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ORIGINAL ARTICLE

Retrospective Study

Background factors influencing postgastrectomy syndromes after various types of gastrectomy

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Abstract

BACKGROUND

Postgastrectomy syndromes (PGS) after curative gastrectomy for gastric cancer are influenced by not only gastrectomy type but also by background factors. Recently, a nationwide PGS study was performed using the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45) questionnaire.

AIM

To determine the influence of each background factor on PGS for each gastrectomy type using PGS assessment study (PGSAS) data as an additional analysis.

METHODS

The data of 2368 patients were obtained from the PGSAS. This included patients undergoing distal gastrectomy (DG) with Billroth I reconstruction, DG with Roux-en-Y reconstruction, total gastrectomy with Roux-en-Y, proximal gastrectomy, pylorus-preserving gastrectomy (PPG), and local resection. Multiple regression analysis was performed to explore the independent effects of each background factor on the main outcome measures (MOMs) of PGSAS-45 for each gastrectomy type. The background factors included postoperative period, age, sex, surgical approach (laparoscopic or open), and the status of the celiac branch of the vagal nerve.

RESULTS

The MOMs of DG and PPG were highly affected by background factors, whereas those of total gastrectomy with Roux-en-Y, proximal gastrectomy, and local resection were not. Worse PGS were found in females, whereas a longer postoperative period alleviated some of the MOMs. For DG and PPG, a laparoscopic approach and preservation of the celiac branch improved several MOMs.

CONCLUSION

Various background factors affected PGS, and their influence varied with the type of gastrectomy performed. Laparoscopic surgery and celiac branch preservation can improve PGS in patients undergoing DG and PPG.

Key words: Postgastrectomy syndrome; Gastrectomy; Gastric cancer; Postgastrectomy Syndrome Assessment Scale-45

Core tip: We determined the influence of each background factor on postgastrectomy syndromes (PGS) for each gastrectomy type in 2368 patients from the PGS assessment study (PGSAS) dataset. The postoperative period, age, and sex affected PGS, and their influence varied with gastrectomy type. PGS after distal gastrectomy and pylorus preserving gastrectomy were highly affected, whereas that after total gastrectomy, proximal gastrectomy, and local resection was not. Worse PGS were observed in females, whereas a longer postoperative period alleviated some of the PGS. Laparoscopic surgery and celiac branch preservation can improve PGS in patients undergoing distal gastrectomy and pylorus preserving gastrectomy.

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INTRODUCTION

Postgastrectomy syndromes (PGS) are serious drawbacks after curative gastrectomy for gastric cancer[1-3]. PGS include various functional disorders, disturbances of living status, and deterioration of quality of life (QoL)[4]. The main causes of PGS are gastrectomy and lymph node dissection. Nevertheless, a variety of other background factors are thought to be involved. For example, dumping syndrome was thought to be related to sex, age, dietary habits, diet content, and the postoperative period in addition to the type of gastrectomy[5,6].

The contribution of these background factors to the occurrence of PGS has not been fully investigated. Recently, the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45), which is a questionnaire that measures PGS psychometrically, has been developed, and nearly 2400 questionnaires have been collected during the PGS assessment study (PGSAS), thus providing basic data to scientifically verify PGS[4]. In addition to the questionnaire items, the PGSAS also collected background data, such as details regarding the surgical procedures, age, sex, and postoperative period. Using data from the PGSAS, determining the effects of these background factors on PGS could be useful.

In this study, we determined the influence of each

Table 1 Relationship of the domains and main outcome measures of the Postgastrectomy Syndrome Assessment Scale

Domain	Main outcome measures
Symptom	Esophageal reflux subscale
	Abdominal pain subscale
	Meal-related distress subscale
	Indigestion subscale
	Diarrhea subscale
	Constipation subscale
	Dumping subscale
	Total symptom score
Living status	Change in body weight
	Ingested amount of food per meal
	Necessity for additional meals
	Quality of ingestion subscale
	Ability for working
Quality of life	Dissatisfaction with symptom
	Dissatisfaction at the meal
	Dissatisfaction at working
	Dissatisfaction for daily life subscale
	Physical component summary of SF-8
	Mental component summary of SF-8

background factor on the main outcome measures (MOMs) of PGSAS-45 by performing a multivariate analysis of data from the PGSAS. However, as the degree of invasiveness is different for each type of gastrectomy, the extent of the influence on each background factor on MOMs is likely to be different depending on the type of gastrectomy. Therefore, we examined the influences of each background factor on MOMs according to the type of gastrectomy.

