Received: 29 July 2024 | Revised: 22 October 2024 | Accepted: 6 November 2024

DOI: 10.1002/ags3.12888

AGSurg Annals of Gastroenterological Surgery Open Access WILEY

ORIGINAL ARTICLE

Possibility of incorrect evaluation of intraoperative blood loss during open and laparoscopic distal pancreatectomy

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Abstract

Aim: Decreasing intraoperative blood loss is one reported advantage of laparoscopic surgery compared with open surgery. However, several reports indicate that blood loss during laparoscopic surgery may be underestimated. No studies have evaluated this possibility in laparoscopic distal pancreatectomy (LDP). Here we evaluated estimated blood loss (e-BL) compared to intraoperative blood loss (i-BL) during distal pancreatectomy (DP).

Methods: This study included 114 patients undergoing DP in our institution during the study period. We examined the relationship between i-BL and e-BL. Based on these results, we further investigated the relationship with LDP.

Results: The laparoscopic approach was used in a significantly higher percentage of patients in e-BL > i-BL group compared to e-BL < i-BL group (55.9% vs 10.9%, $p < 0.0001$). Within the LDP group ($n = 39$), e-BL was significantly more than i-BL (388 ± 248 vs 127 ± 160 mL; $p < 0.0001$). Within the open distal pancreatectomy (ODP) group ($n = 75$), e-BL was significantly less than i-BL (168 ± 324 vs 281 ± 209 mL; $p = 0.0017$). The e-BL > i-BL trend in the LDP group was consistent, regardless of the indication for DP. In contrast, the finding of i-BL > e-BL in the ODP group was limited to patients with pancreatic cancer.

Conclusion: During LDP, e-BL was significantly more than i-BL. During ODP, e-BL was significantly less than i-BL, only in patients with pancreatic cancer. These results suggested the possibility of i-BL underestimation during LDP, and overestimation during ODP in cases with pancreatic cancer.

KEYWORDS
blood loss, distal pancreatectomy, estimation, laparoscopic, open

1 | INTRODUCTION

In the past decade, laparoscopic techniques have been widely applied for hepatobiliary pancreatic surgery.[1–4] Improvements of surgical techniques and devices have enabled the use of laparoscopic methods for pancreatic surgery, especially distal pancreatectomy (DP).[5–10] As found in laparoscopic surgery for other organs, several reports have demonstrated significantly less intraoperative blood loss during laparoscopic distal pancreatectomy (LDP) compared to open distal pancreatectomy (ODP).[11–14] Several potential explanations have been suggested for the reduced blood loss during LDP. One is that the laparoscope-magnified view enables surgeons to identify the detailed anatomical structure and dissect tiny vessels with coagulation. Another is that the pressure gradient produced by pneumoperitoneum directly prevents bleeding.

Considering the findings that perioperative blood transfusion is associated with worse prognosis for pancreatic cancer (PC), LDP with less blood loss might be favorable from the oncological aspect.[15] On the other hand, it has been recently reported that intraoperative blood loss (i-BL) might be underestimated compared with estimated blood loss (e-BL) examined by preoperative and postoperative blood test during laparoscopic surgery.[16,17] However, the abovementioned studies were based on examinations of hepatectomies. To our knowledge, no previous studies have investigated the relationship between i-BL and e-BL during DP.

In the present study, to investigate the possible misestimation of blood loss during DP, we evaluated e-BL in comparison to i-BL during DP. We also assessed the perioperative factors that impacted the relationship between i-BL and e-BL.

2 | MATERIALS AND METHODS

A total of 179 consecutive patients underwent DP for pancreatic disease from January 2010 to December 2021, at the Department of Gastroenterological Surgery, Osaka University Hospital. Of these patients, 65 patients were excluded from this study because they had a history of other abdominal surgery, required other organ resections together with DP, needed intraoperative blood transfusion, underwent other procedures for treating the pancreatic stump (eg, anastomosis into the small intestine), or were converted to an open procedure. This study had a retrospective design and was approved by the Institutional Ethics Review Committee (Certificate Number 22335). After an extensive dialog with the Institutional Ethics Review Committee, patient consent for participation was obtained through an opt-out method.

