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Do All Patients Require Prophylactic Drainage After Gastrectomy for Gastric Cancer? The Experience of a High-Volume Center

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ABSTRACT

Background. Although our previous randomized controlled trial showed that there was no difference in postoperative complications after gastric cancer surgery between patients with and without a prophylactic drains (PDs), PDs are commonly used by most surgeons and at most institutions. However, these results have not yet been validated elsewhere. The purpose of this study was to analyze the incidence, characteristics, and risk factors for a postoperative percutaneous catheter drainage (PCD) procedure after gastric cancer surgery when PDs were not used.

Methods. We reviewed data from 1989 patients who underwent gastrectomy with lymphadenectomy for gastric cancer with curative intent from January 2012 to December 2013.

Results. The incidence of PCD in the abdomen was 1.8 % (22/1249) and 9.1 % (67/740) in patients with and without PD, respectively. In the without-PD group, age [odds ratio (OR) 1.032; $p = 0.013$], male gender (OR for female 0.38; $p = 0.005$), open surgery (OR for minimally invasive surgery 0.16; $p = 0.013$), and longer operative time (OR 1.01; $p < 0.001$) were independent risk factors for postoperative PCD in the abdomen. In the without-PD group, no microbes were detected in the peritoneal fluid obtained by PCD in 72.1 % (44/61) of patients who underwent PCD, and the most commonly identified organisms were *Escherichia coli* and *Candida albicans*.

Conclusion. Not using a PD increased the risk of PCD postoperatively, but no microbes in peritoneal fluid were detected in the most patients. Selective use of PD in patients during gastric cancer surgery may be possible using our risk factor analysis.

Prophylactic intraperitoneal drainage (PD) has been widely used during major abdominal surgery because of its possible advantages.[1,2] These advantages include removing intraperitoneal fluids, such as ascites, blood, and chyle, which can be a source of infection, fever, and abdominal pain after surgery, and assisting the early detection of postoperative hemorrhage and/or leak.[3–5] However, PD can produce discomfort and pain, which may limit early ambulation and postoperative recovery, infection at the insertion site, and ascending infection, caused by migration of bacteria.[6–8] Despites of its potential disadvantages, PD is commonly used for gastric cancer surgery by most surgeons and at most institutions.

Our previous randomized, controlled trial showed no difference in postoperative complications after gastric cancer surgery between patients treated with and without PD.[9] Based on this result, PD has no longer been used routinely for gastric cancer surgery in our institution for several years. Although some surgeons in our institution have abandoned using PD in an attempt to decrease patient discomfort, improve quality of life during early recovery,

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and promote early ambulation, other surgeons continue to use PD. Surgeons favorable using PD thought that early diagnosis and treatment for some critical postoperative complications such as intra-abdominal bleeding, abscess, and anastomotic leakage would be simultaneously possible by using PD.

In our recent, prospective cohort study of postoperative complications after gastrectomy for gastric cancer,[10] we noticed that the incidence of a postoperative intraperitoneal drainage procedure was higher than expected. Because of this observation and because the results of our randomized, controlled trial have not yet been validated at another institution, we conducted the following study to review and analyze the incidence, characteristics, and risk factors for requiring a postoperative intraperitoneal drainage procedure after gastric cancer surgery in patients with and without intraoperative PD.

MATERIALS AND METHODS

Participants

This study was approved by the Institutional Review Board of Yonsei University Severance Hospital (#4-2014-0504). We analyzed data from 1989 patients who underwent gastrectomy for primary gastric cancer with curative intent at Yonsei University Severance Hospital between January 2012 and December 2013. Patients with cancer in a remnant stomach, history of preoperative chemotherapy, stage IV tumor (e.g., with peritoneal seeding or distant metastasis), or R1 resection were excluded. Patients who underwent wedge resection with sentinel lymph node navigations part of a clinical trial also were excluded.

