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ORIGINAL ARTICLE – BONE AND SOFT TISSUE SARCOMAS

Surgical Strategy and Outcomes in Duodenal Gastrointestinal Stromal Tumor

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ABSTRACT

Background. The surgical management of duodenal gastrointestinal stromal tumors (DGIST) is poorly characterized. Limited resection may be technically feasible and oncologically safe, but anatomic considerations may compromise the resection margins due to the proximity of critical structures, thereby necessitating more extensive resections such as pancreaticoduodenectomy.

Methods. Patients undergoing surgery for DGIST at two institutions from 1994 to 2014 were identified. Clinicopathologic and survival data were analyzed to compare outcomes in patients treated with limited or radical resection.

Results. Sixty patients underwent surgery for DGIST. Pancreaticoduodenectomy was performed in 38 % while the rest underwent limited resections. The most common type of limited resection was wedge resection and primary closure (49 %) followed by segmental resection with an end-to-end or side-to-side duodenojejunostomy (27 %). The pancreaticoduodenectomy group tended to have larger tumors with the majority located in D2/3 (87 %) and at the mesenteric border (91 %). The pancreaticoduodenectomy group also had significantly greater intraoperative blood loss, longer operative time, longer hospital stay, and higher 90-day morbidity and readmission rates. The 5-year relapse-free survival, recurrence-free survival, and overall survival for the pancreaticoduodenectomy versus limited resection were 81 versus 56 % ($p = 0.05$), 64 versus 53 % ($p = 0.5$), and 76 versus 72 % ($p = 0.6$), respectively. A surgical algorithm based on the location and size of the tumor is proposed.

Conclusions. Limited resection of DGIST is safe, but may be associated with lower 5-year relapse-free survival. Pancreaticoduodenectomy is recommended for selected patients with DGIST when an R0 resection cannot be performed without removing the ampulla or part of the pancreas.

Gastrointestinal stromal tumors (GISTs) are the most common mesenchymal tumors of the gastrointestinal tract and arise from the interstitial cells of Cajal.[1] GISTs are characterized by overexpression of the KIT (CD117) tyrosine kinase receptor protein and usually harbor a gain-of-function mutation in either *KIT* or platelet-derived growth factor receptor alpha.[2,3] Historically, nearly 50 % of patients were deceased by 5 years after surgery, but with the development of the tyrosine kinase inhibitor imatinib mesylate (Gleevec, Novartis Pharmaceuticals), outcomes in advanced and metastatic GIST have dramatically improved.[1,4] The standard of care for primary localized GISTs is surgical resection. Segmental resections usually suffice because GISTs do not typically infiltrate adjacent structures, lack submucosal spread, and rarely metastasize to lymph nodes.

Although GISTs occur in the duodenum only 1–5 % of the time, they account for 30 % of primary duodenal neoplasms.[5] The surgical management of duodenal GISTs

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(DGIST), including the optimal procedure and techniques of reconstruction, is not well defined due to the complexity of their anatomic location.[6–10] In particular, there is ongoing debate whether radical surgery such as pancreaticoduodenectomy or a limited resection (LR) is the most appropriate procedure for DGIST.[11] Specifically, LR may be technically feasible and oncologically sound, but anatomic considerations may render it more challenging due to the proximity of critical structures, including the papilla, pancreas, and biliary and pancreatic ducts. Radical resection provides good oncologic control and is warranted in some patients. Although pancreaticoduodenectomy is generally safe and associated with low mortality in specialized centers, its associated morbidity remains.[11,12] Here, we analyze the 20-year experience of the surgical management of DGIST of two referral centers, including technical aspects as well as short- and long-term outcomes.

METHODS

Patients with DGIST who underwent surgery with curative intent from 1994 to 2014 at Memorial Sloan Kettering Cancer Center (MSKCC) and the Singapore General Hospital (SGH) were identified. Medical records were reviewed for clinicopathologic variables, comorbidities, medical treatment (e.g., imatinib mesylate or sunitinib), tumor characteristics, and operative data (e.g., type of resection and reconstruction, blood loss, transfusion, operative time). Pathologic data (tumor location, size, margins, and mitoses per 50 high-power fields [HPF]) and outcomes such as hospital stay, readmissions, adjuvant therapy, recurrence, and survival were also analyzed. Approval for the study was obtained from each center's institutional review board.