For the included patients, we recorded preoperative factors (sex, height, weight, disease, and blood tests), preoperative and postoperative hematocrit, and intraoperative factors (surgical approach, operation time, anesthesia time, intraoperative infusion volume, and intraoperative urinary output). We defined i-BL as the sum of the increase in operative gauze weight and the suction fluid volume after subtracting the irrigation fluid volume. We calculated e-BL using total blood volume and hematocrit (HCT) level according to the Gross formula: e-BL (mL) = [total blood volume (mL)] * [HCTpre (%)−HCTpost (%)]/HCTavg (%), in which HCTpre is preoperative HCT, HCTpost is postoperative HCT, and HCTavg is the average of HCTpre and HCTpost[18] Total blood volume was calculated based on the method of Nadler et al: [total blood volume (mL)] = 366.9 × [height (m)]^3 + 32.19 × [weight (kg)] + 604.1 for males, and [total blood volume (mL)] = 0356.1 × [height (m)]^3 + 33.08 × [weight (kg)] + 183.3 for females.[19]

During DP, the pancreas was resected as previously reported.[20] Briefly, a cutline for pancreas dissection was selected in the proximal pancreas, near the portal vein in patients with PC, or 1 cm from the proximal margin of the tumor in patients with a noncancerous lesion. Pancreas dissection was performed using a triple-row liner stapler, and the closure jaw was carefully and slowly clamped, taking over 5 min at a fixed speed. Before completion of the surgery, an intra-abdominal closed-suction drainage tube was placed near the pancreas stump. In patients who underwent spleen removal together with DP, another tube was placed at the left subphrenic space. In terms of the indication of the surgical approach, open or laparoscopic, since the indication of LDP had expanded during the study period, DP in the study period was performed openly or laparoscopically based on the surgeons' skill and preference, except the patients who required combined resection of other organs (excluding the gallbladder and the adrenal gland). DP with the combined resection was indicated only for ODP. DP, whether open or laparoscopic, was performed by surgeons certified by the Japanese Society of Hepato-Biliary-Pancreatic Surgery, or performed under the supervision by them. Furthermore, LDP was performed also under the supervision of surgeons certified via the Endoscopic Surgical Skill Qualification System of the Japan Society for Endoscopic Surgery. Anesthesia during surgery and postoperative intensive care was performed by the same team of experienced anesthesiologists.

Data are described as mean ± standard deviation for continuous variables, and as numbers for categorical variables. Between-group differences were assessed using the Mann–Whitney *U*-test, the chi-square test, and Fisher's exact test, as appropriate. Continuous variables were converted to categorical variables by forming groups of above and below the median value for each variable. We determined the odds ratio (OR) and 95% confidence interval (CI) for each variable. Statistical analyses were performed using the JMP software program (SAS, Cary, NC, USA). A p value of <0.05 was considered statistically significant.

3 | RESULTS

Table 1 summarizes the demographics of the included patients. Among the patients, 59 (51.8%) were diagnosed with PC, and 55 (48.2%) had other diagnoses, such as pancreatic cystic neoplasm and neuroendocrine tumor. DP was performed using an open approach in 75 patients (65.8%), and using a laparoscopic approach in 39 patients

TABLE 1 Demographic information for 114 patients who underwent distal pancreatectomy.

Characteristics	Measurement
Preoperative factors	
Age, y	64 ± 16
Sex, male/female	64/50 (56.1%/43.9%)
BMI, kg/m^2	22.2 ± 3.3
Disease, PC/others	59/55 (51.8%/48.2%)
Hemoglobin, g/dL	12.6 ± 1.5
Platelets, 10^4/μL	21.0 ± 8.4
Albumin, g/dL	3.9 ± 0.4
HbA1c, %	6.1 ± 1.0
Hematocrit, %	
Preoperative	38.1 ± 4.5
Postoperative	35.7 ± 4.6
Intraoperative factors	
Surgical approach, Open/Laparoscopic	75/39 (65.8%/34.2%)
Spleen preserving, (±)	105/9 (7.9%/92.1%)
Operation time, min	272 ± 88
Anesthesia time, min	344 ± 93
Intraoperative blood loss, mL	293 ± 355
Estimated blood loss, mL	243 ± 317
Intraoperative infusion volume, mL	2433 ± 963
Intraoperative urinary output, mL	348 ± 314
Intraoperative fluid balance, mL	1862 ± 848
Intraoperative fluid balance per body weight, mL/kg	32.5 ± 14.5

Note: Data are expressed as the mean ± standard deviation for continuous variables, and the number of patients and the percentage for categorical variables.