MATERIALS AND METHODS

We used the dataset obtained from the PGSAS for this additional analysis. This was approved by all members of the Incentive and Data Analysis Committee of the PGSAS.

The details of the PGSAS have been previously described in detail[4,7]. The PGSAS was a nationwide, large-scale, retrospective observational study that investigated the symptoms, living status, and QoL of patients who underwent gastrectomy and completed the PGSAS-45 questionnaire. The questionnaire consists of 45 items, including items from SF-8 (the 8-item short-form generic health-related QoL questionnaire) and the Gastrointestinal Symptom Rating Scale. The items included in the PGSAS-45 are classified into three domains: the symptom domain, the living status domain, and the QoL domain. Each domain consists of several MOMs.

Patient eligibility criteria for the PGSAS study were as follows: pathological stage IA or IB gastric cancer (except local resection), first-time gastrectomy, age between 20 and 75 years, and an interval of 1 yr or more since gastrectomy. The background factors for this study, along with other perioperative data, were reported through case report forms by the surgeon in charge of the data center. The data for all 2368 eligible patients were used in this study. All patients underwent one of the following six types of gastrectomy: distal partial gastrectomy with Billroth I reconstruction (DGBI), distal partial gastrectomy with Roux-en-Y reconstruction (DGRY), total gastrectomy with Roux-en-Y reconstruction (TGRY), proximal gastrectomy (PG), pylorus-preserving gastrectomy (PPG), and local resection of the stomach (LR).

The PGSAS was approved by the local ethics committees of each participating institution and registered with the University Hospital Medical Information Network's Clinical Trials Registry as trial number 00000 2116.

A multiple regression analysis was performed to explore the influence of independent background factors on MOMs of the PGSAS-45 for each gastrectomy procedure. The details of the MOMs of the PGSAS-45 are shown in Table 1. The background factors consisted of the postoperative period (mo), age, sex, surgical approach (laparoscopic surgery or conventional open surgery), and the status of the celiac branch of the vagal nerve (preserved or sacrificed). Among these, the first eight MOMs from "esophageal reflux subscale" to "total symptom score" were classified as the symptom domain, the five MOMs from "change in body weight" to "ability for working" were classified as the living status domain, and six MOMs from "dissatisfaction with symptoms" to "MCS of SF-8" were classified as the QoL domain (Table 1). Statistical analyses were performed using the StatView software for Windows version 5.0 (SAS Institute, Cary, NC, United States). P values < 0.05 were considered significant. To evaluate effect sizes, β and R^2 were used. Effect sizes were considered small for $\beta \geqslant 0.1$, medium for $\beta \geqslant 0.3$, and large for $\beta \geqslant 0.5$. Corresponding values of R^2 were as follows: small $\geqslant 0.02$; medium $\geqslant 0.13$; and large $\geqslant 0.26$.

RESULTS

The number of patients who underwent each type of gastrectomy procedure and the corresponding background factors are shown in Table 2.

The results of the multiple regression analysis of the background factors and the PGSAS MOMs are shown in Tables 3-8. The tables show the data of the standard regression coefficient (β), calculated probability (P value), and coefficient of determination (R^2). Regarding β, data with $P < 0.1$ were omitted. All patients in the LR group had their vagal nerve preserved; therefore, this variable was excluded from the multiple regression analyses for LR (Table 8).

Table 4 shows the data regarding patients who underwent DGBI. For example, sex was an independent background factor that affected the intensity of the physical component summary of SF-8 with a small but clinically meaningful effect size. The physical component summary scores indicate higher scores (*i.e.* better conditions), and the β value was negative (-0.123). In

Table 2 Background factors for each surgical procedure

	TGRY	DGBI	DGRY	PG	PPG	LR
Number of patients	393	909	475	193	313	85
Postoperative period, mo	35.0 ± 24.6	40.7 ± 30.7	31.7 ± 18.0	40.5 ± 28.1	38.4 ± 27.7	42.9 ± 34.2
Age, yr	63.4 ± 9.2	61.6 ± 9.1	62.0 ± 9.1	63.7 ± 7.7	61.5 ± 8.7	60.8 ± 9.8
Sex: Male/female	276/113	594/311	318/154	139/53	183/126	48/37
Approach laparoscope/open	97/293	415/489	152/320	33/159	136/173	52/33
Celiac branch: Saving/cut	12/371	133/754	28/442	83/105	213/96	84/0

Values are presented as mean ± SD. TGRY: Total gastrectomy with Roux-en-Y reconstruction; DGBI: Distal gastrectomy with Billroth I reconstruction; DGRY: Distal gastrectomy with Roux-en-Y reconstruction; PG: Proximal gastrectomy; PPG: Pylorus preserving gastrectomy; LR: Local resection of the stomach.