Surgery and Evaluations

Distal gastrectomy was performed when the tumor was located in the mid or lower body of the stomach, and it was possible to save the proximal stomach while achieving sufficient tumor margins. When the tumor was located in the upper body of the stomach, total gastrectomy was performed. We performed gastrectomy with D1+ lymph node dissection for clinically early gastric cancer and D2 lymph node dissection for clinically advanced gastric cancer, in accordance with the recent Japanese gastric cancer guidelines.[11] The decision to use PD was left to the discretion of each surgeon. In our institution, some surgeons routinely use PD and others do not. In the PD group, the prophylactic drain was positioned in the subhepatic and/or left subphrenic area except pelvic cavity. Pathologic T and N stage was followed according to American Joint Committee on Cancer (AJCC) 7th edition.[12]

Patient Follow-Up and Definition of a PCD Event

The patients were routinely followed at our outpatient clinic at 1–2 weeks after hospital discharge. When a patient developed fever, abdominal distention, abdominal pain, or dyspnea during the follow-up period, a complete blood cell count and computed tomography scan were obtained at the surgeons' discretion. When the fluid collection in the intra-abdominal and/or pleural cavity was small and symptoms were minimal, the patient was treated conservatively. However, if the fluid collection was large and symptoms were severe or sustained, a catheter was inserted postoperatively into the intra-abdominal and/or pleural cavity. These catheters were inserted percutaneously under ultrasonographic guidance in the interventional radiology department in all instances. For most patients, the fluid flowing out through the catheter was cultured to determine the type of micro-organism. When a patient required a postoperative intraperitoneal and/or pleural drainage procedure within 30 days after gastrectomy, the event was defined as percutaneous catheter drainage (PCD).

Statistical Analyses

Risk factors for PCD were analyzed with odds ratios (ORs) and their 95 % confidence intervals (CIs) using a binary logistic regression model; a multivariable model was selected using the forward likelihood ratio method. A nomogram was created using the finally selected multivariable logistic regression model, and the repetition for its calibration plot was set at 200 ($B = 200$). A receiver operating characteristics (ROC) curve was constructed of the probability of the final multivariable model and the event (PCD insertion in the abdomen), and the optimal cutoff point was determined using the Youden method. The statistical analyses were performed with IBM SPSS 20.0 software (SPSS Inc., Chicago, IL) and R software version 2.9.1 using the "Design" package for creating the nomogram with its calibration plot, and version 3.0.1 using the "pROC" and "Optimal Cutpoints" packages for the ROC curve, area under the curve (AUC), and optimal cutoff point (including its sensitivity, specificity, positive predictive value, and negative predictive value). $p < 0.05$ was considered statistically significant.

RESULTS

Baseline Characteristics

Among the 1989 patients enrolled in this study, 740 (37.2 %) were in the without-PD group and 1249 (62.8 %) were in the with-PD group (Supplement Fig. 1). Baseline

TABLE 1 Baseline characteristics of with and without prophylactic intraperitoneal drainage group

