37 surviving patients. No patients were lost to follow-up. The five- and 10-year overall survival rates were 45.0% [95%CI: 35.5%-54.0%] and 32.9% (95%CI: 23.9%-42.2%), respectively. The five- and 10-year disease-specific survival rates were 53.0% (95%CI: 42.7%-62.3%) and 47.8% (95%CI: 37.4%-57.5%). For the 104 patients with R0 resection, the five- and 10-year overall survival rates were 47.1% (95%CI:

37.3%-56.3%) and 34.5% (95%CI: 25.1%-44.0%) and disease-specific survival rates were 55.8% (95%CI: 45.2%-65.2%) and 50.3% (95%CI: 39.5%-60.2t), respectively. For tumor stages I, II, and III, the five-year overall survival rates were 81.5% (95%CI: 61.1%-91.8%), 61.3% (95%CI: 40.5%-74.0%), and 17.1% (95%CI: 7.3%-29.3%) (Figure 1), and disease-specific survival rates were 95.8% (95%CI: 73.9%-99.4%), 63.8% (95%CI: 44.2%-78.1%), and 22.6% (95%CI: 10.4%-37.7%), respectively.

### Factors influencing survival

Univariate and multivariate analyses were performed to identify prognostic factors of overall and cancer-specific survival. The results of the univariate analysis are shown in Table 2. In the multivariate analysis, body mass index (BMI) and tumor stage were the independent prognostic factors of overall survival (both  $P < 0.01$ ), and BMI, tumor stage, tumor site, lymph node invasion, and Lauren's classification (intestinal vs diffuse) were independent prognostic factors of cancer-specific survival (all  $P < 0.05$ ). Of note, significantly more patients with BMI  $< 25$  had metastatic lymph nodes than those with BMI  $> 25$  (67.9% vs 49.1%,  $P < 0.05$ ).

### Quality of surgical care

The parameters reflecting the quality of care are shown in Table 3. Overall 30-d mortality was 1.8%, including one death from cerebral stroke and one from severe pneumonia. The overall complication rate was 26.6% (29/109) with 12.8% surgical and 14.7% general morbidity rates. The 30-d reoperation rate was 3.7% due to postoperative hemorrhage ( $n = 1$ ), pleural empyema ( $n = 1$ ), esophagojejunal anastomotic leak in a cirrhotic patient ( $n = 1$ ), and colon obstruction ( $n = 1$ ). The median postoperative hospital stay was 10 (8-12) d. Seven patients had a late reoperation because of bowel obstruction caused by locoregional recurrence or intra-abdominal carcinosis.

## DISCUSSION

The treatment of gastric cancer is complex and has evolved from surgical management to a multi-disciplinary model<sup>[12]</sup>. Consequently, overall five-year survival rates across all tumor stages range from 33%-47% as reported in European randomized trials<sup>[7,8]</sup>. In the present cohort of patients undergoing D2 gastrectomy for gastric cancer without routine pancreaticosplenectomy and multimodal treatment, the five-year overall and cancer-specific survival rates were 45% and 53%, and slightly higher, at 47% and 56%, respectively, for those having R0 resection. Asian studies have reported higher survival rates ranging from 59% up to 70% depending on the extent of lymphadenectomy, with minor survival benefit gained