Table 3 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for total gastrectomy with Roux-en-Y reconstruction

	Postop period		Age		Sex [female]		Approach [laparo]		Celiac branch [saved]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	β	*P*	R^{2}[2]	*P*
Esophageal reflux SS											0.015	> 0.10
Abdominal pain SS					0.129	0.0141					0.02	> 0.10
Meal-related distress SS							0.094	0.0849			0.014	> 0.10
Indigestion SS							0.093	0.0813			0.049[3]	0.0021[3]
Diarrhea SS	-0.089	0.0978			-0.143	0.0057					0.028	0.0588
Constipation SS			0.145	0.0056							0.023	> 0.10
Dumping SS			-0.163[3]	0.0026[3]							0.045[3]	0.0079[3]
Total symptom score											0.015	> 0.10
Change in BW					-0.095	0.0751					0.018	> 0.10
Ingestion amount of food			-0.111	0.0361							0.017	> 0.10
Need of additional food			0.126[3]	0.0159[3]			0.092	0.0928			0.030[3]	0.0451[3]
Quality of ingestion SS			-0.134[3]	0.0106[3]	-0.102	0.0516					0.032[3]	0.036[3]
Ability for working			0.133[3]	0.0120	0.118[3]	0.025[3]			0.131[3]	0.0124[3]	0.048[3]	0.0040[3]
Dissatisfaction: symptom							0.099	0.0677			0.034[3]	0.0265[3]
Dissatisfaction: meal							0.116	0.0327			0.026	0.0813
Dissatisfaction: working											0.016	> 0.10
Dissatisfaction SS							0.106	0.0508			0.030[3]	0.0476[3]
PCS of SF-8			-0.174	0.0007[3]					-0.145[3]	0.0045[3]	0.059[3]	0.0004[3]
MCS of SF-8									-0.125	0.016	0.02	> 0.10

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination; [3]Significantly independent factors with a small effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

addition, the physical component summary scores for women were significantly worse than those of men. Similarly, age and the preservation of the celiac branch of the vagal nerve were independent factors with a small effect size affecting the diarrhea subscale of the PGSAS. The diarrhea subscale had higher scores (*i.e.*, worse conditions). The diarrhea subscale scores for older patients were superior to those of younger patients, and those who had vagal preservation had scores that were superior to those of patients without vagal preservation. These two background factors were statistically independent.

All of these data are summarized in Table 9. The numbers in each column are the aggregate number of MOMs with an independent, significant effect based on each background factor. For ease of understanding, addition of the MOMs was carried out separately for the two groups, the symptom domain group and the living status or QoL domain group. The MOMs with a positive effect were counted as +1, and the MOMs with a negative effect were counted as -1.

Regarding the postoperative period, several MOMs were alleviated because of the length of the postoperative period. These MOMs were mainly within the living status or the QoL domains. Regarding the gastrectomy procedure, many MOMs improved with the passage of time after DGRY; in contrast, no MOM improved with the passage of time after TGRY or PG.

Age and sex also affected several MOMs of the PGSAS. For older patients, several MOMs belonging to the symptom domain were alleviated; in contrast, several MOMs belonging to the living status or QoL domains had worsened. There were numerous MOMs that were worse for women after DGBI and DGRY, but

Table 4 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for the cases of distal gastrectomy with Billroth I reconstruction