	Without PD ($n = 740$)	With PD ($n = 1249$)
Age	57.8 ± 12.0 (58.0, 28–86)[b]	59.4 ± 12.1 (60.0, 23–86)[b]
Sex		
Male	457 (61.8 %)	809 (64.8 %)
Female	283 (38.2 %)	440 (35.2 %)
BMI	22.9 ± 2.7 (22.9, 16.0-34.5)[b]	23.5 ± 3.1 (23.3, 14.5-40.0)[b]
ASA score		
I	264 (35.7 %)	414 (33.1 %)
II	396 (53.5 %)	629 (50.4 %)
III	77 (10.4 %)	187 (15.0 %)
IV	3 (0.4 %)	19 (1.5 %)
Previous abdominal surgery		
No	552 (74.6 %)	946 (75.7 %)
Yes	188 (25.4 %)	303 (24.3 %)
Modality		
Open	579 (78.2 %)	434 (34.7 %)
MIS (laparoscopy/robot)	161 (21.8 %, 96/65)	815 (65.3 %, 637/178)
Extent of gastrectomy		
Subtotal	582 (78.6 %)	950 (76.1 %)
Total	158 (21.4 %)	299 (23.9 %)
Extent of LND		
D1+	190 (25.7 %)	610 (48.8 %)
D2	550 (74.3 %)	639 (51.2 %)
Combined resection		
No	670 (90.5 %)	1079 (86.4 %)
Gallbladder only	47 (6.4 %)	86 (6.9 %)
Spleen and/or pancreas and/or liver	13 (1.8 %)	40 (3.2 %)
Others[a]	10 (1.4 %)	44 (3.5 %)
Sizes (mm)	31.3 ± 23.2 (25.0, 2–200)[b]	35.6 ± 28.1 (28.0, 2–250)[b]
Depth of tumor		
Mucosa	259 (35.0 %)	388 (31.1 %)
Submucosa	225 (30.4 %)	383 (30.7 %)
Proper muscle	91 (12.3 %)	120 (9.6 %)
Subserosa	60 (8.1 %)	143 (11.4 %)
Serosa	101 (13.6 %)	210 (16.8 %)
Adjacent organ invasion	4 (0.5 %)	5 (0.4 %)
pNstage		
pN0	547 (73.9 %)	884 (70.8 %)
pN1 (1–2)	66 (8.9 %)	141 (11.3 %)
pN2 (3–6)	74 (10.0 %)	84 (6.7 %)
pN3a (7–15)	37 (5.0 %)	88 (7.0 %)
pN3b (>15)	16 (2.2 %)	52 (4.2 %)
Number of retrieved LNs	35.7 ± 12.6 (34.0, 9–90)[b]	35.8 ± 13.8 (28.0 6–99)[b]
Histology		
Differentiate	281 (38.0 %)	501 (40.1 %)
Undifferentiate	448 (60.5 %)	719 (57.6 %)
Others[c]	11 (1.5 %)	29 (2.3 %)
Lauren		
Intestinal	335 (45.3 %)	603 (48.3 %)
Diffuse	346 (46.8 %)	541 (43.3 %)
Others[d]	59 (7.9 %)	105 (8.4 %)
Blood loss (g)	93.3 ± 106.2 (60, 10–850)[b]	91.0 ± 135.9 (50.5, 10–2610)[b]
Operative time (min)	166.1 ± 44.0 (160.0, 79–360)[b]	189.5 ± 63.2 (180.0, 78–660)[b]

PD prophylactic intraperitoneal drainage, *ASA* American Society of Anesthesiologists, *MIS* minimally invasive surgery, *LND* lymph node dissection, *LN* lymph nodes

[a] Including combined resection of colon, ovary, uterus, esophagectomy, small intestine, appendix, diverticulum, nephrectomy, and adrenalectomy

[b] Median and range

[c] Lymphoepithelioma-like carcinoma

[d] Mixed type and indeterminate type

characteristics of the patients are shown in Table 1. The mean age was 57.8 and 59.4 years in the without- and with-PD groups, respectively. In both groups, the proportion of males was >60 % and the mean BMI was approximately 23. Tumor characteristics were similar to those noted in our previous report.[13] Mean blood loss was approximately 90 mL in both groups, and the mean operative time was 189.5 min in the with-PD group and 166.1 min in the without-PD group.

Patients Requiring Postoperative PCD

PCD in the intra-abdominal and/or pleural cavity was required postoperatively in 2.3 % of patients in the with-PD group and 9.7 % of patients in the without-PD group; this difference was statistically significant (χ^2 test, $p < 0.001$). In the with-PD group, 1.8 % of patients (22/1249) required PCD in the abdomen postoperatively, and eight of these patients had leakage. In the without-PD group, 9.1 % of patients (67/740) required PCD in the abdomen postoperatively, and four of these patients had leakage. The incidence of leakage was not statistically different between the with- and without-PD groups (Fisher's exact test, $p = 0.519$).