Abbreviations: BMI, body mass index; HbA1c, glycated hemoglobin A1c; PC, pancreatic cancer.

(34.2%). To investigate the relationship between i-BL and e-BL in each patient, both were calculated for all patients and plotted in a scatter diagram (Figure 1A). We found no correlation between i-BL and e-BL in all patients ($r = 0.1719$, $p = 0.0674$). According to this correlation, we divided the patients into two groups based on the relationship between i-BL and e-BL: 59 patients (51.8%) were in the group of e-BL > i-BL, and 55 patients (48.2%) in the group of e-BL < i-BL. We next investigated the factors influencing this relationship (Table 2). The laparoscopic approach was used in a significantly higher percentage of patients in the e-BL > i-BL group compared to the e-BL < i-BL group (55.9% vs 10.9%, $p < 0.0001$). Furthermore, the e-BL > i-BL group had higher percentages of the patients with greater intraoperative fluid balance and greater intraoperative fluid balance per body weight compared to the e-BL < i-BL group (the greater intraoperative fluid balance; 59.3% vs 40.0%, $p = 0.0392$, the greater intraoperative fluid balance per body weight; 61.0% vs 38.2%, $p = 0.0144$). Additionally, disease was identified as a marginally significant factor. Although the difference was not statistically significant, PC was diagnosed in a lower percentage of the patients in the e-BL > i-BL group than in the e-BL < i-BL group (44.1% vs 60.0%, $p = 0.0959$). To identify independent factors that were significantly associated with the e-BL > i-BL relationship, we performed multivariate analysis including four factors: the surgical approach (open/laparoscopic), the intraoperative fluid balance, the intraoperative fluid balance per body weight, and the disease (PC/others). This analysis revealed that the laparoscopic approach was the only independent factor significantly associated with the e-BL > i-BL relationship (OR = 0.1153, 95% CI = 0.041–0.322, $p < 0.0001$).

Based on the significant association of the surgical approach with the relationship between i-BL and e-BL, we next investigated the differences between the ODP and LDP groups (Table 3). Compared to the LDP group, the ODP group showed significantly higher age (66 ± 15 vs 59 ± 18 y, $p = 0.0380$) and percentage of patients with PC (61.3% vs 33.3%, $p = 0.0043$). Other preoperative factors did not significantly differ between the two groups. With regard to intraoperative factors, compared to the LDP group, the ODP group had significantly shorter operation time (243 ± 78 vs 327 ± 76 min, $p < 0.0001$) and anesthesia time (312 ± 85 vs 402 ± 79 min, $p < 0.0001$), and lower percentage of spleen preserving (0.0% vs 23.1%, $p < 0.0001$). These differences were acceptable when considering the patient selection bias for the surgical approach. Interestingly, although the i-BL was significantly greater in the ODP group compared to the LDP group (281 ± 209 vs 127 ± 160 mL, $p < 0.0001$), the e-BL was significantly smaller in the ODP group than in the LDP group (168 ± 324 vs 388 ± 248 mL, $p = 0.0001$). We also investigated postoperative drainage volume through the intraoperatively inserted abdominal drainage tubes. There were no significant differences between the ODP group and the LDP group at the volume until the end of the day of surgery (90 ± 60 vs 81 ± 78 mL, $p = 0.5087$), the volume on the first day after surgery (183 ± 147 vs 147 ± 105 mL, $p = 0.1369$), or the volume until the end of the first day after surgery (273 ± 185 vs 227 ± 149 mL, $p = 0.1592$). Furthermore, we illustrated the relationship between i-BL and e-BL in each group according to the surgical approach using a scatter diagram (Figure 1B,C), and used a box-and-whisker plot to show i-BL and e-BL according to the type of surgery (Figure 2). Within the LDP group, e-BL was significantly more than i-BL (388 ± 248 vs 127 ± 160 mL; $p < 0.0001$). In contrast, within the ODP group, e-BL was significantly less than i-BL (168 ± 324 vs 281 ± 209 mL; $p = 0.0017$). These results suggested the possibility of blood loss underestimation in the LDP group, as well as the possibility of blood loss overestimation in the ODP group.