	Postop period		Age		Sex [female]		Approach [laparo]		Celiac branch [saved]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	β	*P*	R^2[2]	*P*
Esophageal reflux SS			0.064	0.0633							0.015	0.0224
Abdominal pain SS					0.121[3]	0.0004[3]	-0.086	0.0175			0.028[3]	0.0002[3]
Meal-related distress SS					0.122[3]	0.0003[3]			-0.087	0.0111	0.034[3]	< 0.0001[3]
Indigestion SS					0.067	0.0519			-0.096	0.0057	0.014	0.0305
Diarrhea SS			-0.155[3]	< 0.0001[3]					-0.130[3]	0.0002[3]	0.042[3]	< 0.0001[3]
Constipation SS					0.068	0.0472					0.008	> 0.10
Dumping SS			-0.141[3]	< 0.0001[3]	0.141[3]	< 0.0001[3]	-0.066	0.0837	-0.067	0.0657	0.056[3]	< 0.0001[3]
Total symptom score			-0.083	0.0258	0.105[3]	0.0047[3]	-0.071	0.0677	-0.102[3]	0.0061[3]	0.037[3]	< 0.0001[3]
Change in BW									0.099	0.0049	0.016	0.02
Ingestion amount of food			-0.086	0.0125							0.009	> 0.10
Need of additional food	-0.114[3]	0.0012[3]	0.074	0.030	0.102	0.0028[3]	-0.115[3]	0.0014[3]			0.034[3]	< 0.0001[3]
Quality of ingestion SS			-0.07	0.0437							0.01	> 0.10
Ability for working			0.177[3]	< 0.0001[3]	0.098	0.0046	-0.067	0.0632			0.042[3]	< 0.0001[3]
Dissatisfaction: symptom					0.128[3]	0.0002[3]					0.023[3]	0.0013[3]
Dissatisfaction: meal	-0.077	0.0296			0.086	0.0125					0.017	0.0117
Dissatisfaction: working					0.095	0.0054	-0.071	0.0499			0.015	0.0193
Dissatisfaction SS					0.119	0.0005					0.019	0.0067
PCS of SF-8			-0.065	0.0591	-0.123[3]	0.0003[3]	0.076	0.0355			0.025[3]	0.0005[3]
MCS of SF-8					-0.120[3]	0.0005[3]	0.109[3]	0.0026[3]			0.027[3]	0.0003[3]

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination; [3]Significantly independent factors with a small effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

Table 5 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for distal gastrectomy with Roux-en-Y reconstruction

	Postop period		Age		Sex [female]		Approach [laparo]		Celiac branch [saved]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	β	*P*	R^2[2]	*P*
Esophageal reflux SS					0.094	0.0439					0.017	> 0.10
Abdominal pain SS	-0.103[3]	0.0286[3]			0.226[3]	< 0.0001[3]					0.066[3]	< 0.0001[3]
Meal-related distress SS			-0.085	0.0660	0.197[3]	< 0.0001[3]					0.053[3]	0.0001[3]
Indigestion SS	-0.091	0.0567			0.093	0.0456					0.029[3]	0.0200[3]
Diarrhea SS											0.007	> 0.10
Constipation SS											0.015	> 0.10
Dumping SS			-0.094	0.0556	0.196[3]	< 0.0001[3]					0.058	0.0002[3]
Total symptom score					0.136[3]	0.0062[3]					0.031[3]	0.0251[3]
Change in BW			-0.112[3]	0.0199[3]	-0.085	0.073					0.026[3]	0.0362[3]
Ingestion amount of food											0.007	> 0.10
Need of additional food	-0.113[3]	0.0190[3]			0.132[3]	0.0046[3]					0.032[3]	0.0106[3]
Quality of ingestion SS			-0.165[3]	0.0005[3]			-0.082	0.0919			0.031[3]	0.0142[3]
Ability for working	-0.105[3]	0.0303[3]	0.181[3]	0.0001[3]							0.052[3]	0.0003[3]
Dissatisfaction: symptom	-0.112[3]	0.0196[3]			0.128[3]	0.0059[3]	-0.100[3]	0.0399[3]			0.032[3]	0.0107[3]
Dissatisfaction: meal	-0.149[3]	0.0020[3]			0.078	0.0911					0.028[3]	0.0241[3]
Dissatisfaction: working	-0.118[3]	0.0138[3]			0.105[3]	0.0241[3]					0.025[3]	0.0385[3]
Dissatisfaction SS	-0.148[3]	0.0022[3]			0.127[3]	0.0067[3]					0.036[3]	0.0055[3]
PCS of SF-8											0.013	> 0.10
MCS of SF-8	0.094	0.0506			-0.084	0.074					0.020	0.0977