Time of Postoperative PCD Insertion in the Abdomen

Figure 1 shows the number of patients who required PCD insertion in the abdomen overtime after surgery. In the without-PD group patients who required PCD in the abdomen, PCD was performed at 3–27 days postoperatively; 90 % of these were performed within the first 2 weeks after surgery (Fig. 1a), and four patients in this group had leakage. In the with-PD group patients who required PCD in the abdomen, PCD was performed at 5–31 days after gastrectomy; PCD was performed evenly throughout this time period (Fig. 1b). Eight patients experienced leakage. Three of these patients required PCD after the PD tube was removed, and for the other five PD group patients with leakage, PCD was performed while their PD tube was still in place. No intestinal or vessel injury occurred in those patients undergoing PCD.

Risk Factors for Postoperative PCD

Table 2 shows the risk factors for postoperative intra-abdominal PCD in the without- and with-PD groups. In the without PD group, univariable analysis indicated that the following were risk factors for postoperative PCD insertion: old age, male gender, no previous abdominal surgery, open surgery (compared with MIS surgery), total gastrectomy, D2 lymph node dissection (compared with D1+ dissection), combined resection, aggressive tumor characteristics (large size, deep invasion, and with lymph node metastasis), greater blood loss, and longer operative time. During multivariable analysis, age (OR 1.032; $p = 0.013$), male gender (OR for females 0.38; $p = 0.005$), open surgery (OR for MIS 0.16; $p = 0.013$), and longer operative time (OR 1.01; $p < 0.001$) were identified as independent risk factors.

In the with-PD group, univariable analysis indicated that the following were risk factors for postoperative PCD:

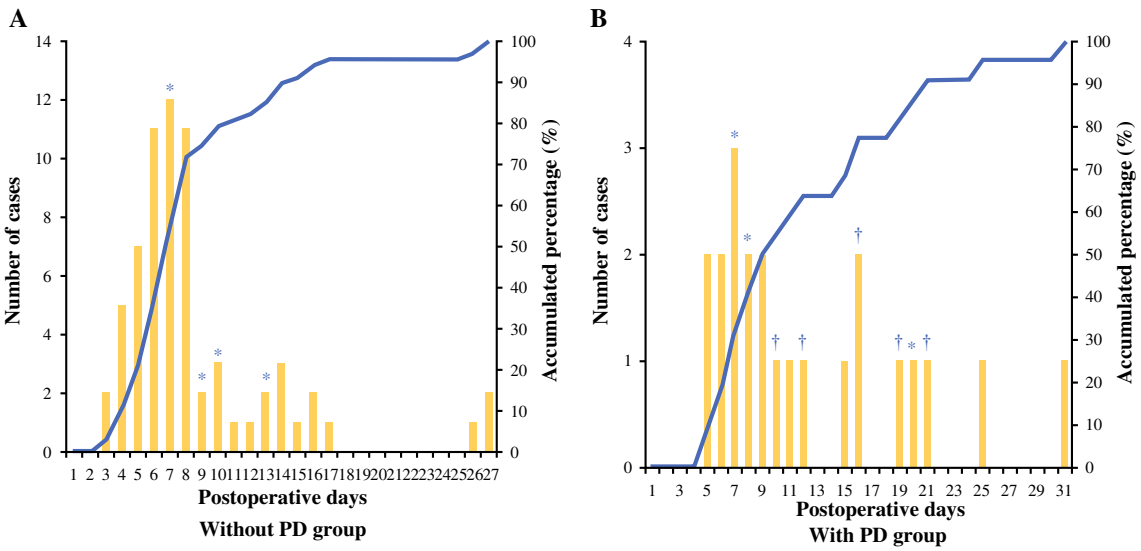

FIG. 1 *Bar graph* and *ogive graph* of the number of patients who required postoperative PCD in the abdomen over time. **a** Without prophylactic intra-peritoneal drainage group. **b** With prophylactic intra-peritoneal drainage group (*asterisk* and *dagger* represent patients with leakage; *asterisk* PD was not in place when PCD was performed, *dagger* PD was in place when PCD was performed). *PD* prophylactic intra-peritoneal drainage, *PCD* percutaneous catheter drainage