The preoperative assessment included a complete history and physical examination, laboratory investigations, and in many cases endoscopy with endoscopic ultrasonography and biopsy. Routine imaging consisted of triphasic computed tomography or magnetic resonance imaging of the abdomen and pelvis. Patients with DGIST were discussed at a weekly multidisciplinary disease management conference, which included gastrointestinal and hepatopancreatobiliary surgeons, medical oncologists, radiologists, gastroenterologists, and pathologists. The decision for neoadjuvant therapy was made by the primary surgeon and consensus at a multidisciplinary conference. The rationale for neoadjuvant therapy was an attempt to downstage the disease to avoid a radical resection if possible. The strategy of neoadjuvant treatment was initiated in 2002. The response to neoadjuvant treatment was assessed with Response Evaluation Criteria in Solid Tumors (RECIST version 1.1) and Choi response criteria with computed tomography at least every 3 months.[13,14] Adjuvant imatinib was implemented as part of a clinical trial in 2002 (MSKCC).[15] Decisions on adjuvant therapy were made by the primary surgeon and the medical oncologist with a multidisciplinary tumor board. In general, tumors that were regarded as high Miettinen risk or those with R1 or close margins were considered for adjuvant therapy (SGH).

Decision for a radical resection (i.e., pancreaticoduodenectomy) or a local resection was made primarily by the attending surgeon based on a variety of factors, including tumor size, location (D1/2/3/4), and especially the proximity to the mesenteric border. Technical and oncologic considerations included the proximity to the ampulla or pancreas, adequacy of margins, and feasibility of bowel reconstruction. Generally, if the tumor was large, located in D2 or D2/3, or near the mesenteric border, pancreaticoduodenectomy was chosen.

Pancreaticoduodenectomy was performed at MSKCC using a previously reported technique.[16] The technique of pancreaticoduodenectomy and LR for GIST at SGH has also been previously described.[9,10] Pathologic specimens were reviewed by a sarcoma or gastrointestinal pathologist. The diagnosis of GIST was based on standard criteria—consistent histologic features and immunohistochemistry that included CD117.[17] Locoregional recurrence was defined as the recurrence at or near the initial site of the primary tumor or resection bed. Distant recurrence was defined as peritoneal, liver, or extra-abdominal disease.

Relapse-free survival (RpFS) was calculated from the date of surgery to the first recurrence. Recurrence-free survival (RFS) and overall survival (OS) were calculated from the date of surgery to the first recurrence or death or until the time of death, respectively. Patients who did not experience the event of interest by the end of the study were censored at the time of last follow-up. Survival rates were estimated using the Kaplan–Meier method and stratified log-rank test. Analyses were performed using statistical software (SPSS software, version 21). Continuous variables were compared using the Student t test or Mann-Whitney test, as appropriate for the type of distribution. Categorical variables were compared using $\chi 2$ or the Fisher exact test depending on the number of observations. Two-tailed statistical analyses were used to calculate p values, and $p < 0.05$ was considered significant.

RESULTS

Patient and Tumor Characteristics

A total of 60 patients with DGIST was included (MSKCC $n = 37$; SGH $n = 23$). Males comprised 52 % ($n = 31$) of the group, and the median age was 58 [interquartile range (IQR), 50–69 years]. The majority

($n = 37$, 62 %) underwent some type of LR while the remaining patients ($n = 23$, 38 %) had a pancreaticoduodenectomy (Table 1). The most common tumor site was D2 or D2/D3 junction ($n = 38$, 63 %), followed by D3 or D3/D4 junction ($n = 13$, 22 %). Tumor locations are summarized in Fig. 1a.

Neoadjuvant Therapy

Six (10 %) patients received neoadjuvant imatinib (400 mg per day), one of whom also received sunitinib (50 mg per day) as second-line therapy. The median duration of neoadjuvant treatment was 6.5 months (IQR, 2–18 months), with resulting stable disease in four patients (67 %) and partial response in two patients (23 %) according to the Response Evaluation Criteria in Solid Tumors (RECIST version 1.1) and Choi response criteria.[13,14] Of these six patients, three required pancreaticoduodenectomy, three received LR and all achieved an R0 resection. In the two cases of partial response, one patient underwent a pancreaticoduodenectomy and one patient underwent LR.