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination; [3]Significantly independent factors with a small effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

Table 6 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for proximal gastrectomy

	Postop period		Age		Sex [female]		Approach [laparo]		Celiac branch [saved]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	β	*P*	R^2[2]	*P*
Esophageal reflux SS											0.019	> 0.10
Abdominal pain SS											0.005	> 0.10
Meal-related distress SS											0.018	> 0.10
Indigestion SS											0.009	> 0.10
Diarrhea SS					-0.131	0.082					0.030	> 0.10
Constipation SS			0.159	0.037							0.032	> 0.10
Dumping SS											0.009	> 0.10
Total symptom score											0.016	> 0.10
Change in BW	0.128	0.0905									0.027	> 0.10
Ingestion amount of food	0.151	0.0437									0.035	> 0.10
Need of additional food											0.015	> 0.10
Quality of ingestion SS											0.031	> 0.10
Ability for working	-0.123	0.094	0.284[3]	0.0002[3]					-0.146[3]	0.0470[3]	0.112[3]	0.0010[3]
Dissatisfaction: symptom											0.009	> 0.10
Dissatisfaction: meal	-0.153	0.0439									0.029	> 0.10
Dissatisfaction: working									-0.160	0.0334	0.035	> 0.10
Dissatisfaction SS									-0.125	0.0963	0.027	> 0.10
PCS of SF-8	0.19	0.0115	-0.138	0.0666							0.052	0.0849
MCS of SF-8											0.021	> 0.10

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination. [3]Significantly independent factors with a small effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

Table 7 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for pylorus-preserving gastrectomy

	Postop period		Age		Sex [female]		Approach [laparo]		Celiac branch [saved]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	β	*P*	R^2[2]	*P*
Esophageal reflux SS											0.019	> 0.10
Abdominal pain SS	-0.116	0.0707									0.025	> 0.10
Meal-related distress SS	-0.134	0.0353									0.029	> 0.10
Indigestion SS											0.01	> 0.10
Diarrhea SS							0.11	0.0929			0.012	> 0.10
Constipation SS			0.108	0.0611	0.200[3]	0.0006[3]					0.050[3]	0.0096[3]
Dumping SS	-0.122	0.0752									0.030	> 0.10
Total symptom score											0.025	> 0.10
Change in BW											0.009	> 0.10
Ingestion amount of food					-0.135	0.0220					0.026	> 0.10
Need of additional food	-0.119	0.0625			0.156[3]	0.0075[3]					0.040[3]	0.0374[3]
Quality of ingestion SS	-0.132[3]	0.0391[3]	-0.129	0.0278[3]							0.047[3]	0.0160[3]
Ability for working			0.179[3]	0.0023[3]	0.153[3]	0.0090[3]					0.056[3]	0.0055[3]
Dissatisfaction: symptom	-0.127	0.0477							-0.106	0.0754	0.033	0.0792
Dissatisfaction: meal	-0.164[3]	0.0101[3]					-0.114	0.0789	-0.129[3]	0.0295[3]	0.044[3]	0.0215[3]
Dissatisfaction: working											0.008	> 0.10
Dissatisfaction SS	-0.145	0.0238							-0.111	0.0631	0.031	> 0.10
PCS of SF-8	0.163[3]	0.0108[3]	-0.103	0.0785			0.150[3]	0.0221[3]			0.044[3]	0.0241[3]
MCS of SF-8											0.009	> 0.10

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination. [3]Significantly independent factors with a small effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

Table 8 Multiple regression analysis exploring independent factors affecting the Postgastrectomy Syndrome Assessment Scale scores for local resection of stomach

	Postop period		Age		Sex [female]		Approach [laparo]			
MOMs	β[1]	*P*	β	*P*	β	*P*	β	*P*	R^2[2]	*P*
Esophageal reflux SS									0.048	> 0.10
Abdominal pain SS			-0.347[4]	0.0012[4]	0.194	0.0695			0.160[4]	0.0069[4]
Meal-related distress SS									0.037	> 0.10
Indigestion SS									0.031	> 0.10
Diarrhea SS			-0.218	0.0481					0.072	> 0.10
Constipation SS									0.027	> 0.10
Dumping SS									0.008	> 0.10
Total symptom score									0.035	> 0.10
Change in BW									0.095	> 0.10
Ingestion amount of food									0.001	> 0.10
Need of additional food									0.051	> 0.10
Quality of ingestion SS	0.304[4]	0.0076[4]	-0.215[3]	0.0437[3]					0.167[4]	0.0066[4]
Ability for working	-0.221[3]	0.0514[3]							0.116[3]	0.0410[3]
Dissatisfaction: symptom									0.036	> 0.10
Dissatisfaction: meal									0.038	> 0.10
Dissatisfaction: working									0.078	> 0.10
Dissatisfaction SS									0.037	> 0.10
PCS of SF-8									0.056	> 0.10
MCS of SF-8			0.229	0.0386					0.083	> 0.10

