Textbook Outcome and Survival After Gastric Cancer Resection with Curative Intent: A Population-Based Analysis

Mariagiulia Dal Cero[1], Marta Román[2], Luis Grande[1], Concepción Yarnoz[3], Fernando Estremiana[4], Amaia Gantxegi[5], Clara Codony[6], Yanina Gobbini[7], Elisenda Garsot[8], Dulce Momblan[9], Marta González-Duaigües[10], Alexis Luna[11], Noelia Pérez[12], Aurora Aldeano[13], Sonia Fernández[14], Carles Olona[15], Judit Hermoso[16], Laura Pulido[17], Juan José Sanchez-Cano[18], Mercè Güell[19], David Salazar[20], Marta Gimeno[1], Manuel Pera[1], on behalf of the Spanish EURECCA Esophagogastric Cancer Group.

[1] Section of Gastrointestinal Surgery, Hospital Universitario del Mar, Hospital del Mar Medical Research Institute (IMIM). Department of Surgery, Universitat Autònoma de Barcelona, Barcelona, Spain.

[2] Department of Epidemiology and Evaluation, Hospital Universitario del Mar, Hospital del Mar Medical Research Institute (IMIM), Barcelona, Spain.

[3] Department of Surgery, Complejo Hospitalario de Navarra, Pamplona, Spain.

[4] Department of Surgery, Hospital Universitari de Bellvitge, L´Hospitalet de Llobregat, Barcelona, Spain.

[5] Department of Surgery, Hospital Vall d´Hebron, Barcelona, Spain.

[6] Department of Surgery, Hospital Universitari Josep Trueta, Girona, Spain.

[7] Department of Surgery, Hospital de Sant Joan Despí Moisès Broggi, Sant Joan Despí, Barcelona, Spain.

[8] Department of Surgery, Hospital Universitari Germans Trias i Pujol, Universitat Autònoma de Barcelona, Badalona, Barcelona, Spain.

[9] Department of Surgery, Hospital Clinic, Barcelona, Spain.

[10]Department of Surgery, Hospital Universitari Arnau de Vilanova, Lleida, Spain.

[11]Department of Surgery, Hospital Universitari Parc Taulí de Sabadell, Sabadell, Barcelona, Spain.

[12]Department of Surgery, Hospital Universitari Mútua Terrassa, Terrassa, Barcelona, Spain.

[13]Department of Surgery, Hospital General de Granollers, Granollers, Barcelona, Spain.

[14]Department of Surgery, Hospital Sant Pau, Barcelona, Spain.

[15]Department of Surgery, Hospital Universitari de Tarragona, Joan XXIII, Tarragona, Spain.

[16]Department of Surgery, Hospital Universitari de Vic, Vic, Barcelona, Spain.

[17]Department of Surgery, Hospital de Mataró, Consorci Sanitari del Maresme, Mataró, Barcelona, Spain.

[18]Department of Surgery, Hospital Universitari de Sant Joan, Reus, Tarragona, Spain.

[19]Department of Surgery, Althaia Xarxa Assistencial i Universitária de Manresa, Manresa, Spain.

[20]Department of Surgery, Hospital Universitari de Igualada, Igualada, Barcelona, Spain.

Corresponding author: Manuel Pera, Section of Gastrointestinal Surgery, Hospital Universitari del Mar, C/ Passeig Maritim 25-29, 08003, Barcelona, Spain. Tel.: +34 932802151, E-mail: pera@parcdesalutmar.cat

Conflicts of Interest: There are no conflicts of interest to be declared.

Source of Funding: No funding to declare

Category: Original article

Running head: Textbook outcome in gastric cancer surgery

ABSTRACT

Background: The concept of textbook outcome (TO) has been proposed for analyzing quality of surgical care. This study assessed the incidence of TO among patients undergoing curative gastric cancer resection, predictors for TO achievement, and the association of TO with survival.

Method: All patients with gastric and gastroesophageal junction cancers undergoing curative gastrectomy between January 2014-December 2017 were identified from a population-based database (Spanish EURECCA Registry). TO included: macroscopically complete resection at the time of operation, R0 resection, ≥15 lymph nodes removed and examined, no serious postoperative complications (Clavien-Dindo ≥II), no re-intervention, hospital stay ≤14 days, no 30-day readmissions and no 90-day mortality. Logistic regression was used to assess the adjusted achievement of TO. Cox survival regression was used to compare conditional adjusted survival across groups.

Results: In total, 1293 patients were included, and TO was achieved in 541 patients (41.1%). Among the criteria, “macroscopically complete resection” had the highest compliance (96.5%) while “no serious complications” had the lowest compliance (63.7%). Age (OR 0.53 for the 65-74 years and OR 0.34 for the ≥75 years age group), Charlson comorbidity index ≥3 (OR 0.53, 95%CI 0.34-0.82), neoadjuvant chemoradiotherapy (OR 0.24, 95%CI 0.08-0.70), multivisceral resection (OR 0.55, 95%CI 0.33-0.91), and surgery performed in a community hospital (OR 0.65, CI95% 0.46-0.91) were independently associated with not achieving TO. TO was independently associated with conditional survival (HR 0.67, 95%CI 0.55-0.83).

Conclusion: TO was achieved in 41.1% of patients who underwent gastric cancer resection with curative intent and was associated with longer survival.

Word count: 248

Keywords: Textbook outcome, gastric cancer, gastrectomy, quality indicators, survival analysis

INTRODUCTION

The European CanCer Organization (ECCO) promotes the establishment of high-quality cancer services and provides a comprehensive description of the essential requirements for high-quality cancer care [1]. Among several measures, the centralization of procedures and the use of multimodal treatments to improve outcomes of cancer patients have been proposed [1].