**Table 2** Univariate analyses of prognostic factors for five-year survival (*n* = 109)

Variables	OS			DSS		
	Events/patients	HR (95%CI)	<i>P</i> value	Events/patients	HR (95%CI)	<i>P</i> value
Age (yr)			0.15 <sup>1</sup>			0.72 <sup>1</sup>
< 60	16/29	1		13/29	1	
60-75	31/47	1.33 (0.73-2.44)		23/47	1.22 (0.62-2.42)	
> 75	25/33	1.59 (0.85-2.97)		15/33	1.23 (0.54-2.79)	
Sex			0.83			0.67
Male	34/51	1		26/51	1	
Female	38/58	1.05 (0.66-1.67)		25/58	0.89 (0.51-1.54)	
BMI (kg/m <sup>2</sup> )			0.02			0.01
< 25	43/56	1		33/56	1	
> 25	29/53	0.56 (0.35-0.90)		18/53	0.47 (0.27-0.84)	
ASA			0.61			0.43
I - II	25/42	1		22/42	1	
III-IV	47/67	1.13 (0.70-1.85)		29/67	0.80 (0.46-1.39)	
Operation type			0.05			0.04 <sup>1</sup>
D2	27/51	1		20/51	1	
D2 + splenectomy	38/48	1.59 (0.97-2.61)		24/48	1.44 (0.81-2.56)	
D2 + adjacent organ resection	7/10	1.80 (0.78-4.16)		7/10	3.67 (1.25-10.80)	
Radicality			0.02			< 0.01
R0	67/104	1		46/104	1	
R1	5/5	3.18 (1.24-8.14)		5/5	4.43 (1.69-11.59)	
Neoadjuvant/ adjuvant therapy			0.02 <sup>1</sup>			< 0.01 <sup>1</sup>
No	41/69	1		20/69	1	
Neoadjuvant	1/2	0.75 (0.10-5.48)		1/2	1.53 (0.21-11.40)	
Adjuvant	30/38	1.82 (1.13-2.93)		30/38	3.55 (2.01-6.28)	
Tumor site			0.07 <sup>1</sup>			< 0.01 <sup>1</sup>
Upper third	14/21	1		8/21	1	
Middle third	26/43	0.91 (0.48-1.75)		15/43	0.95 (0.40-2.25)	
Lower third	25/38	1.04 (0.54-2.01)		21/38	1.54 (0.68-3.48)	
All levels	7/7	2.87 (1.14-7.21)		7/7	4.74 (1.70-13.23)	
Tumor stage			< 0.01 <sup>1</sup>			0.03 <sup>1</sup>
I	13/38	1		4/38	1	
II	19/27	2.98 (1.47-6.05)		12/27	5.96 (1.92-18.50)	
III	31/34	5.99 (3.09-11.62)		26/34	15.34 (5.30-44.38)	
IV	9/10	10.15 (4.18-24.66)		9/10	30.67 (9.17-102.65)	
Lauren classification			0.66			0.03
Intestinal	34/50	1		18/50	1	
Diffuse <sup>2</sup>	38/59	1.11 (0.66-1.77)		33/59	1.87 (1.05-3.33)	
Lymph node invasion						< 0.01
No	20/45	1		9/45	1	
Yes	52/64	2.90 (1.72-4.89)		42/64	4.95 (2.40-10.23)	
Lymph node ratio (%)			< 0.01 <sup>1</sup>			< 0.01
0	20/45	1		9/45	1	
1-9	9/15	1.88 (0.85-4.14)		7/15	3.03 (1.12-8.16)	
10-25	16/20	2.69 (1.37-5.28)		12/20	4.11 (1.70-9.95)	
> 25	27/29	3.74 (2.09-6.70)		23/29	7.00 (3.22-15.20)	

<sup>1</sup>*P* for linearity; <sup>2</sup>Three mixed type tumors included. ASA: American Society of Anesthesiologists; BMI: Body mass index; DSS: Disease-specific survival; HR: Hazard ratio; OS: Overall survival.

by D3 or D4 lymphadenectomy compared with less radical dissection<sup>[10,11,21]</sup>.

Variability in survival rates among studies may, in part, depend upon tumor stage distribution, use of neoadjuvant and adjuvant treatments, and differences in the quality of the surgical care. The reported five-year survival rates for curative surgical resection ranges from 60%-90% for patients with stage I, 30%-50% for patients with stage II disease, and 10%-25% for patients with stage III disease<sup>[22]</sup>, which is in line with what was observed in the present study. The results indicate that tumor stage and a BMI < 25 are predictive of overall survival, with additional

factors of tumor site, Lauren classification, and lymph node invasion predictive of cancer-free survival. Although the lymph node ratio is a prognostic tool that can be used to stratify patients with gastric cancer undergoing limited lymph node dissection and to reduce stage migration<sup>[19]</sup>, this was only a significant prognostic factor for survival in the univariate, but not multivariate, analysis in the present study.