[1]β: standardized regression coefficient. If β is positive, then the score of the main outcome measures (MOMs) of the patient in the category in [brackets] is higher when the factor has a nominal scale, and the score of the MOMs of the patient with a larger value is higher when the factor has a numeric scale; [2]R^2: coefficient of determination. [3]Significantly independent factors with a small effect size; [4]Significantly independent factors with a medium effect size. Change in body weight, ingestion amount of food, quality of ingestion subscale, physical component summary, and mental component summary indicate higher scores (*i.e.*, better conditions). Other outcome measures indicate higher scores (*i.e.*, worse conditions). Interpretation of effect size: None or very small (β < 0.100, R^2 < 0.020); Small ($\beta \geqslant 0.100$, $R^2 \geqslant 0.020$); Medium ($\beta \geqslant 0.300$, $R^2 \geqslant 0.130$); Large ($\beta \geqslant 0.500$, $R^2 \geqslant 0.260$). MOMs: Main outcome measures; SS: Subscale; PCS: Physical component summary; MCS: Mental component summary; BW: Body weight; postop: Postoperative; laparo: Laparoscopic.

Table 9 Summary of the effects of the background factors for the main outcome measures of Postgastrectomy Syndrome Assessment Scale-45 according to the type of surgery

Method	Domain	Postop period	Age	Sex (female)	Approach (laparo)	Celiac branch (saved)
TGRY	Symptoms		+1			
	Living status or QoL		-4	-1		-2
DGBI	Symptoms		+2	-4		+2
	Living status or QoL	+1	-1	-4	+2	
DGRY	Symptoms	+1		-4		
	Living status or QoL	+6	-3	-4	+1	
PG	Symptoms					
	Living status or QoL		-1			+1
PPG	Symptoms			-1		
	Living status or QoL	+1	-2	-2	+1	+1
LR	Symptoms		+1			-
	Living status or QoL	+2	-1			-

Numbers in each column are the aggregate number of main outcome measures of Postgastrectomy Syndrome Assessment Scale. The main outcome measures having positive effects independently by each background factor were counted as + 1, and the main outcome measures having negative effects independently by each background factor were counted as - 1. TGRY: Total gastrectomy with Roux-en-Y reconstruction; DGBI: Distal gastrectomy with Billroth I reconstruction; DGRY: Distal gastrectomy with Roux-en-Y reconstruction; PG: Proximal gastrectomy; PPG: Pylorus preserving gastrectomy; LR: Local resection of the stomach; Postop: Postoperative; laparo: Laparoscopic; QoL: Quality of life.

not after PG and LR. This was true in all three domains (symptom, living status, and QoL).

A few MOMs were attained after laparoscopic distal gastrectomy and laparoscopic PPG compared to conventional open surgery, which included MOMs of the living status or QoL domains, but not the symptom domain. Preservation of the celiac branch of the vagus positively affected the MOMs of the symptom domain in DGBI patients and those of the living status or QoL domains in PG and PPG patients. However, this procedure negatively affected the MOMs in TGRY patients.

DISCUSSION

Although various background factors were considered to be involved in PGS, there have been no well-validated reports on this issue. The effects of background factors

were also investigated by previous PGSAS studies[4,6-10]; however, the factors in these studies were only used for the multivariate analysis and to exclude the effect of group comparisons. Therefore, the essential effects of background factors on PGS have not been investigated. Our paper is the first investigation to include all background factors reported in the PGSAS.

We confirmed that various background factors affected many MOMs of the PGSAS-45. The influence of background factors on MOMs was different for each factor. Arranging these factors in descending order of influence yields the following: sex, age, postoperative period, celiac branch saving, and the laparoscopic approach. This was a unique finding of our analysis.