TABLE 2 Risk factors for postoperative intra-abdominal percutaneous catheter drainage in without and with prophylactic intraperitoneal drainage group

	Without PD				With PD			
	Univariable		Multivariable		Univariable		Multivariable	
	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value
Age	**1.038 (1.015–1.061)**	**0.001**	**1.032 (1.007–1.058)**	**0.013**	1.035 (0.997–1.075)	0.069		
Sex		**<0.001**		**0.005**		0.223		
Male	1		1		1			
Female	**0.29 (0.15–0.56)**		**0.38 (0.19–0.74)**		0.58 (0.23–1.45)			
BMI		0.306				0.255		
<18.5	0.75 (0.17–3.31)				3.60 (0.72–17.80)			
18.5–22.9	1				1			
23–25	1.50 (0.85–2.63)				1.86 (0.67–5.17)			
25–28	0.61 (0.26–1.42)				0.57 (0.12–2.77)			
>28	1.13 (0.33–3.93)				2.30 (0.58–9.05)			
ASA score		0.706				0.226		
I	1				1			
II	1.23 (0.70–2.14)				1.99 (0.64–6.22)			
III/IV	1.29 (0.55–3.03)				3.08 (0.89–11.02)			
Previous abdominal surgery		**0.021**				0.866		
No	1				1			
Yes	**0.43 (0.21–0.88)**				0.92 (0.34–2.51)			
Modality		**<0.001**		**0.013**		**0.007**		
Open	1		1		1			
MIS (laparoscopy/robot)	**0.10 (0.02–0.41)**		**0.16 (0.04–0.68)**		**0.30 (0.12–0.72)**			
Extent of gastrectomy		**<0.001**				0.067		
Subtotal	1				1			
Total	**2.80 (1.65–4.72)**				2.24 (0.95–5.29)			
Extent of LND		**0.004**				0.115		
D1+	1				1			
D2	**3.20 (1.44–7.13)**				2.07 (0.84–5.11)			
Combined resection		**0.043**				0.085		
No	1				1			
Gallbladder	**2.70 (1.24–5.88)**				3.45 (1.12–10.64)			
Spleen and/or pancreas and/or liver	**2.07 (0.45–9.60)**				3.73 (0.82–16.88)			
Others[a]	**2.85 (0.59–13.77)**				1.65 (0.21–12.75)			
Sizes (mm)		**0.006**				**0.045**		
<30	1				1			
>31	**2.04 (1.23–3.38)**				**2.45 (1.02–5.89)**			
Depth of tumor		**0.002**				**0.002**		**0.003**
EGC	1				1		1	
AGC	**2.24 (1.35–3.71)**				**4.42 (1.72–11.36)**		**4.27 (1.65–11.04)**	
LNM		**0.030**				**0.004**		
LN negative	1				1			
LN positive	**1.79 (1.06–3.03)**				**3.59 (1.52–8.48)**			
Histology		**0.023**				0.694		
Differentiate	1				1			
Undifferentiate	**0.60 (0.36–1.01)**				0.69 (0.30–1.61)			
Others[b]	**2.92 (0.74–11.56)**				NA			
Lauren		0.146				0.802		
Intestinal	1				1			
Diffuse	0.61 (0.36–1.03)				0.74 (0.30–1.82)			
Others[c]	0.57 (0.20–1.66)				0.96 (0.21–4.34)			

TABLE 2 continued

	Without PD				With PD			
	Univariable		Multivariable		Univariable		Multivariable	
	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value	OR (95 % CI)	*p* value
Blood loss (g)	**1.002 (1.000–1.004)**	**0.025**			**1.002 (1.000–1.003)**	**0.026**		
Operative time (min)	**1.012 (1.007–1.018)**	**<0.001**	**1.01 (1.005–1.016)**	**<0.001**	**1.007 (1.003–1.012)**	**0.002**	**1.007 (1.002–1.012)**	**0.003**