Esophageal and gastric cancer has not been immune to this policy. Several regions/countries in Europe have centralized surgical procedures, adopted common protocols and, more importantly, created registries, standardizing and auditing oncological results. In recent years, some national European registries such as the Danish Esophagus, Cardia and Stomach Neoplasm Database (DECV), the UK National Oesophago-Gastric Cancer Audit (NOGCA), the Swedish National Register for Esophageal and Gastric Cancer (NREV) and the Dutch Upper Gastrointestinal Cancer Audit (DUCA) have been developed [2-5]. Additionally, a consortium of cancer societies, including ECCO, has created a program to improve surgical quality, through the European EURECCA (EUropean REgistration of Cancer CAre) Registry, which originally focused on colon and rectal cancer but now it has also included other cancers, embedding esophagogastric cancer [6]. Its objective is to be a 'registered trademark' for quality assurance in cancer management in Europe. The Spanish EURECCA Esophagogastric Cancer Registry (SEEGCR) was launched in 2013 as a population-based registry aiming to improve outcomes by measuring quality of care, giving benchmarked feedback to surgeons and stimulating improvement initiatives [7].

The centralization process has usually been carried out analyzing only two variables, hospital volume and 30-day mortality, extracted in some cases from non-audited administrative databases [8,9]. A single variable, no matter how important it is, does not reflect the multidisciplinary aspect of surgical quality. For this reason, the “textbook outcome” (TO) concept has been recently developed as a tool to estimate “all-in” quality performance [10]. TO is a composite quality measure that has been used to define the achievement of multiple “ideal” or “optimal” surgical or postoperative outcomes. TO has been

used originally to assess the results of surgery in colon cancer [11] and then has been used in esophagogastric cancer surgery [12-19] and in other cancer and non-cancer surgeries [20-27].

Moreover, some studies in the field of esophagogastric cancer surgery have suggested a relationship between achieving TO and improved long-term survival [14-19]. However, only two of them are population-based cohort studies [14,16] and both have methodological limitations such as lack of standard definition of complications, evaluation restricted only within 30 postoperative days, mortality evaluated within 30 postoperative days or a limited audit of their data. Strict criteria in the definitions and the period in which complications are evaluated are a key factor in achieving TO and consequently may influence survival analysis.

The aims of this study, using a population-based registry, were to assess TO achievement among patients undergoing potentially curative resection of gastric cancer, to identify factors associated with its achievement and to assess the association between TO and survival.

PATIENTS AND METHODS

Data Source

For this multi-institutional population-based cohort study, data were retrieved from the SEEGCR linked to the EURECCA Upper GI network in Europe [7]. To date, the registry collects prospective clinical data from all patients with primary esophageal, gastro-esophageal junction and gastric cancer undergoing resection in 49 public hospitals from six regions covering nearly a population of 14 million people. Ninety-six variables are collected from each patient by the principal investigator at each institution The online data cover information in four different categories: *Patient characteristics*: patient data (6 items) and comorbidities (5 items); *Care process*: diagnosis and staging (11 items), preoperative optimization (4 items), neoadjuvant therapy (4 items); *Surgery and histopathology*: Surgery (17 items), histopathology (24 items); *Postoperative period*: hospital stay and complications (16 items), follow-up (9 items) [7]. Moreover, detailed definitions specifically for comorbidities, blood transfusion practices, postoperative complications, histopathology findings, and quality outcome measures are used since January 2014 to standardize data collection. In particular, postoperative complications are defined and recorded according to the Esophageal Complication Consensus Group (ECCG), the Gastrectomy Complications Consensus Group (GCCG), and graded with the Clavien-Dindo classification [28-30]. Validation of completeness and accuracy of the data registration (period 2014-2017) in the SEEGCR dataset from two of these regions has recently been performed by external data verification. The completeness and accuracy rates were 97% and 95%, respectively [7].

Study Population

All patients with primary gastric or gastro-esophageal junction (GEJ) cancer who underwent partial or total gastrectomy with curative intent were included. For the purpose of the present study, hospitals from two autonomous communities, Catalonia and Navarre, representing almost 8.5 million population were included. There were 18 participating hospitals from Catalonia and 1 from Navarre. These 19 hospitals had completed at least four years of recruitment (January 1, 2014 and December 31, 2017). The project was approved by the

local ethics committee of each participating center. The SEEGCR has a specific Patient Information Sheet and Informed Consent. Follow-up data were collected until December 2020.

Definitions

For this analysis, TO was defined based on a selection of 8 relevant outcome parameters representing the ideal patient outcome after surgery: a macroscopically complete resection according to the surgeon at the end of the operation, a microscopically radical resection (R0), a minimum of 15 lymph nodes removed and examined, no serious postoperative complications (serious complications were defined as Clavien-Dindo $\geq$ grade II), no surgical reinterventions within 30 days after surgery, hospital stay $\leq$ 14 days, no mortality within 90 days after surgery, and no unplanned readmissions within 30 days after discharge. TO was achieved when all 8 parameters were met in the same patient. Patients with missing data regarding any of the parameters included within the definition of TO were excluded. Clinical TNM stage was used as defined by the seventh TNM staging edition of cancer of the stomach [31].

To evaluate variation in hospital outcomes on TO, hospitals were classified in three categories (community, reference and high technology) based on both number of hospital beds and technological level according to the National Catalogue of Hospitals from the Spanish National Health System and the Spanish Network of Hospital Costs [32,33].

Statistical Analysis

Clinical and demographic characteristics and tumor and treatment variables were presented as frequencies and percentages, and they were compared among patients who did or did not have TO using the two-sided z-test for the comparison of proportions. Association between the achievement of TO and patient, tumor and treatment characteristics were compared using logistic regression to estimate the odds ratios (OR) with their 95% confidence intervals (95% CI).