Finally, to focus on the finding that the disease had a marginal impact on the relationship between i-BL and e-BL, we performed a subgroup analysis to investigate the influence of the disease on the relationship between i-BL and e-BL within the ODP group and the LDP group (Figure 3). In the LDP group, e-BL at least tended to be greater than i-BL, regardless of the disease: $p = 0.0518$ for cases with PC, and $p < 0.0001$ for cases with other diseases (Figure 3A). In contrast, within the ODP group, we found no significant difference between i-BL and e-BL among cases with other diseases ($p = 0.1028$), and e-BL was significantly smaller than i-BL only among cases with

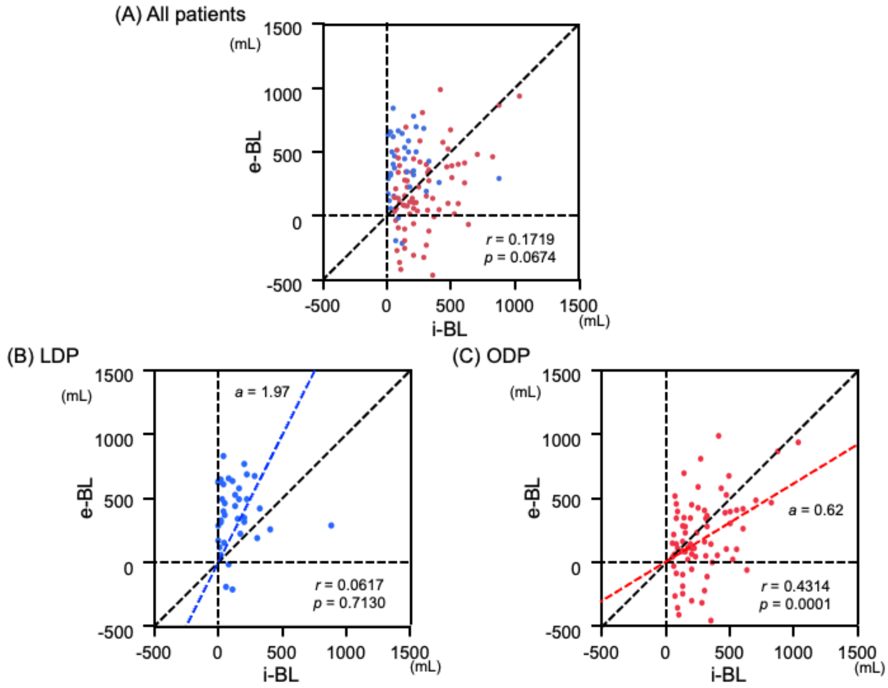

FIGURE 1 Scatter diagram showing the relationship between i-BL and e-BL among all patients included in this study, and for groups stratified according to the surgical approach. (A) Among all patients, the relationships between i-BL and e-BL varied in each case ($r=0.1719$, $p=0.0674$). (B) Within the LDP group, the line indicated a liner regression for the correlation between i-BL and e-BL ($a=0.62$, $r=0.4314$, $p=0.0001$). (C) Within the ODP group, the line indicated a liner regression for the correlation between i-BL and e-BL ($a=1.97$, $r=0.0617$, $p=0.7130$). Blue plots and line indicate the cases that underwent LDP. Red plots and line indicate the cases that underwent ODP. e-BL, estimated blood loss; i-BL, intraoperative blood loss; LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy.

PC ($p<0.0001$) (Figure 3B). These findings suggested that the underestimation of blood loss in the LDP group did not depend on the disease, but the overestimation of blood loss in the ODP group may depend on the disease, being limited to the patients with PC.

4 | DISCUSSION

The present study demonstrated two main findings: that i-BL was underestimated during LDP, and that i-BL was overestimated during ODP, but only in patients with PC. Our results showed that e-BL was significantly greater than i-BL among the patients who underwent LDP, and that the surgical approach was the only factor associated with the e-BL > i-BL relationship. These findings are consistent with previous reports from hepatectomies.[16,17] With regards to the extent of the underestimation, Oba et al reported that e-BL tended to be roughly three times higher than i-BL among patients who underwent laparoscopic hepatectomy.[17] Our present study demonstrated a similar trend in the extent of i-BL underestimation in cases of LDP, with e-BL being roughly two-fold higher than i-BL.