Statistically significant values are given in bold

OR odds ratio, *PD* prophylactic intra-peritoneal drainage, *ASA* American Society of Anesthesiologists, *MIS* minimally invasive surgery, *LND* lymph node dissection, *LN* lymph nodes

[a] Including combined resection of colon, ovary, uterus, esophagectomy, small intestine, appendix, diverticulum, nephrectomy, and adrenalectomy

[b] Lymphoepithelioma-like carcinoma

[c] Mixed type and indeterminate type

open surgery (compared with MIS surgery), larger tumor size, advanced gastric cancer, presence of lymph node metastasis, greater blood loss, and longer operative time. During multivariable analysis, only the tumor depth (OR of AGC 4.27; $p = 0.003$) and operative time (OR 1.007; $p = 0.003$) were identified as independent risk factors in the with PD group.

Prediction Model for Selective Inserting PD for Gastric Cancer Surgery

A nomogram was constructed for predicting postoperative PCD in the abdomen when prophylactic PD was not used for gastric cancer surgery (Fig. 2a). Risk factors selected by the prediction model (multivariable analysis of the without PD group in Table 2) were used for the nomogram. These factors included gender, surgical modality, age, and operative time. The actual probability of the event (PCD in the abdomen) correlated closely with the predicted probability, and the mean absolute error was 0.008 for the calibration plot (Supplement Fig. 2), thereby indicating that the nomogram was acceptable. The ROC curve (Fig. 2b) of the probability of the prediction model and the event (PCD in the abdomen) showed that the AUC was 0.753 and the optimal cutoff point for the probability of predicting PCD was 0.09807. The sensitivity of this prediction model was 74.6 %, specificity was 66.6 %, positive predictive value was 18.2 %, and negative predictive value was 96.3 %.

Microbes in Fluid Obtained by PCD

Table 3 shows the microbial culture results of the fluids obtained by postoperative PCD in the abdomen and/or pleural cavity. In the without-PD group, peritoneal fluid was obtained for culture in 91 % of the patients (61/67) who underwent PCD in the abdomen; no microbes were detected in 72.1 % of these patients (44/61). Two patients experienced leakage and the *Escherichia coli* and *Enterococcus faecium* was detected in the peritoneal fluid obtained by PCD.

In the with-PD group, peritoneal fluid was obtained for culture in 72.7 % of the patients (16/22) who underwent PCD in the abdomen; no microorganisms were detected in 43.8 % of these patients (7/16). In most patients [88.2 % (15/17) of patients in the without PD group and 100 % (8/8) of patients in the with PD group], no microbes were detected from the pleural fluid obtained by PCD.

DISCUSSION

The present study showed that the incidence of postoperative PCD after gastric cancer surgery was higher in the without-PD group than the with-PD group. However, more than 90 % of patients without a PD did not require postoperative drainage and no microbes were detected in more than two-thirds (72.1 %) of those who underwent PCD. Considering that postoperative PCD relieved uncomfortable symptoms in patients with intra-abdominal fluid collections and most of the collections did not appear to be pathologic, routine use of PD during surgery in all patients would be overtreatment. Because most microbes cultured from peritoneal fluids obtained by PCD were commensal organisms from the small intestine, particular attention to avoiding contamination during the anastomosis may decrease the rate of peritoneal fluid infection.