Data from Asian studies show that D2 dissection provides better survival rates compared with D1 dissection<sup>[10,11,21]</sup>, and that a more extended lymphadenectomy does not improve survival. However, European randomized studies failed to demonstrate

**Table 3** Parameters reflecting the quality of care (*n* = 109)

Parameter	Value
Duration of surgery (min)	230 (200-255)
Operative blood loss (mL)	500 (300-900)
Hospital stay (d)	10 (8-12)
Number of lymph nodes studied	19 (11-25)
30-d mortality	2 (1.8)
30-d morbidity <sup>1</sup>	29 (26.6)
General morbidity	
Cardiac	1 (0.9)
Pleural effusion	8 (7.3)
Pneumonia	3 (1.8)
Pleural empyema	1 (0.9)
Urinary tract infection	2 (1.8)
Thromboembolism	1 (0.9)
Cerebral infarction	1 (0.9)
Surgical morbidity	
Bleeding	1 (0.9)
Anastomotic leak <sup>2</sup>	3 (2.8)
Abdominal abscess	7 (6.4)
Wound infection	1 (0.9)
Common bile duct injury	1 (0.9)
Bowel obstruction	1 (0.9)
Dindo-Clavien classification <sup>[32]</sup> , severe morbidity	9 (8.3)
Grade III	3 (2.8)
Grade IV	3 (2.8)
Grade V	3 (2.8)

<sup>1</sup>Figures are not additive because some patients had > 1 complication;

<sup>2</sup>Two of these were treated conservatively. Data are presented as median (IQR) or *n* (%).

any survival benefit from D2 over D1 dissection. Five-year survival rates were 35% (D1) and 33% (D2) in the MRC trial<sup>[7]</sup>, and 45% and 47%, respectively, in the Dutch trial<sup>[8]</sup>. This, in combination with high morbidity and mortality rates, has led to a reserved attitude against D2 surgery in Western centers. However, results from a 15-year follow-up of the Dutch trial showed a significant survival benefit for D2 without pancreaticosplenectomy compared to D1 (35% vs 22%)<sup>[8]</sup>. Moreover, a recent meta-analysis including eight randomized controlled trials with 2044 patients confirmed that there is no overall survival benefit for D2 lymphadenectomy, but found a benefit among patients who had resection without a splenectomy and/or pancreatectomy<sup>[6]</sup>. Importantly, some previous randomized trials have been scrutinized based on the inclusion of a large number of operating surgeons and heterogeneous surgical techniques. Thus, universal standardization and surgical quality control of D2 dissection is needed to improve evaluation of the oncologic outcome<sup>[23,24]</sup>. Currently, radical D2 gastrectomy is indicated for resectable stage I B-III disease, provided that patients are medically fit and the procedure is carried out in specialized, high-volume centers with appropriate surgical expertise and postoperative care<sup>[12]</sup>.

Despite radical surgery, a substantial proportion of patients relapse, which indicates that there is a need for additional therapeutic modalities, such as radiation and chemotherapy, though more evidence

is needed with regard to the (neo)adjuvant setting<sup>[25]</sup>. A randomized phase III study performed in the United States (Intergroup 0116) demonstrated a survival benefit with postoperative chemoradiotherapy compared with surgery alone based primarily on patients undergoing D1 gastrectomy<sup>[26]</sup>. The European UK MRC MAGIC trial demonstrated a survival benefit when patients with resectable stage II and III gastric cancers undergoing either D1 or D2 surgery were treated with three cycles of preoperative chemotherapy (epirubicin, cisplatin, and FU) followed by an additional three cycles of postoperative chemotherapy compared with surgery alone<sup>[15]</sup>. As a result, perioperative chemotherapy has been widely adopted as the standard of care throughout the United Kingdom and Europe. However, additional real-life data is needed, as a recent Norwegian study showed that perioperative chemotherapy was completed in less than half of the patients in line with the MAGIC trial, and the tumor response did not afford any long-term survival benefit<sup>[27]</sup>. Nevertheless, a recent meta-analysis containing data from 17 randomized trials confirmed an overall survival benefit for FU-based chemotherapy for gastric cancer compared with surgery alone (55.3% vs 49.6%, HR = 0.82, 95%CI: 0.76-0.90)<sup>[28]</sup>. Particularly, data from the Japanese ACTS-GC<sup>[29]</sup> and the Korean CLASSIC<sup>[30]</sup> trials showed that adjuvant chemotherapy improves overall survival after D2 gastrectomy. Recent European guidelines recommend either chemoradiotherapy or chemotherapy delivered in the adjuvant setting for patients with  $\geq$  stage I B gastric cancer who undergo surgery without preoperative chemotherapy<sup>[12]</sup>. Although neoadjuvant and adjuvant treatments were used in our cohort of patients, the protocol was not uniform during the study period due to the lack of an international consensus regarding various treatment strategies.