Previous reports have speculated that the blood loss in laparoscopic hepatectomy may be underestimated due to insufficient suctioning of blood accumulated in the abdominal cavity because of the small work space available during laparoscopic surgery.[16] To examine the fluid volume that was not suctioned from the body during the surgery and confirm the hypothesis, we investigated the drainage volume until the end of the day of surgery, and on the first day after surgery, This analysis has not been performed in previous investigations of hepatectomy. We expected that the results would indicate a cause of the underestimation; however, the residual fluid did not significantly differ between the LDP group and the ODP group. Therefore, it remains uncertain whether the hypothesis is valid. If the hypothesis is true, fluid collection may be insufficient, since the drainage tubes were placed on the upper side and patients varied in how often they got out of the bed. As the other possible cause of the underestimation, we focused on the larger intraoperative fluid balance and intraoperative fluid balance per body weight in the LDP group than the ODP group, which may be due to the longer anesthesia and operation time of LDP compared to ODP. This may lead to more diluted blood, resulting in an increased e-BL in the LDP group, which could have contributed to the underestimation in the LDP group.

Our finding that i-BL was overestimated during ODP, only in the patients with PC, was unexpected. This conclusion was based on the result that e-BL was significantly less than i-BL in cases of ODP, but only among the patients with PC. The finding would indicate that the suctioned fluid was not necessarily derived from the blood itself during the surgery, although this was not directly proven. Interestingly, this has not been found in the previous reports investigating hepatectomy.[16,17] Furthermore, this i-BL overestimation was not found among the patients with diseases other than in the present study. These findings suggest that PC may be associated with the i-BL overestimation. Notably, when DP is indicated for PC, DP

TABLE 2 Univariate and multivariate analysis of factors affecting the relationship between e-BL and i-BL among included patients.

Characteristics	Univariate e-BL > i-BL (*n* = 59)	Univariate e-BL < i-BL (*n* = 55)	*p* value	Multivariate OR (95% CI)	*p* value
Age, ≤69/>69 y	27/32 (45.8%/54.2%)	30/25 (54.5%/45.5%)	0.3484		
Sex, Male/Female	34/25 (57.6%/42.4%)	30/25 (54.5%/45.5%)	0.7404		
BMI, ≤21.8/>21.8 kg/m^2	33/26 (55.9%/44.1%)	24/31 (43.6%/56.4%)	0.1889		
Disease, PC/Others	26/33 (44.1%/55.9%)	33/22 (60.0%/40.0%)	0.0959	0.7710 (0.3213–1.8499)	0.5611
Preoperative hemoglobin, ≤12.6/>12.6 g/dL	27/32 (45.8%/54.2%)	31/24 (56.4%/43.6%)	0.2574		
Preoperative platelets, ≤19.8/>19.8 10^4/μL	29/30 (49.2%/50.8%)	29/26 (52.7%/47.3%)	0.7028		
Preoperative albumin, ≤3.9/>3.9 g/dL	27/32 (45.8%/54.2%)	32/23 (58.2%/41.8%)	0.1842		
Preoperative HbA1c, ≤5.9/>5.9%	35/24 (59.3%/40.7%)	25/30 (45.5%/54.5%)	0.1378		
Preoperative hematocrit, ≤38.1/>38.1%	27/32 (45.8%/54.2%)	30/25 (54.5%/45.5%)	0.3484		
Surgical approach, Open/Laparoscopic	26/33 (44.1%/55.9%)	49/6 (89.1%/10.9%)	<0.0001	0.1153 (0.041–0.322)	<0.0001
Spleen preserving, ±	52/7 (88.1%/11.9%)	53/2 (96.4%/3.6%)	0.1645		
Operation time, ≤255/>255 min	26/33 (44.1%/55.9%)	31/24 (56.4%/43.6%)	0.1889		
Anesthesia time, ≤328/>328 min	25/34 (42.4%/57.6%)	32/23 (58.2%/41.8%)	0.1334		
Intraoperative infusion volume, ≤2200/>2200 mL	27/32 (45.6%/54.4%)	26/29 (47.3%/52.7%)	0.8717		
Intraoperative urinary output, ≤240/>240 mL	32/27 (54.4%/45.6%)	25/30 (45.5%/54.5%9)	0.3484		
Intraoperative fluid balance, ≤1680/>1680 mL	24/35 (40.7%/59.3%)	33/22 (60.0%/40.0%)	0.0392	1.5263 (0.4345–5.357)	0.5061
Intraoperative fluid balance per body weight, ≤30/>30 mL/kg	23/36 (39.0%/61.0%)	34/21 (61.8%/38.2%)	0.0144	0.3956 (0.117–1.354)	0.1359

Note: Data are expressed as number and the percentage.