Our results showed that the incidence of postoperative leakage in the with- and without-PD groups was similar, and most PCDs were performed within 2 weeks after surgery. Therefore, if we can identify patients with an increased risk for postoperative PCD, it will be possible to selectively insert a PD during surgery. During our risk factor analyses, male gender, older age, open surgery, and longer operative time were identified as independent risk factors for postoperative PCD in patients without PD. Differences in fat distribution according to gender are well known. Women have a higher amount of body fat, especially in the gluteal-femoral area, whereas men have more

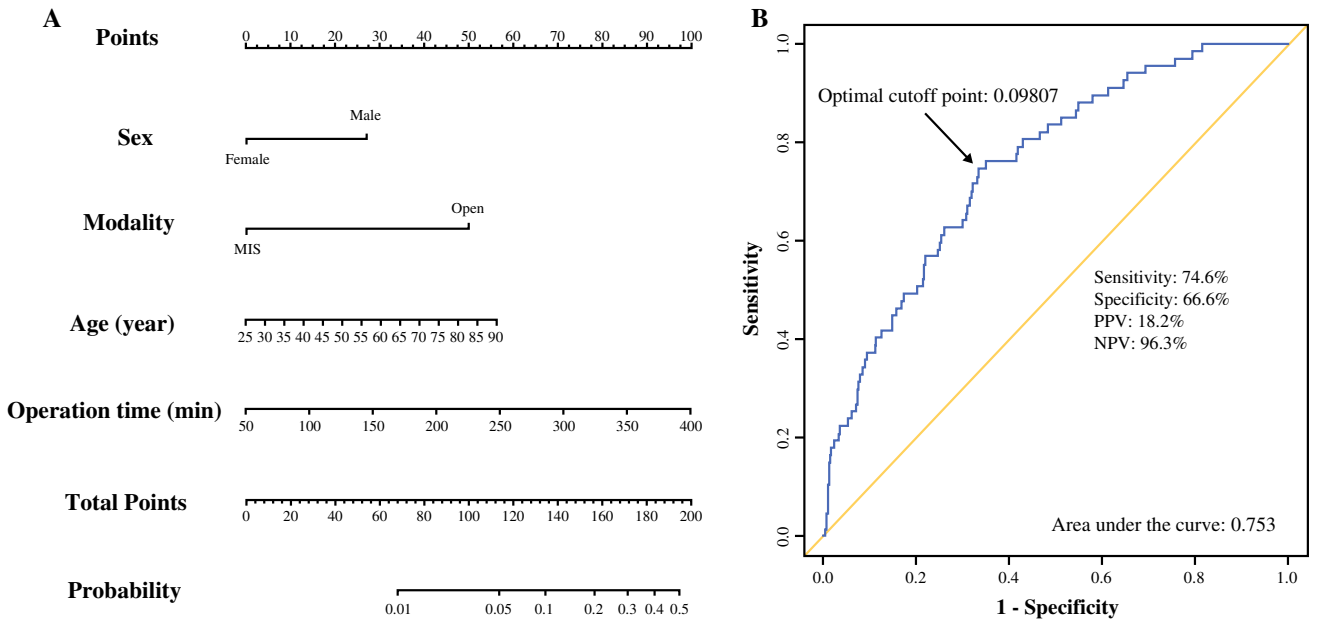

FIG. 2 Nomogram and its receiver operating characteristics (ROC) curve for predicting postoperative PCD in the abdomen in the without prophylactic intra-peritoneal drainage group. **a** Nomogram from the final multivariable analysis of the binary logistic regression model. **b** ROC curve and its diagnostic performance. *PCD* percutaneous catheter drainage

visceral fat.[14] A greater quantity of visceral fat may result in more peritoneal fluid after gastric cancer surgery. Wound healing is known to differ between young and aged individuals because of delayed re-epithelialization, angiogenesis, secretion of growth factors, and collagen deposition with increasing age.[15] Thus, sealing injured lymphatics during surgery could be delayed in older patients and lead to the accumulation of more fluid in the peritoneal cavity. Open surgery was likely identified as an independent risk factor for postoperative PCD because of the surgical devices used. In the present study, only an electrocautery device (Bovie) was used during most of the open surgeries, whereas ultrasonic devices were always used for MIS. Several previous reports have indicated that ultrasonic devices are more effective than electrocautery devices to reduce lymphatic fluid accumulation after surgery because of their sealing effects.[16–18] Finally, longer operative time may represent more difficult and extensive surgery, such as total gastrectomy, more extended lymph node dissection, or combined resection.