Surgical Techniques and Complications

The most common type of LR was wedge resection and primary closure (49 %), followed by a segmental resection with an end-to-end or side-to-side duodenojejunostomy (27 %). The different types of LR and reconstruction are summarized and illustrated in Table 2 and Fig. 1b. Pancreaticoduodenectomy at MSKCC was performed with a pancreaticojejunostomy, while pancreaticogastrostomy was used at SGH.

There was greater intraoperative blood loss for pancreaticoduodenectomy (1000 vs. 200 ml, $p = 0.001$), although perioperative transfusions were not different. The median operating time was longer in the pancreaticoduodenectomy group versus LR group (317 vs. 140 min, $p < 0.001$). Overall 90-day morbidity and Grade 3 or worse complications were higher in the pancreaticoduodenectomy group than in the LR group (70 vs. 24 %, $p = 0.001$; 43 vs. 5 %, $p = 0.001$, respectively; Table 3). There was no 90-day postoperative mortality in either group. After pancreaticoduodenectomy, the median duration of hospital stay was longer (11 vs. 8 days, $p = 0.003$) with a significantly higher 30- and 90-day readmission rate than in the LR group (30 days, 39 vs. 3 %, $p < 0.001$; 90 days, 39 vs. 11 %, $p = 0.02$) (Tables 1, 2).

Pathologic Findings

The tumors tended to be larger in the pancreaticoduodenectomy group (median 80 vs. 45 mm, $p = 0.1$). The majority of patients who underwent pancreaticoduodenectomy had tumors located in D2 or D2/D3 junction (87 vs. 49 %) and involving the mesenteric/pancreatic aspect (91 vs. 5 %, $p < 0.001$). All patients in the pancreaticoduodenectomy group had an R0 resection compared to 84 % in the LR group ($p = 0.1$). According to the Miettinen risk classification, 10 (43 %) GISTs in the pancreaticoduodenectomy group were considered at high risk of recurrence compared to 14 (38 %) in the LR group ($p = 0.8$) (Table 1).[18]

Adjuvant Treatment and Survival

Adjuvant therapy (imatinib mesylate, 400 mg per day) was initiated in 15 patients (25 %) with a median treatment length of 18.5 months (IQR, 10.5–38.2 months); 6 were in the pancreaticoduodenectomy group and 9 in the LR group (26 vs. 25 %, $p = 0.9$). There was no difference in the median duration of adjuvant therapy between the 2 groups [pancreaticoduodenectomy: 18.5 months (IQR, 10.5–43 months) vs. LR: 18.5 months (IQR, 5–41 months); $p = 0.8$).

Overall, 15 patients (25 %) had experienced recurrence at a median of 72 months (RpFS). Fourteen (93 %) recurrences were distant (all in the liver) and 1 (7 %) was locoregional (peritoneal nodule near previous resection bed). There were no significant differences in the recurrence pattern between the pancreaticoduodenectomy and LR groups ($p = 0.46$), although the numbers were small. For the entire population, after a median follow-up of 38 months (IQR, 21–72 months), the median RpFS, RFS, and OS were 72, 69, and 95 months, respectively. Compared to LR, pancreaticoduodenectomy had a trend to improved median RpFS (not reached vs. 60 months, $p = 0.05$), but similar median RFS ($p = 0.5$) and median OS ($p = 0.6$). The 5-year RpFS, RFS, and OS for the pancreaticoduodenectomy group versus the LR group were 81 versus 56 %, 64 versus 53 %, and 76 versus 72 %, respectively (Table 1; Fig. 2).