Abbreviations: 95% CI, 95% confidence interval; BMI, body mass index; e-BL, estimated blood loss; HbA1c, glycated hemoglobin A1c; i-BL, intraoperative blood loss; OR, odds ratio; PC, pancreatic cancer.

is performed together with lymph node dissection, and such lymph node dissection is not performed at hepatectomy or DP for other diseases. Therefore, it is possible that lymph fluid accumulating in the abdominal cavity secondary to the lymph node dissection may dilute the blood, resulting in the overestimation of i-BL during ODP for PC.

When considering the clinical application of our results, it is important to think about the possibilities of misestimation regardless of the actual i-BL amount, which may lead to more intensive care for the patients. Additionally, when studies report decreased i-BL during laparoscopic surgery, the possibility of misestimation should always be kept in mind. However, our present results do not disprove or lessen the advantage that laparoscopic surgery reduces blood loss. Notably, it has been reported that LDP has multiple advantages associated with less blood loss, such as the identification of the detailed anatomical structure and the dissection of tiny vessels with coagulation.[21,22] In this context, the present study results should be taken as a recommendation to properly evaluate the amount of blood loss with consideration of the reduced blood loss due to laparoscopic surgery. For proper evaluation, it is recommended to aspirate the accumulated fluid from the abdominal cavity at the end of LDP as much as possible.

TABLE 3 Demographic information for patients according to surgical approach.

Characteristics	ODP ($n=75$)	LDP ($n=39$)	p value
Preoperative factors			
Age, y	66 ± 15	59 ± 18	0.0380
Sex, male/female	42/33 (56.0%/44.0%)	22/17 (56.4%/43.6%)	0.9666
BMI, kg/m^2	22.4 ± 3.5	21.9 ± 2.8	0.4725
Disease, PC/others	46/29 (61.3%/38.7%)	13/26 (33.3%/66.7%)	0.0043
Hemoglobin, g/dL	12.4 ± 1.4	12.9 ± 1.7	0.1459
Platelets, 10^4/μL	20.3 ± 9.4	22.1 ± 6.3	0.2053
Albumin, g/dL	3.9 ± 0.3	4.0 ± 0.5	0.1902
HbA1c, %	6.3 ± 1.0	5.9 ± 1.1	0.1100
Hematocrit, %			
Preoperative	37.6 ± 4.2	39.2 ± 4.9	0.1029
Postoperative	36.0 ± 4.6	35.3 ± 4.6	0.4050
Intraoperative factors			
Spleen preserving, ±	75/0 (100.0%/0.0%)	30/9 (76.9%/23.1%)	<0.0001
Operation time, min	243 ± 78	327 ± 76	<0.0001
Anesthesia time, min	312 ± 85	402 ± 79	<0.0001
Intraoperative blood loss, mL	281 ± 209	127 ± 160	<0.0001
Estimated blood loss, mL	168 ± 324	388 ± 248	0.0001
Intraoperative infusion volume, mL	2382 ± 1006	2533 ± 880	0.4094
Intraoperative urinary output, mL	338 ± 304	366 ± 333	0.6616
Intraoperative fluid balance, mL	1760 ± 860	2058 ± 799	0.0694
Intraoperative fluid balance per body weight, mL/kg	30.3 ± 13.3	36.8 ± 15.9	0.0305
Total drainage volume via abdominal drainage tubes			
Until the end of the day of surgery, mL	90 ± 60	81 ± 78	0.5087
On the first day after surgery, mL	183 ± 147	147 ± 105	0.1369
Until the end of the first day after surgery, mL	273 ± 185	227 ± 149	0.1592

Note: Data are expressed as the mean ± standard deviation for continuous variables, and the number of patients and the percentage for categorical variables.

Abbreviations: BMI, body mass index; HbA1c, glycated hemoglobin A1c; LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy; PC, pancreatic cancer.