Before interpreting the results, the domain of the PGSAS-45 should be discussed. The background factors had a variety of effects on MOMs of the PGSAS in the symptom, living status, and QoL domains. The MOMs in the symptom domain include the unpleasant subjective complaints directly related to gastrectomy and vagotomy. These complaints could be improved directly by interventions such as improvement of the surgical procedure and nutrition guidance. On the other hand, MOMs in the living status or QoL domain are influenced by multiple factors, and it is not as easy to improve them with direct interventions. Therefore, the factors affecting MOMs of the symptom domain are more direct and serious, whereas factors affecting MOMs of the living status and QoL may be complex and difficult to interpret.

As stated before, sex was the most influential background factor. Many MOMs in all three domains were worse in women, who may be more likely to report dissatisfaction with daily life as well as postgastrectomy symptoms, such as dumping syndrome, than men[5,6,10]. Our results support these findings. This may, in part, be explained by the fact that women are more sensitive to the restrictions caused by gastrectomy. Age was also a factor that had a significant effect. The MOMs that were alleviated with age belonged to the symptom domain; however, MOMs that worsened with age belonged to the living status or QoL domains. This observation was attributed to aging. The postoperative period is known to be an important factor in the development of PGS[11]. Many MOMs were alleviated over time, but most of these were in the living status or QoL domains.

A unique finding of this analysis is that the degree of the effect varied according to the type of gastrectomy. For example, the PGSAS MOMs of distal gastrectomies, both DGBI and DGRY, were greatly affected by background factors. In contrast, the MOMs of LR were better than those of DG and were not influenced to a significant degree. The MOMs of TGRY and PG were even more interesting. These procedures were associated with more severe symptoms than DG, but the background factors had little impact on the PGSAS MOMs. We presumed that the extent of gastric function loss due to TGRY and PG was sufficiently great to overshadow the influence of background factors. Moreover, the degree of influence of background factors on PPG was intermediate between that for DG and LR. This may be explained by the loss of gastric function as well, which is less severe after PPG than DG but greater than that after LR.

Among these background factors, the laparoscopic approach and preservation of the celiac branch of the vagus were interventional factors. Therefore, it is crucial to examine the effect of these interventional factors on PGS according to the type of gastrectomy in order to effectively alleviate symptoms and improve postoperative QoL.

Laparoscopic surgery continues to make remarkable progress, and laparoscopic-assisted gastrectomy for early gastric cancer is among the standard treatments in Japan. Laparoscopic gastrectomy is considered equally curative and less invasive than open gastrectomy[12,13]. However, it remains unclear whether laparoscopic gastrectomy alleviates PGS. There are reports of improved postoperative QoL following laparoscopic gastrectomy[14] and also reports wherein the QoL deteriorated[15]. This difference seems to depend on the timing of the assessment. The report that concluded that PGS had improved evaluated the outcome 3 mo postoperatively[14] and was designed to be disadvantageous to open surgery. Generally, the only difference between laparoscopic surgery and conventional open surgery is the length of the incision. Therefore, a large difference in PGS between laparoscopic and open surgery may be unexpected. In fact, a well-designed controlled trial showed no difference between the two procedures[16]. In our study, a few MOMs were better after laparoscopic DGBI, DGRY, and PPG than after conventional open surgery, but these were not related to the symptom domain. This result was valid considering that the difference in the approach itself may result in only slight differences in QoL. In addition, laparoscopic gastrectomy did not improve PGS in gastrectomy procedures that produced numerous complaints, such as TG and PG, or in gastrectomy procedures that were associated with fewer complaints, such as LR.

Preservation of the celiac branch of the vagus reduced some MOMs for DGBI, PG, and PPG, but not for DGRY and TGRY. The celiac branch of the vagus widely divides the parasympathetic nerve to the digestive system via the celiac ganglion and regulates the motility of the digestive tract, the secretion of gastrointestinal hormones, and pancreatic endocrine function[17,18]. Preservation of the celiac branch of the vagus nerve[19] has been reported to be effective in reducing diarrhea after gastrectomy[20,21]. Our results support these findings. We concluded that preservation of the celiac branch is recommended as long as radicality can be achieved. Interestingly, according to our data, the significance of this procedure may be observed only with a reconstruction that retains physiological food passage. It is possible that preservation of the celiac

branch in Roux-en-Y reconstruction may be ineffective.