DISCUSSION

Duodenum GISTs are rare and surgically challenging due to the complex anatomy and intricate relationship of critical structures in a small area.[19] About a third of small-bowel GISTs are located in the duodenum.[11,20,21] In a large study on DGIST by Miettinen et al., the most frequent site was the second portion of the duodenum, followed by the third, fourth, and first portion, similar to our findings (Fig. 1a).[22]

Surgical resection is the treatment of choice, with resection with negative margins and avoidance of tumor rupture the critical goals. The optimal procedure for DGIST remains controversial and should be tailored to the tumor location and size and patient's fitness. There are only a handful of

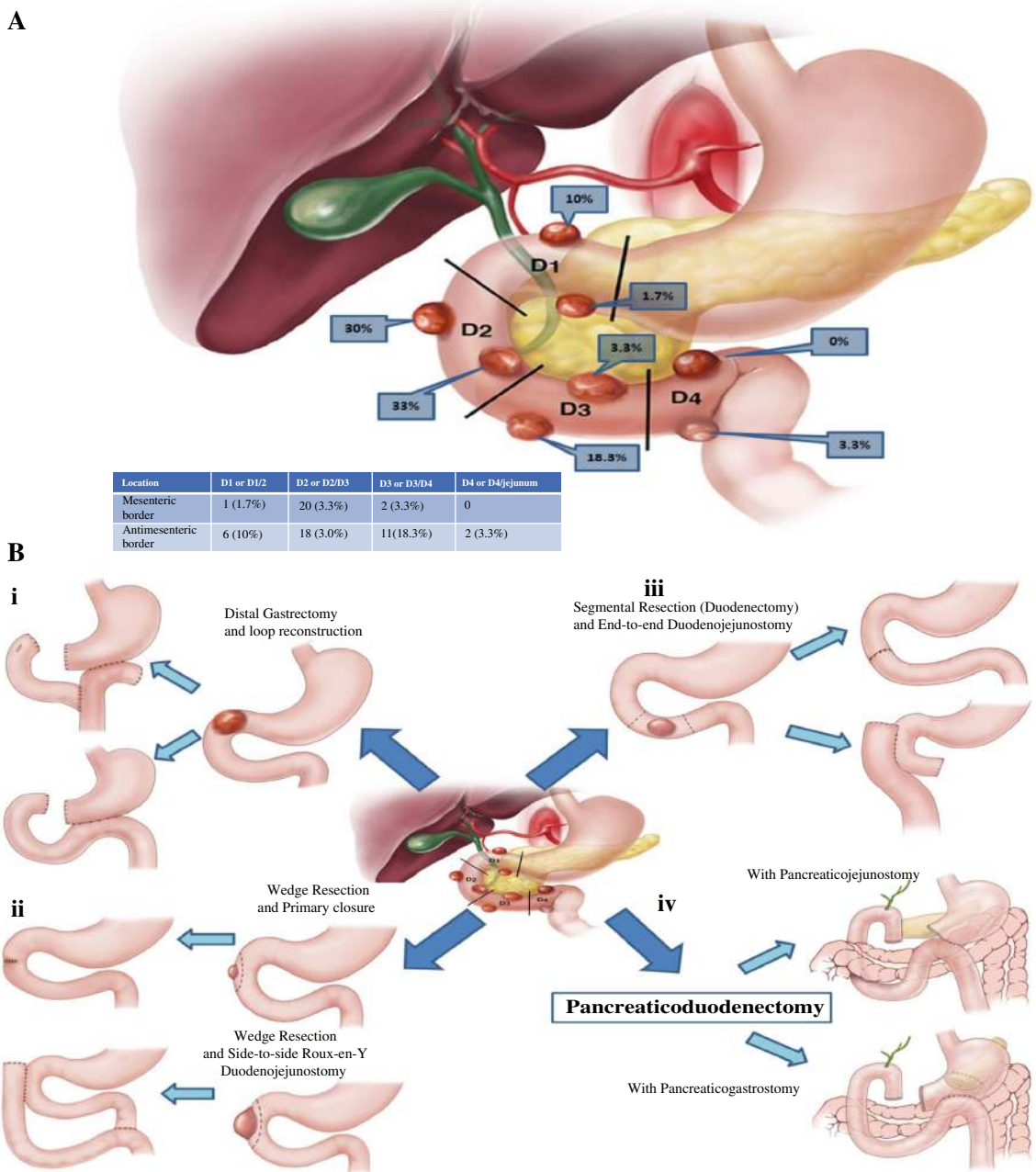
TABLE 1 Radical versus limited resection