This present study has several limitations. First, the time from the end of the surgery until performance of the postoperative blood tests (the results of which were used for e-BL calculation) was not the same among all patients. The amounts of the infusion fluid and urinary volume were different among the patients, suggesting differences in the timepoint of the e-BL evaluation. Second, e-BL was based on the Gross formula, which was originally designed for use in cases with a normo-volemic situation. Considering our finding that there were significant differences in intraoperative fluid balance and intraoperative fluid balance per body weight between the e-BL > i-BL group and the e-BL < i-BL group, it remains uncertain whether these patients had a normo-volemic situation. Third, there were some exclusion criteria in this study, such as patients who had a history of other abdominal surgery, required other organ resections together with DP, needed intraoperative blood transfusion, underwent other procedures for treating the pancreatic stump, or were converted to an open procedure. This indicates that, for clinical application of our results, we need to pay attention to the exclusion. Lastly, this study design was a retrospective analysis, suggesting the existence of bias in the patients and groups, such as selection bias of the surgical approach. Although we compared the backgrounds of the two groups, the biases must be considered. In the future, our results should be validated with other prospective studies.

The present study demonstrated that e-BL was significantly greater than i-BL in cases of LDP, and that e-BL was significantly less than i-BL in cases of ODP, only among patients with PC. These results suggest the possibility of incorrect evaluation of intraoperative blood loss during DP, not only in patients who undergo LDP but also in those who undergo ODP. We should consider these results when performing postoperative management of patients after DP.

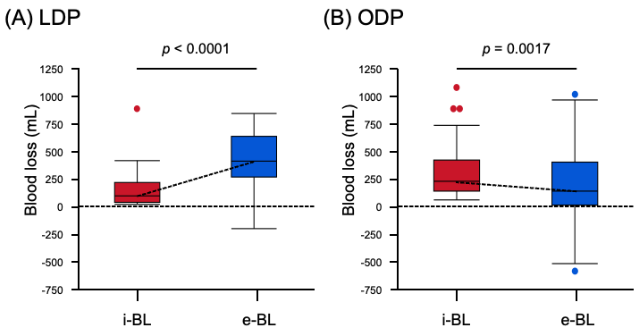

FIGURE 2 Box-and-whisker plots showing blood loss in subgroups stratified according to the surgical approach. (A) Within the LDP group, e-BL was significantly greater than i-BL (388 ± 248 vs 127 ± 160 mL; $p < 0.0001$). (B) Within the ODP group, e-BL was significantly smaller than i-BL (168 ± 324 vs 281 ± 209 mL; $p = 0.0017$). In these plots, the lines within the boxes represent the median values; the upper and lower edges of the boxes represent the 25th and 75th percentiles, respectively; and the upper and lower bars outsides the boxes represent the 90th and 10th percentiles, respectively. An outlier was defined as a data point located outside the whiskers of the boxplot. Dotted lines connect the median values. e-BL, estimated blood loss; i-BL, intraoperative blood loss; LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy.