Overall and conditional survival was compared using Kaplan-Meier survival plots and log rank test. Patients who died in the first 90 postoperative days were excluded for the analyses on conditional survival. Multivariable Cox regression was used to study the association between TO and conditional survival adjusted for confounders and presented as the adjusted hazard ratio (HR) with corresponding 95% CI. The proportional hazards assumption was verified, and potential confounders remained in the model when the assumption was met. All tests were two-sided with a 5% significance level. Statistical analyses were performed using SPSS Software (IBM SPSS Statistics 22 and R 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Study Cohort

The current study population includes 1295 patients entered in the SEEGCR between January 2014 and December 2017. Two patients were excluded because at least one of the 8 parameters to calculate TO was missing. Finally, a study cohort of 1293 patients was available for analysis. Patient, tumor and operative characteristics are shown in **Table 1**.

Textbook Outcome

Overall, TO was achieved in 531 of 1293 patients (41.1%). The rates of the eight TO outcome parameters and the cumulative percentages are displayed in **Figure 1.** The outcome parameter least frequently achieved was “no serious complications”, which occurred in 63.7% of patients, while the most frequently achieved was “macroscopically complete resection” (96.5%). The percentage of patients who achieved TO did increase from 40.7% in 2014 to 47.1% in 2017 ($p = 0.015$). This increase appeared to be driven by an increase in compliance of four variables of the TO (R0 resection, lymph node yield $\geq$15, hospital stay $\leq$14 days and no serious complications) being only statistically significant regarding the lymph node yield $\geq$15 ($p=0.012$) (**Figure 2)**

Hospitals were classified according to the number of beds and technological equipment into three categories: community centers (n=7; 304 patients); reference centers (n=7; 547 patients) and high technology centers (n= 5; 442 patients). A lower rate of TO was achieved in community hospitals compared to reference and high technology centers (19.9, 44.0 and 36.1%, respectively) ($p = 0.010$).

Factors Associated With TO

In the bivariate analysis, factors that reduce the likelihood of TO included age $\geq$75 years, weight loss >10%, ASA score III-IV, Charlson comorbidity index (CCI) $\geq$3, preoperative Hb <10 gr/dL, cancer of the gastric stump, Laurén’s intestinal type, cT stage 4b, no neoadjuvant therapy or receiving neoadjuvant chemoradiotherapy, surgery performed in a community hospital, open surgery,

urgent indication, and multivisceral resection (**Table 1**). On the other hand, factors associated with the achievement of TO in bivariate analysis were age <65 years, body mass index between 24-24.9 kg/m^2, weight loss <5%, ASA score I-II, CCI = 0, preoperative Hb ≥10 gr/dL, tumor located at antrum-pylorus, Laurén's mixed type, patients receiving neoadjuvant chemotherapy, surgery performed in 2017, minimally invasive surgery, elective surgery, and surgery without multivisceral resection (**Table 1**).

In multivariate analysis it was shown that age ≥65 years, CCI ≥3, neoadjuvant chemoradiotherapy, multivisceral resection and surgery performed in a community hospital were independent predictive factors for not achieving TO (**Table 2**).

Association between TO and survival

The median follow-up was 36.6 months (IQR 27.8) for patients with TO and 28.1 months (IQR 31.6) for patients without TO. Eighty patients died within the first 90 days after surgery. Overall survival in patients who achieved TO was significantly higher compared to those who did not [92.39 (95%CI: 90.14 - 94.68) vs 76.10% (95%CI: 73.13 - 79.19); 79.89 (95%CI: 76.48 - 83.45) vs 62.51% (95%CI: 59.14 - 66.08) and 72.79 (95%CI: 68.90 - 76.90) vs 53.48% (95%CI: 49.93 - 57.28) at 12, 24 and 36 months, respectively (p<0.001 in all comparisons; **Figure 3A**). As 90-day mortality is one of the variables evaluated in TO, a conditional survival analysis was carried out, excluding cases dying within 90 days. In this scenario, the significant differences were maintained between patients who achieved TO versus those who did not [92.39 (95%CI: 90.14 - 94.68) vs 84.65 (95%CI: 81.99 - 87.40); 79.89 (95%CI: 76.48 - 83.45) vs 69.54% (95%CI: 66.14 - 73.12 and 72.79 (95%CI: 68.90 - 76.90) vs 59.49% (95%CI: 55.78 - 63.45) at 12, 24 and 36 months, respectively (p<0.001, **Figure 3B**).

After adjusting for confounding factors, patients with TO had better conditional survival than patients without TO (**Table 3**). Factors also associated with a decreased risk of mortality included non-diffuse Laurén subtype and minimally invasive surgery. Factors associated with an increased risk of

mortality included age ≥75, weigh loss ≥ 5%, ASA score III-IV, CCI ≥ 3, total gastrectomy, urgent surgical indication, cT stages 3, 4a and 4b, positive cN stage and surgery performed in a community hospital.

The influence of each TO variable on conditional survival is shown in **Table 4**. As in previous studies, the parameter “no 90-day mortality” was not included in the multivariable Cox proportional hazard model. Failure to obtain R0 resection and the presence of serious complications were independently associated with worse conditional survival.

DISCUSSION

In this population-based cohort study, TO has significantly improved over the study period from 40.7% in 2014 to 47.1% in 2017 in patients undergoing gastric cancer resection with curative intent. Of the eight outcome parameters included in TO, the “no serious complications” was the least achieved (63.7%) whereas the most accomplished was the “macroscopically complete resection” (96.5%). Independent factors associated with not achieving TO were age ≥65 years, CCI ≥3, neoadjuvant chemoradiotherapy, multivisceral resection and surgery performed in a community hospital. Overall and conditional survival in patients who achieved TO was significantly longer compared to those who did not.