Variable	Total	Radical resection	Limited resection	P^a
Demographic data				
No. of patients	60	23 (38 %)	37 (62 %)	NA
Male gender	31 (52 %)	15 (65 %)	16 (43 %)	0.1
Age, years	58 (50–69)	57 (49–69)	59 (50–70)	0.3
Median ASA	2 (2–2)	2 (1–2)	2 (2–2)	0.5
Follow-up, mo	38 (21–72)	65 (22–84)	26 (17–51)	0.03
Operative details				
Estimated blood loss, ml	400 (100–1560)	1000 (500–1560)	200 (100–475)	0.001
Blood transfusion, U	0 (0–1)	0 (0–1)	0 (0–0)	0.9
Operative time, min	235 (131–306)	317 (253–350)	140 (110–236)	<0.001
Postoperative outcomes				
90 days morbidity	25 (42 %)	16 (70 %)	9 (24 %)	0.001
90 days mortality	0	0	0	NA
Grade 3 or higher complications	12(20 %)	10 (43 %)	2 (5 %)	0.001
Length of hospital stay	9 (7–14)	11 (8–19)	8 (7–10)	0.003
Patients requiring ICU stay	3 (5 %)	1 (4 %)	2 (5 %)	1
30 days readmission	10(17 %)	9 (39 %)	1 (3 %)	<0.001
90 days readmission	13(22 %)	9 (39 %)	4 (11 %)	0.02
Tumor characteristics				
Tumor size, mm	52 (35–88)	80 (40–95)	45 (30–72)	0.1
Site of tumor				0.08
D1 or D1/D2 junction	7 (12 %)	1 (4 %)	6 (16 %)	
D2 or D2,3 junction	38 (63 %)	20 (87 %)	18 (49 %)	
D3 or D3,4 junction	13 (22 %)	2 (9 %)	11 (30 %)	
D4 or D4/jejunum junction	2 (3 %)	0	2 (5 %)	
Site of tumor at mesenteric border	23 (38 %)	21 (91 %)	2 (5 %)	<0.001
Mitotic figures/50 HPF	3 (1–10)	4 (1–15)	2.5 (1–7.25)	0.5
Miettinen risk[18]				
Very low/low risk	24(40 %)	8 (35 %)	16 (43 %)	0.8
Intermediate risk	12 (20 %)	5 (22 %)	7 (19 %)	
High risk	24 (40 %)	10 (43 %)	14 (38 %)	
Resection status				
R0	54 (90 %)	23 (100 %)	31 (84 %)	0.1
R1	6 (10 %)	0	6 (16 %)	
Adjuvant therapy e.g., imatinib mesylate	15 (25 %)	6 (26 %)	9 (25 %)	0.9
Survival outcome				
No. of patients with recurrence	15 (25 %)	5 (22 %)	10 (27 %)	0.7
Type of recurrence				0.46
Locoregional	1 (7 %)	0	1 (10 %)	
Distant	14 (93 %)	5 (100 %)	9 (90 %)	
RpFS, mo, median (95 % CI)	72 (51-NR)	Not reached	60 (40–80)	0.050
5 years RpFS, % (95 % CI)	69 % (52–85)	81 % (62–99)	56 % (29–83)	
RFS, mo, median (95 % CI)	69 (56–82)	72 (31-NR)	60 (40–80)	0.5
5 years FS, % (95 % CI)	60 % (44–76)	64 % (43–86)	53 % (28–79)	
OS, mo, median (95 % CI)	95 (49–141)	Not reached	86 (56–116)	0.6
5 years OS, % (95 % CI)	75 % (61–89)	76 % (57–94)	72 % (49–94)	

Continuous variables are presented as median (interquartile range); categorical variables are presented as *n* (%)

ASA American Society of Anesthesiologist, *HPF* high power field, *ICU* intensive care unit, *RpFS* relapse-free survival, *RFS* recurrence-free survival, *OS* overall survival, *NR* not reached

[a] Univariate analysis performed for radical resection and limited resection groups only, not whole cohort



Location	D1 or D1/2	D2 or D2/D3	D3 or D3/D4	D4 or D4/jejunum
Mesenteric border	1 (1.7%)	20 (3.3%)	2 (3.3%)	0
Antimesenteric border	6 (10%)	18 (3.0%)	11(18.3%)	2 (3.3%)