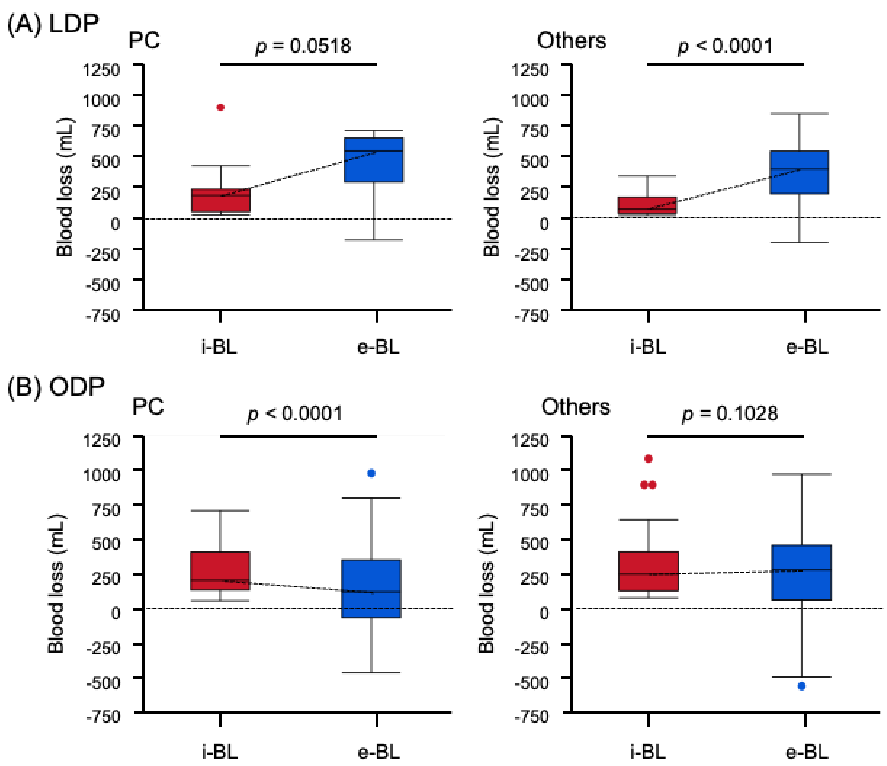

FIGURE 3 Box-and-whisker plots showing blood loss in groups stratified according to diagnosis. (A) Analysis of plots for the LDP group. (Left panel) Among cases diagnosed as pancreatic cancer (PC), e-BL was marginally greater than i-BL (422 ± 251 vs 190 ± 233 mL; $p = 0.0518$). (Right panel) Among cases with diseases other than pancreatic cancer, e-BL was significantly greater than i-BL (371 ± 249 vs 95 ± 96 mL; $p < 0.0001$). (B) Analysis of plots for the ODP group. (Left panel) Among cases diagnosed as PC, e-BL was significantly smaller than i-BL (139 ± 315 vs 268 ± 170 mL; $p < 0.0001$). (Right panel) Among cases with diseases other than pancreatic cancer, there was no significant difference between e-BL and i-BL (215 ± 339 vs 302 ± 261 mL; $p = 0.1028$). In these plots, the lines within the boxes represent the median values; the upper and lower of the boxes represent the 25th and 75th percentiles, respectively; and the upper and lower bars outsides the boxes represent the 90th and 10th percentiles, respectively. An outlier was defined as a data point located outside the whiskers of the boxplot. Dotted lines connect the median values. e-BL, estimated blood loss; i-BL, intraoperative blood loss; LDP, laparoscopic distal pancreatectomy; ODP, open distal pancreatectomy; PC, pancreatic cancer.

AUTHOR CONTRIBUTIONS

Keisuke Toya: Conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing – original draft; writing – review and editing. **Yoshito Tomimaru:** Conceptualization; project administration; writing – review and editing. **Shogo Kobayashi:** Conceptualization; funding acquisition; project administration; supervision; writing – review and editing. **Kazuki Sasaki:** Formal analysis; investigation. **Yoshifumi Iwagami:** Methodology; software. **Daisaku Yamada:** Formal analysis; methodology; visualization. **Takehiro Noda:** Formal analysis; resources. **Hidenori Takahashi:** Conceptualization; supervision; writing – review and editing. **Yuichiro Doki:** Funding acquisition; supervision. **Hidetoshi Eguchi:** Conceptualization; project administration; supervision; writing – review and editing.

ACKNOWLEDGMENTS

The authors have no conflict of interest directly relevant to the content of this article.

FUNDING INFORMATION

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST STATEMENT

Author Y.D. is an editorial member of the *Annals of Gastroenterological Surgery*, but we declare that we have no conflict of interest for this article.

DATA AVAILABILITY STATEMENT

Data that support the results of the present study are available on reasonable request from the corresponding author.

ETHICS STATEMENT

Approval of the research protocol by an Institutional Reviewer Board: This study had a retrospective design and was approved by the Institutional Ethics Review Committee (Certificate Number 22335). Patient consent for participation was obtained through an opt-out method. This study did not include material from other sources.

Informed Consent: Patient consent for participation was obtained through an opt-out method.

Registry and the Registration No. of the study/trial: N/A.

Animal Studies: This study did not include material from other sources.

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How to cite this article: Toya K, Tomimaru Y, Kobayashi S, Sasaki K, Iwagami Y, Yamada D, et al. Possibility of incorrect evaluation of intraoperative blood loss during open and laparoscopic distal pancreatectomy. Ann Gastroenterol Surg. 2025;9:569–577. https://doi.org/10.1002/ags3.12888