Traditional assessment of quality for complex surgery has relied mainly on the analysis of individual healthcare outcome parameters such as mortality, morbidity, readmission or length of hospital stay. With the increasing need for more reliable quality indicators related to surgical care, composite quality measures have been proposed as more effective than the use of individual measures to assess hospital performance [34-36]. In this context, TO has been proposed as a quality measure that provides a comprehensive summary of patient course and hospital performance [10]. However, there is no consensus about the items that should be included in the construct and the teams have adapted them according to the type of intervention, their interests and possibilities. In our study we have introduced a modification of the original TO definition proposed by Busweiler et al [12] in an attempt to be more demanding with the requirements of some outcome variables. We have reduced the limit of the length of hospital stay from 21 to 14 days to consider that the patient meets TO criteria, and we have evaluated mortality at 90 days instead of 30 days.

Even in this stricter scenario, the overall degree of achieving TO in our study was 41.1%, higher than the proportion of 32.1% and 35% reported in two consecutive studies from the DUCA [12,16]. The least achieved outcome parameter in our study was “no serious complications”, while this quality measure was better achieved in the DUCA (63.7% vs 88.3%). Possible explanations could be the high rate of Clavien-Dindo II complications (48%) and

a high postoperative transfusion rate (16%) detected in our study. Both conditions were considered “serious complications” according to the predefined definition for TO to allow a better comparison with previous data [12,19]. However, other studies, considered “serious complication” when Clavien-Dindo grade was ≥III. Among patients included in the DUCA registry, the quality measure least achieved was “at least 15 lymph nodes in the resected specimen” (57.1% of cases) while this outcome had 80.4% of compliance in the SEEGCR. Probably, this higher lymph node yield could be related to the consensus reached by the pathologists of the SEEGCR during the study period in two workshops especially devoted to the standardization of the histopathological evaluation.

The percentage of patients who achieved TO did significantly increase from 40.7% in 2014 to 47.1% in 2017. This increase appeared to be driven by an increase in compliance regarding four parameters of TO (R0 resection, lymph node yield ≥ 15, hospital stay ≤ 14 days, and no serious complications). Although speculative, this increase in TO achievement could, in part, be explained by two factors: the implementation of a patient blood management (PBM) program and the previously mentioned consensus among pathologists. In a recent multicenter quality improvement project assessing the implementation of a PBM program (2016-2017) among SEEGCR hospitals we observed a significant reduction in the transfusion rate and improvement in postoperative outcomes as compared with previous years [37].

In our study, a multivariate analysis was carried out to define clinical, demographic, tumor and treatment characteristics associated with not achieving TO. Some variables identified in our study, such as ASA, CCI, tumor location, cT stage, neoadjuvant chemoradiotherapy or multivisceral resection have previously been described [12]. It is noteworthy that an independent factor in our study has been the level of hospital complexity, a category based on a combination of case load and available technology. In this setting, patients undergoing gastrectomy at community hospitals had lower percentages of TO achievement in comparison to reference and high technology hospitals. The influence of hospital volume on TO was analyzed in two studies from the Netherlands and Canada [13,16]. In the DUCA database, TO was achieved in

23% of patients who underwent surgery in hospitals performing 0 to 19 gastrectomies per year, 29% in hospitals performing 20 to 39 gastrectomies per year, and 27% in hospitals performing >40 gastrectomies per year. However, the association between TO achievement and hospital volume was not confirmed in a recent population-based study from the PRESTO database in Ontario [13]. No formal regionalization of gastric cancer surgery in Ontario as compared to the Netherlands and the two Spanish regions included in our study may explain this difference.

A remarkable result of our study was the association of TO with patient survival after gastrectomy for cancer. Since 90-day mortality was one of the outcome parameters included in TO, additionally to the actuarial overall survival, a conditional survival removing patients who died within 90 days was calculated. In both scenarios, patients who achieved TO had a significantly longer survival than those who did not achieve TO. A multivariable Cox regression model adjusted for confounders demonstrated a 33% decreased risk of mortality when TO was achieved. Our results are in line with findings of four previous studies [14,16,17,19]. However, two of them are single center [17,19] and two are population-based cohort studies [14,16] with methodological limitations such as lack of standard definition of complications, their evaluation restricted only within 30 postoperative days, mortality evaluated within 30 postoperative days or a limited audit of their data. The use of strict criteria in the definitions and the period in which complications are evaluated are key factors in achieving TO and consequently may have an influence on survival.

Taken together the variation in TO achievement between hospitals and the association of this quality measure with survival may underline the importance of implementing TO in national audits for hospitals performing gastric cancer surgery.

There are several limitations to our study. First, TO is a composite measure calculated from retrospective data collected prospectively in the SEEGCR, which implies the possibility of some inaccuracies. Second, the criteria that we chose to calculate TO are different from the ones used in the previous studies. However, the strength is that our registry has recently been

audited confirming high completeness and accuracy rates that contain granular information about postoperative complications and outcome measures using strictly defined criteria [7].

In summary, TO could be achieved in up to 47.1% of patients who underwent resection of gastric cancer with curative intent and was associated with longer overall and conditional survival. TO may be useful to assess and monitor hospital variations in overall quality of care.

Acknowledgements: The authors thank Professor Jan van Lanschot (Erasmus Medical Center, Rotterdam, The Netherlands) for his valuable comments and Marta Pulido, MD, for editorial assistance.