This study has some limitations. Similar to the results of other PGSAS reports, our results were only statistical estimates because of the retrospective nature of our study. However, our results are valid as this study involved a sufficient number of patients. Furthermore, it is difficult to perform a prospective study focusing on this issue.

In conclusion, various background factors affected PGS. The degree of the effect varied according to the type of gastrectomy. The influence patterns of each background factor on the PGSAS MOMs were different. Many MOMs were alleviated over time and some worsened among women. Older age reduced the MOMs of the symptom domain, while worsening those of the living status or QoL domains. Furthermore, some surgical interventions, such as laparoscopic surgery and preservation of the celiac branch of the vagus, can alleviate some negative outcomes in patients undergoing DG and PPG.

ARTICLE HIGHLIGHTS

Research background

Postgastrectomy syndromes (PGS) are serious drawbacks after curative gastrectomy for gastric cancer. The main causes of PGS are gastrectomy and lymph node dissection. Nevertheless, a variety of other background factors are thought to be involved, such as age, sex, and postoperative period.

Research motivation

Although various background factors were considered to be involved in PGS, there have been no well-validated reports on this issue. In addition, there are two types of background factors: interventional and non-interventional. The non-interventional factors are age, sex, and postoperative period. The interventional factors are the laparoscopic approach and preservation of the celiac branch of the vagus. It is crucial to examine the effect of these interventional factors on PGS according to the type of gastrectomy in order to alleviate symptoms and improve quality of life (QoL).

Research objectives

We determined the influence of each background factor on PGS. However, as the invasiveness differs for each type of gastrectomy, the influence of background factors on PGS is likely to be different depending on the specific procedure. Therefore, we examined the influences of each background factor on PGS according to the type of gastrectomy.

Research methods

We conducted this retrospective study by using the dataset obtained from the PGS assessment study (PGSAS). The PGSAS was a nationwide, large-scale, retrospective observational study that investigated the symptoms, living status, and QoL of patients who underwent gastrectomy and completed the Postgastrectomy Syndrome Assessment Scale-45 questionnaire (PGSAS-45). A dataset comprising 2368 patients was analyzed. Multiple regression analysis was performed to explore the independent effects of each background factor on main outcome measures (MOMs) of PGSAS-45 for each gastrectomy type. The MOMs were classified into three domains, the symptom domain, the living status domain, and the QoL domain. The background factors included postoperative period, age, sex, surgical approach (laparoscopic or open), and the status of the celiac branch of the vagal nerve.

Research results

Regarding the postoperative period, several MOMs were alleviated because of the length of the postoperative period. These MOMs were mainly in the living status or the QoL domains. Regarding the gastrectomy procedure, several MOMs improved with the passage of time after DGRY; in contrast, no MOM improved with the passage of time after TGRY or PG. Age and sex also affected several MOMs of the PGSAS. For older patients, several MOMs belonging to the symptom domain were alleviated; in contrast, many MOMs belonging to the living status or QoL domain had worsened. There were many MOMs that were worse for women after DGBI and DGRY, but not after TG and LR. A few MOMs were attained after laparoscopic distal gastrectomy and laparoscopic PPG compared to conventional open surgery, which included MOMs in the living status or QoL domain, but not the symptom domain. Preservation of the celiac branch of the vagus positively affected the MOMs of the symptom domain for DGBI patients and the MOMs of the living status or QoL domain for PG and PPG patients.

Research conclusions

Various background factors affected the PGS. The degree of the effect varied according to the type of gastrectomy. The influence patterns of each background factor on the PGSAS MOMs were different. Many MOMs were alleviated over time yet worsened among women. Older age reduced the MOMs of the symptom domain, yet worsened the MOMs in the living status or QoL domains. Furthermore, surgical interventions, such as laparoscopic surgery and preservation of the celiac branch of the vagus, can alleviate some of the negative outcomes in patients undergoing DG and PPG.

Research perspectives

We confirmed that various background factors affected many MOMs of the PGSAS-45. The influence of background factors on MOMs was different for each factor. Arranging these factors in descending order of influence yields the following: sex, age, postoperative period, celiac branch saving, and the laparoscopic approach. The preservation of the celiac branch of the vagus can reduce some PGS for the procedures that retains physiological food passage. Laparoscopic DG or PPG may be recommended to alleviate some negative outcomes relating to living status and QoL.

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