Additional parameters can be used to assess the quality of surgical care, including postoperative mortality, reoperation rate, and 30-d readmission rate. The mortality rate within 30 d after a surgical procedure for gastric cancer has been reduced substantially over the last decades. Indeed, the postoperative mortality rate in this patient series (1.8%) is within the reported range of 0%-2%<sup>[9-11]</sup>, and is similar to earlier European multicenter randomized trials<sup>[7,8]</sup>. Furthermore, the 30-d morbidity (26.6%) is in line with other reports: 20.9%-28.1% in the JCOG trial<sup>[11]</sup> and 17.9% by Degiuli *et al.*<sup>[9]</sup>. Early postoperative complications typically include bleeding, ileus, cholecystitis, pancreatitis, pulmonary infections, thromboembolism, and anastomotic leakage, which is the most significant complication after total gastrectomy. In our report, the rate of symptomatic leakage was 2.8%, within the commonly reported incidence range of 1.9%-4.5%. The reoperation rate (3.7%) also compares well with the figures reported from other centers<sup>[10,11]</sup>. Asian studies show that, even in high-volume centers, there is a certain amount

of morbidity associated with major gastric surgery. Overall, the current international standards of care were well met in this series of patients treated with D2 gastrectomy and combined modality therapy for gastric cancer.

This single-center audit should be interpreted with some caution. The number of patients is relatively small due to a declining incidence of gastric cancer in Western Europe. In addition, some changes in the management were made during the study period, including the addition of multidisciplinary team meetings and some modifications in chemotherapy regimens. However, the mortality, reoperation, and local recurrence rates are low. Currently, endoscopic ultrasound can be used to determine the proximal and distal extent of the tumor and provide further assessment of the T and N stages. Moreover, laparoscopy with or without peritoneal washings for malignant cells is now recommended to exclude occult metastatic disease in all stage I B-III stomach cancers considered potentially resectable<sup>[31]</sup>.

In conclusion, the present audit indicates that D2 lymphadenectomy with pancreatic preservation and selective splenectomy is a safe surgical strategy for patients with locally advanced gastric cancer. The oncologic outcome is largely determined by the stage of the disease at presentation, which can be improved through the use of neoadjuvant and adjuvant chemotherapy regimens.

## COMMENTS

### Background

Morbidity and mortality rates after D2 gastrectomy are relatively high in European randomized studies, and evidence of a long-term survival benefit has been controversial. Nevertheless, D2 lymphadenectomy has been adopted for treatment protocols for gastric cancer, despite the lack of quality audits in some countries.

### Research frontiers

Asian studies show that D2-3 lymphadenectomy improves survival and can be performed with acceptable complication rates. The present study evaluates the long-term oncologic outcomes of 109 consecutive D2 gastrectomy patients with gastric adenocarcinoma at the authors' institution. Clinicopathologic factors affecting survival were assessed, and the quality of surgery was a secondary outcome measure.

### Innovations and breakthroughs

The overall five-year and disease-specific survivals for the 109 patients in this cohort were 45.0% and 53.0%, respectively, which are in line with European studies. The mortality associated with D2 lymphadenectomy without routine pancreatectomy and/or splenectomy was only 1.8%, and morbidity was 26.6%. Low body mass index, advanced stage, tumor site, Lauren classification, and lymph node invasion were independent prognostic factors for poor survival.

### Applications

Large randomized studies are essential for defining clinical guidelines. However, it is important to report how these guidelines are implemented in clinical practice. In this series, the Western standards for long-term oncologic outcome and quality of surgical care were well met.

## Peer-review

The authors examined long-term oncologic outcome and quality of surgical care in gastric cancer patients treated with D2 lymphadenectomy without routine pancreaticosplenectomy. Clinicopathologic factors affecting survival were assessed. Their results show that in this consecutive series, survival and morbidity rates were comparable with European studies. Mortality was low. To this end, D2 gastrectomy is a safe surgical option for gastric cancer, and can be well implemented in clinical practice.

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