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Table 1. Baseline characteristics of patients with and without TO after potentially curative gastric cancer resection

			TEXTBOOK OUTCOME				
		n	No (n=762, 58.9%)		Yes (n=531, 41.1%)		*P* Value
			n	%	n	%	
Clinical and demographic variables							
Sex	Male	789	478	62.7	311	58.6	
	Female	504	284	37.3	220	41.4	
Age, years	0-64	378	168	22.0	210	39.5	<0.001
	65-74	396	235	30.8	161	30.3	
	≥ 75	519	359	47.1	160	30.1	<0.001
BMI, kg/m^2	< 18.4	34	23	3.0	11	2.1	
	18.5-23.9	523	312	40.9	211	39.7	
	24-29.9	497	276	36.3	221	41.6	<0.05
	≥ 30	221	139	18.2	82	15.4	
	Unknown	18	12	1.6	6	1.2	
Weight loss#, %	0 – 4.9	751	422	55.4	329	62.0	0.018
	5 – 9.9	302	182	23.9	120	22.6	
	≥ 10	183	120	15.7	83	11.9	0.049
	Unknown	57	38	5.0	19	3.6	
ASA score	I-II	664	350	45.9	314	59.1	<0.001
	III-IV	629	412	54.1	217	40.9	<0.001
CCI score	0	651	347	45.5	304	57.3	<0.001
	1 - 2	474	288	37.8	186	35.0	
	≥ 3	168	127	16.7	41	7.7	<0.001
Preoperative Hb, gr/dL	< 10	199	138	18.1	61	11.5	0.001
	≥ 10	1094	624	81.9	470	88.5	0.001
Tumor variables							
Location	Antrum – pylorus	672	372	48.8	300	56.5	0.008
	Corpus	445	269	35.3	176	33.1	
	Fundus	46	30	3.9	16	3.0	
	Linitis	17	11	1.4	6	1.1	
	Stump	25	21	2.8	4	0.8	0.01
	GEJ	88	59	7.7	29	5.5	
Laurén subtype	Diffuse	396	227	29.8	169	31.8	
	Intestinal	693	432	56.7	261	49.2	0.007
	Mixed	161	80	10.5	81	15.3	0.011
	Not applicable	20	10	1.3	10	1.9	
	Unknown	23	13	1.7	10	1.9	
cT stage*	1	215	118	15.5	97	18.3	
	2	322	188	24.7	134	25.2	
	3	434	250	32.8	184	34.7	
	4a	216	132	17.3	84	15.8	
	4b	39	29	3.8	10	1.9	0.047
	Unknown	67	45	5.9	22	4.1	
cN stage*	Negative	712	414	54.3	298	56.1	
	Positive	554	326	42.8	228	42.9	
	Unknown	27	22	2.9	5	0.9	
cM stage*	0	1262	741	97.2	521	98.1	
	1	13	8	1.0	5	0.9	
	Unknown	18	13	1.7	5	0.9	

(cont)

Table 1 (continuation). Baseline characteristics of patients with and without TO after potentially curative gastric cancer resection

			TEXTBOOK OUTCOME				
		n	No (n=762, 58.9%)		Yes (n=531, 41.1%)		*P* Value
			n	%	n	%	
Treatment variables							
Neoadjuvant therapy	Chemotherapy	316	165	21.7	151	28.4	0.005
	No	952	577	75.7	375	70.6	0.041
	Chemoradiotherapy	25	20	2.6	5	0.9	0.030
Hospital complexity	Community	305	199	26.1	106	20.0	0.010
	Reference	546	313	41.1	233	43.9	
	High technology	442	250	32.8	192	36.1	
Year of operation	2014	337	200	26.3	137	25.8	
	2015	345	206	27.1	139	26.1	
	2016	314	198	26.0	116	21.8	
	2017	297	157	20.6	140	26.3	0.015
Surgical approach	Open	830	520	68.2	310	58.4	<0.001
	Minimally invasive	463	242	31.8	221	41.6	<0.001
Type of gastrectomy	Subtotal	738	421	55.2	317	59.7	
	Total	555	341	44.8	214	40.3	
Timing of surgery	Elective	1263	737	96.7	526	99.1	0.006
	Urgent	30	25	3.3	5	0.9	0.006
Multivisceral resection	No	1180	677	88.8	503	94.7	<0.001
	Yes	113	85	11.2	28	5.3	<0.001

Abbreviations: BMI, Body mass index; ASA, American Society of Anesthesiologists; GEJ, Gastroesophageal junction; CCI, Charlson comorbidity index; #at the time of diagnosis; *Seventh edition, American Joint Commission on Cancer. Different at $p < 0.05$ in a two-sided test of equality for column proportions (z-test). Tests are adjusted using the Bonferroni correction for multiple comparison.

Table 2. Logistic regression analysis of factors associated with the Textbook Outcomes after gastric cancer surgery with curative intent

		OR	95% CI for EXP(B)		*P* Value
			Lower	Upper	
Sex	Female vs. Male	1.16	0.90	1.50	
Age, years	0-64	Ref.			
	65-74	0.53	0.39	0.73	<0.001
	≥75	0.34	0.24	0.48	<0.001
BMI, kg/m^2	< 18.4	Ref.			
	18.5-23.9	1.71	0.75	3.86	
	24-29.9	2.28	1,00	5.20	
	≥30	1.71	0.73	4.00	
Weight loss#, %	0-4.9%	Ref.			
	5-9.9%	0.99	0.74	1.34	
	≥10%	0.80	0.55	1.17	
ASA score	III-IV vs. I-II	0.81	0.62	1.06	
CCI score	0	Ref.			
	1-2	0.98	0.74	1.29	
	≥3	0.53	0.34	0.82	0.005
Preoperative Hb, mg/dL	≥10 vs. <10	1.34	0.93	1.91	
Location	Antrum-pylorus	Ref.			
	Corpus	0.76	0.55	1.04	
	Fundus	0.80	0.39	1.63	
	Linitis	0.77	0.25	2.34	
	Gastric stump	0.48	0.15	1.52	
	GEJ	0.72	0.40	1.30	
Laurén subtype	Diffuse	Ref.			
	Intestinal	1.13	0.84	1.52	
	Mixed	1.77	1.18	2.66	
cT stage	1	Ref.			
	2	0.83	0.56	1.21	
	3	0.95	0.63	1.43	
	4a	0.93	0.56	1.52	
	4b	0.64	0.26	1.62	
cN stage	+ vs. -	1.05	0.77	1.43	
cM stage	+ vs. -	0.94	0.27	3.21	
Neoadjuvant therapy	Chemotherapy	Ref.			
	No	0.88	0.63	1.25	
	Chemoradiotherapy	0.24	0.08	0.70	0.009
Hospital complexity	High technology	Ref.			
	Reference	0.90	0.68	1.20	
	Community	0.65	0.46	0.91	0.012
Year	2014	Ref.			
	2015	1.11	0.80	1.55	
	2016	0.88	0.62	1.24	
	2017	1.28	0.91	1.81	
Surgical approach	Open vs. MI	0.83	0.64	1.08	
Type of gastrectomy	Total vs. subtotal	0.82	0.59	1.15	
Timing of surgery	Urgent vs. elective	0.43	0.15	1.22	
Multivisceral resection	yes vs. no	0.55	0.33	0.91	0.021