Our nomogram shows that it may be possible to apply PD in gastric cancer surgery selectively, because the nomogram can be used to predict a considerable need for PCD after surgery when PD is not used during surgery (AUC: 0.753). For example, if we did not apply PD in a patient with a probability <0.09807, which was calculated by the nomogram at the end of the operation, the patient would have a 96.3 % likelihood of not requiring PCD. It also is likely that the risk of PCD after gastric cancer surgery can be reduced by using ultrasonic devices during open surgery and by performing careful intraoperative manipulations to avoid contamination during the anastomosis. Although there were no PCD-related complications, such as bowel injury or bleeding, in the patients enrolled in this study, every interventional procedure has potential risks and may cause patient discomfort. Therefore, our nomogram should be helpful to identify patients who would benefit from prophylactic PD during surgery.

One limitation of this study is that the decision regarding whether to insert a PD was left to the discretion of the surgeon (some surgeons routinely used PD, whereas others routinely did not); this non-random selection process may have influenced our results. Another limitation is the uncertainty whether this result can be reproducible in other centers and other countries especially where preoperative chemotherapy and/or radiotherapy or limited lymph node dissection is the standard of care. The other limitation is the design of this study, retrospective cohort study. Thus, we are going to perform a randomized, controlled trial to compare the outcomes between routinely used PD group and selectively used PD based on the present nomogram group. If it works in the trial, validation in other centers and other countries may be the next step.

In conclusion, not using PD during gastric cancer surgery increased the risk of PCD postoperatively, but no microbes in peritoneal fluid were detected in the most patients. Selective use of PD in patients during gastric cancer surgery by risk factor analysis using a nomogram is possible, and the clinical efficacy of this approach should be evaluated in further studies.

TABLE 3 Details of culture results from the fluids through postoperative percutaneous catheter drainage

Abdomen	Without PD ($n = 67$)	No. of patients with leak	With PD ($n = 22$)	No. of patients with leak
Without culture	6 (9.0 %)	0	6 (27.3 %)	2
With culture	61 (91.0 %)	4	16 (72.7 %)	6
No growth	44 (72.1 %)	2	7 (43.8 %)	1
Gram positive				
Streptococcus intermedius	1 (1.6 %)	0		
Enterococcus faecium	1 (1.6 %)	1	1 (6.3 %)	1
Streptococcus mitis			1 (6.3 %)	1
Enterococcus faecalis	1 (1.6 %)	0		
Streptococcus anginosus	2 (3.3 %)	0		
Diphtheroids	1 (1.6 %)	0		
Staphylococcus aureus			1 (6.3 %)	0
Staphylococcus intermedius	1 (1.6 %)	0		
Bacillus species			1 (6.3 %)	1
Gram negative				
Pseudomonas aeruginosa			1 (6.3 %)	1
Klebsiella pneumonia	2 (3.3 %)	0		
Enterobacter cloacae	2 (3.3 %)	0	1 (6.3 %)	1
Enterobacter aerogene			2 (12.5 %)	1
Escherichia coli	3 (4.9 %)	1	2 (12.5 %)	0
Bacteroides fragilis	2 (3.3 %)	0		
Prevotella disiens	1 (1.6 %)	0		
Proteus mirabilis			1 (6.3 %)	0
Fungus				
Candida albicans	3 (4.9 %)	0	1 (6.3 %)	1
Pleura	**Without PD ($n = 18$)**	**No. of patients with leak**	**With PD ($n = 10$)**	**No. of patients with leak**
Without culture	1 (5.6 %)	0	2 (20.0 %)	0
With culture	17 (94.4 %)	3	8 (80.0 %)	0
No growth	15 (88.2 %)	3	8 (100 %)	0
Gram positive				
Streptococcus intermedius	1 (5.9 %)			
Gram negative				
Bacteroides fragilis	1 (5.9 %)			

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CONFLICT OF INTEREST The authors declare that they have no conflict of interest.

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