Abbreviations: BMI, Body mass index; Ref, reference; ASA, American Society of Anesthesiologists; CCI, Charlson comorbidity index; MI, minimally invasive; GEJ, gastroesophageal junction. at the time of diagnosis.

Table 3. Association between Textbook Outcome and conditional survival

		HR	95% CI for HR		*P* Value
			Lower	Upper	
Textbook Outcome	Yes vs. no	0.67	0.55	0.83	<0.001
Sex	Male vs female	0.88	0.71	1.08	
Age, years	0-64	Ref.			
	65-74	1.17	0.89	1.55	
	≥75	1.94	1.45	2.59	<0.001
BMI, kg/m^2	< 18.4	Ref.			
	18.5-23.9	0.80	0.45	1.42	
	24-29.9	0.84	0.47	1.50	
	≥30	0.64	0.35	1.19	
Weight loss[#], %	0-4.9%	Ref.			
	5-9.9%	1.46	1.15	1.84	0.002
	≥10%	1.93	1.48	2.54	<0.001
ASA score	I-II vs. III-IV	1.34	1.08	1.65	0.008
CCI score	0	Ref.			
	1-2	1.14	0.91	1.43	
	≥3	1.42	1.03	1.96	0.030
Preoperative Hb, mg/dL	<10 vs. ≥10	1.08	0.83	1.42	
Location	Antrum-pylorus	Ref.			
	Corpus	0.78	0.60	1.00	
	Fundus	0.61	0.32	1.17	
	Linitis	1.19	0.63	2.25	
	Gastric stump	1.52	0.84	2.74	
	GEJ	0.83	0.54	1.29	
Laurén subtype	Diffuse	Ref.			
	Intestinal	0.58	0.46	0.72	<0.001
	Mixed	0.71	0.52	0.99	0.038
cT stage	1	Ref.			
	2	1.15	0.79	1.68	
	3	1.88	1.29	2.74	0.001
	4a	1.90	1.24	2.92	0.003
	4b	2.04	1.08	3.85	0.027
cN stage	- vs. +	1.29	1.01	1.63	0.040
cM stage	- vs. +	1.50	0.75	3.00	
Neoadjuvant therapy	Chemotherapy	Ref.			
	No	0.99	0.76	1.31	
	Chemoradiotherapy	1.00	0.50	1.99	
Hospital complexity	High technology	Ref.			
	Reference	1.00	0.80	1.27	
	Community	1.35	1.03	1.77	0.031
Year	2014	Ref.			
	2015	0.90	0.70	1.16	
	2016	1.06	0.81	1.38	
	2017	0.84	0.62	1.15	
Surgical approach	MI vs. open	0.71	0.57	0.88	0.001
Type of gastrectomy	Total vs. subtotal	1.53	1.18	2.00	0.004
Timing of surgery	Elective vs. Urgent	2.23	1.29	3.86	0.001
Multivisceral resection	No vs. yes	1.34	0.96	1.89	

Abbreviations: BMI, Body mass index; Ref, reference; ASA, American Society of Anaesthesiologists; CCI, Charlson comorbidity index; MI, minimally invasive; GEJ, gastroesophageal junction. [#]at the time of diagnosis.

Table 4. Impact of each outcome TO parameter on conditional survival

		HR	95% CI for HR	
			Lower	Upper
Complete resection	Yes vs. no	0.82	0.54	1.25
R0 resection	Yes vs. no	0.29	0.22	0.38
Lymph node yield ≥ 15	Yes vs. no	0.85	0.68	1.07
Hospital stay ≤ 14 days	Yes vs. no	0.83	0.64	1.09
No serious complications	Yes vs. no	0.69	0.54	0.88
No 30-day reintervention	Yes vs. no	1.15	0.81	1.65
No 30-day readmission	Yes vs. no	1.07	0.75	1.53

LEGENDS

Figure 1. Cumulative “Textbook outcome” (TO) and per variable rate for patients undergoing gastric cancer resection with curative intent. Bars represent the percentage meeting each criterion; solid line represent the cumulative percentage of patients achieving TO.

Figure 2. Percentages of each quality metric of the “Textbook Outcome” composite over the course of the study period (* p=0.0012)

Figure 3. Overall (A) and conditional (B) survival of patients who underwent curative surgery for gastric cancer and whether or not achieved a “Textbook Outcome (TO)”. [(A) p<0.001; (B) p<0.001; (log rank test)]

Figure 1

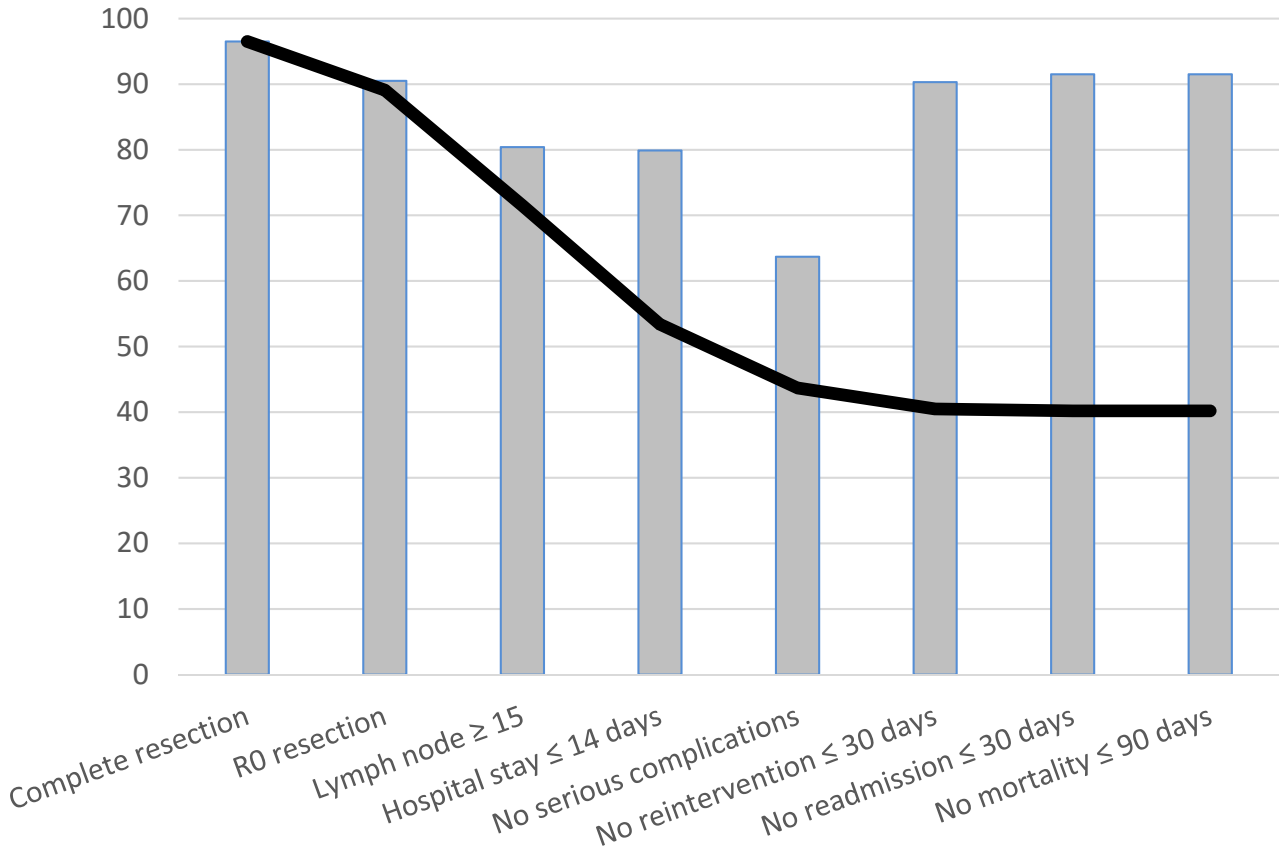

100
90
80
70
60
50
40
30
20
10
0
Complete resection
R0 resection
Lymph node ≥ 15
Hospital stay ≤ 14 days
No serious complications
No reintervention ≤ 30 days
No readmission ≤ 30 days
No mortality ≤ 90 days

Figure 2

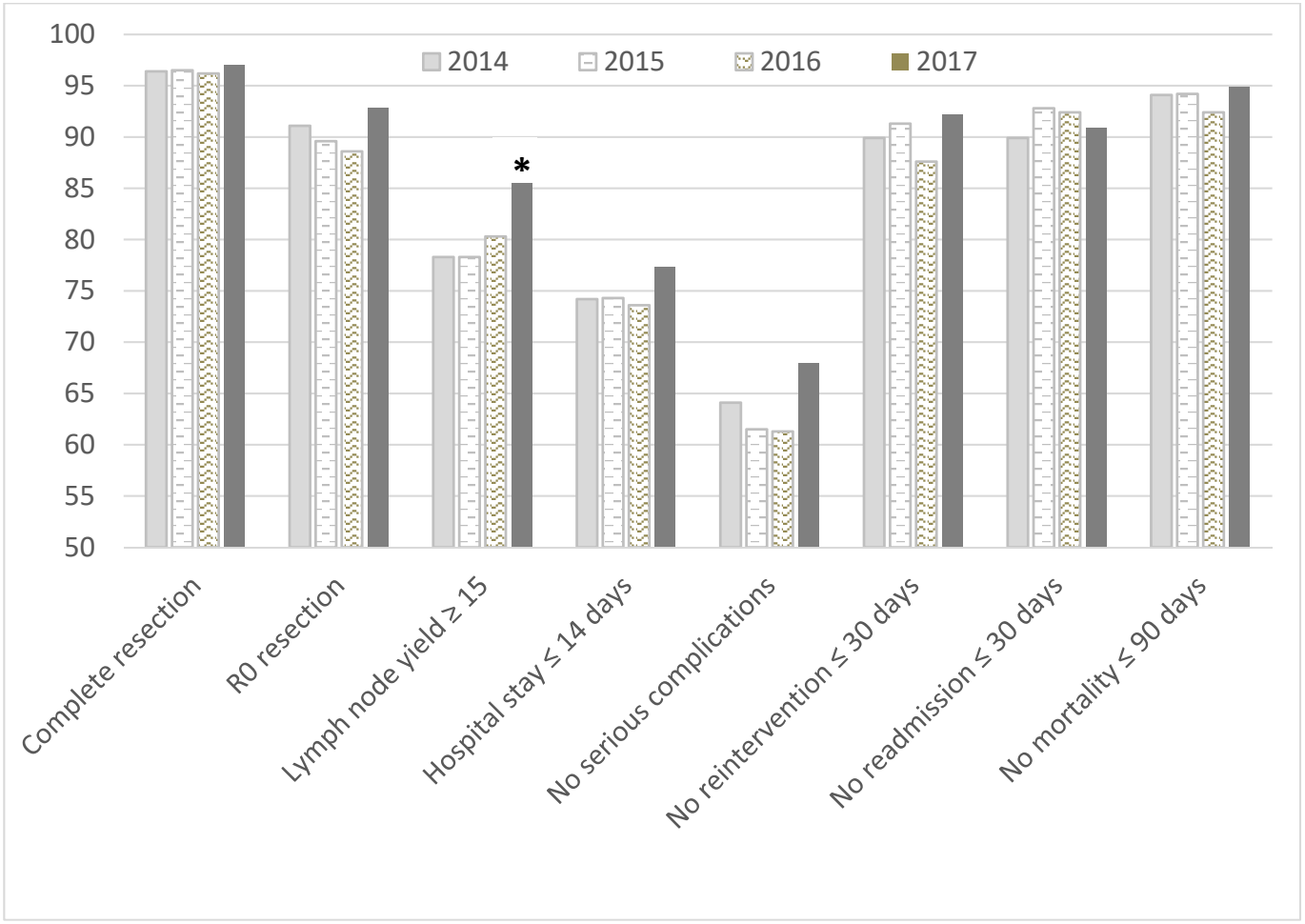
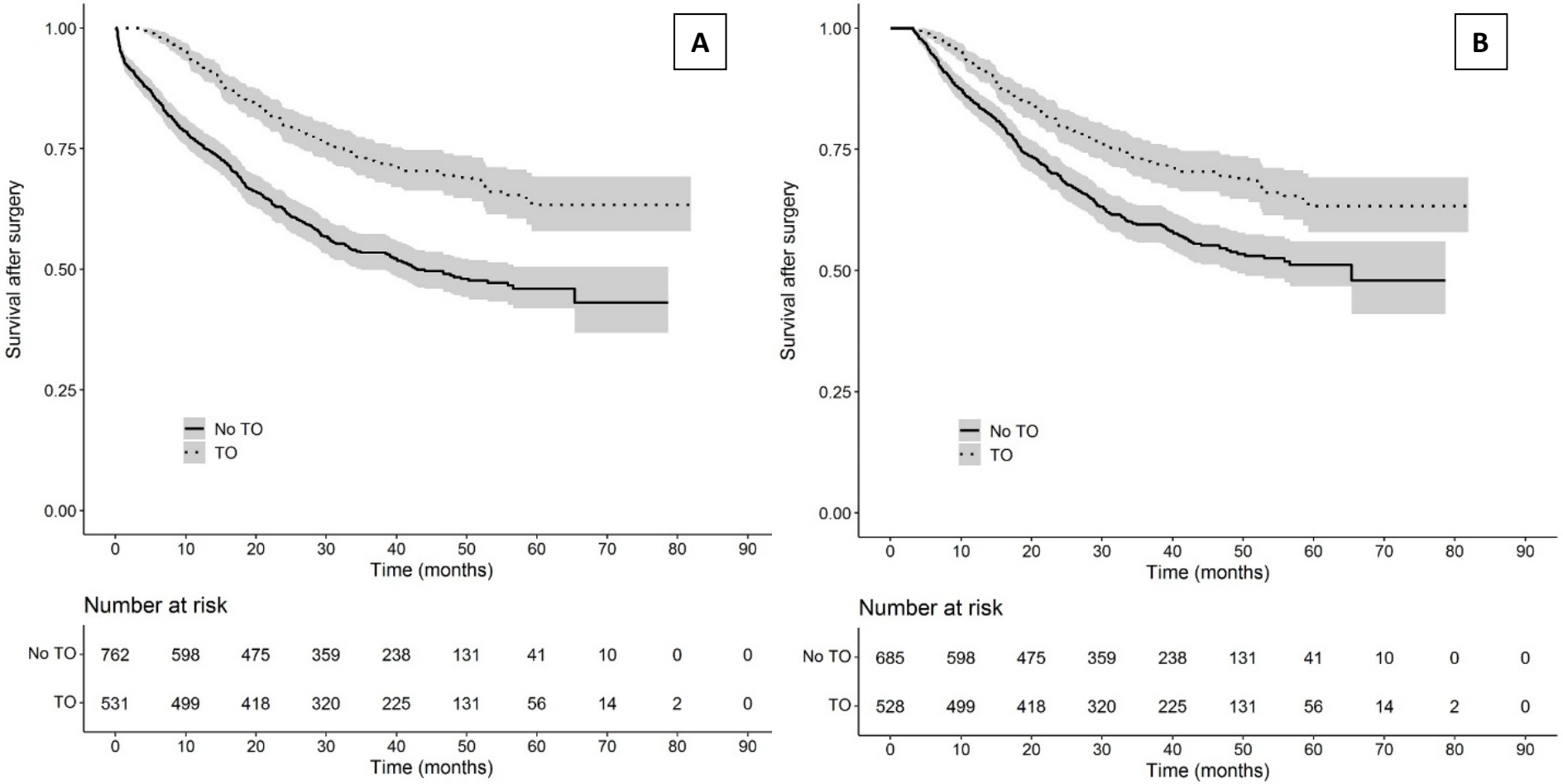

100
95
90
85
80
75
70
65
60
55
50
2014
2015
2016
2017
*
Complete resection
R0 resection
Lymph node yield ≥ 15
Hospital stay ≤ 14 days
No serious complications
No reintervention ≤ 30 days
No readmission ≤ 30 days
No mortality ≤ 90 days

Figure 3


A
B
Survival after surgery
1.00
0.75
0.50
0.25
0.00
No TO
TO
Time (months)
0
10
20
30
40
50
60
70
80
90
Number at risk
No TO
762
598
475
359
238
131
41
10
0
0
TO
531
499
418
320
225
131
56
14
2
0
No TO
685
598
475
359
238
131
41
10
0
0
TO
528
499
418
320
225
131
56
14
2
0