FIG. 1 Resection and reconstruction options by location of duodenal gastrointestinal stromal tumor (GIST). **a** Location of duodenal GISTs classified according to duodenal site and mesenteric versus antimesenteric border. *D1* first part of duodenal, *D2* second part of duodenum, *D1/2* junction between D1 and D2, *D3* third part of duodenum, *D2/3* junction between D2 and D3, *D4* fourth part of duodenum, *D3/4* junction between D3 and D4, *D4/jejunum* junction between D4 and jejunum. **b** Various techniques and options of resection and reconstruction of duodenal GISTs according to location and size. *i* Distal gastrectomy for D1 GIST followed by either Roux-en-Y or loop reconstruction. *ii* Wedge resection of D2 GIST followed by primary closure if amenable, with side-to-side Roux-en-Y duodenojejunostomy if not. *iii* Segmental resection of D2 or D2/3 GIST with end-to-end or side-to-side duodenojejunostomy. *iv* Resection of mesenteric based GIST via pancreaticoduodenectomy with either pancreaticojejunostomy or pancreaticogastrostomy loop reconstruction

retrospective studies directly comparing perioperative and long-term outcomes of radical resections, such as pancreaticoduodenectomy, to LR in the management of DGISTs.[11] However, available data suggest that in selected patients, LR is safe and oncologically comparable to radical resection.[10,11,23,24] A recent meta-analysis compared 162 patients who underwent LR and 98 patients who underwent pancreaticoduodenectomy. Tumors in patients who underwent

TABLE 2 Limited resection/reconstruction procedures

Procedure	*n* (%)
Wedge resection and primary closure	18 (49)
Segmental resection end-to-end duodenojejunostomy or side-to-side Roux-en-Y duodenojejunostomy	10 (27)
Wedge resection with side-to-side Roux-en-Y duodenojejunostomy	6 (16)
Distal gastrectomy with loop or Roux-en-Y gastrojejunostomy	3 (8)

TABLE 3 Complications of any grade

Complication	Whole population (%)	Radical resection (%)	Limited resection (%)
Pancreatic fistula	3 (5)	2 (9)	1 (3)
Anastomotic bowel leak	4 (7)	3 (13)	1 (3)
Bile leak	2 (3)	2 (9)	0
Pancreatitis	2 (3)	2 (9)	0
Intra-abdominal collection, abscess, or infection	14 (23)	12 (52)	2 (5)
Intra-abdominal bleeding or hematoma	2 (3)	2 (9)	0
Paralytic ileus, delayed gastric emptying	6 (8)	3 (13)	3 (8)
Ascites	5 (8)	3 (13)	2 (5)
Pleural effusion/pneumonia	11(19)	7 (30)	4 (11)
Wound infection/line sepsis/urinary tract infection	6 (10)	3 (13)	3 (8)
Acute renal failure	2 (3)	1 (4)	1 (3)
Acute coronary syndrome (e.g., myocardial infarction)	1 (2)	0	1 (3)

pancreaticoduodenectomy were more likely to be larger (≥5 cm; 76 vs. 37 %, odds ratio [OR] 5.5), located at D2 (81 vs. 29 %, OR 10), have a high mitotic count (≥5/50 HPF; 34 vs. 19 %, OR 2.2), and be classified as high risk (60 vs. 32 %, OR 3.2) compared to tumors in patients who underwent LR. This study also found that LR was associated with a lower postoperative morbidity rate than pancreaticoduodenectomy (20.7 vs. 48.3 %, RR: 0.43) and not associated with an increased rate of local recurrence. LR had better disease-free survival compared to pancreaticoduodenectomy (hazard ratio 2.07) and a lower rate of distant metastasis (9 vs. 26 %, OR 0.28).[11] In contrast, we did not find a statistical difference in RFS or OS between local resection and pancreaticoduodenectomy in our data, although there was a trend toward improved RpFS ($p = 0.05$) in favor of radical resection (Table 1; Fig. 2). Referral bias, difference in the follow-up period between the two groups, limited sample size and patient selection likely account for disparate findings.

Surgical Techniques

The main concern regarding LR for GISTs is the risk of involved margins and the accompanying theoretical increased risk of local recurrence, especially for large tumors in the pancreaticoduodenal complex due to the proximity of critical structures.[11,25–27] Achieving wide margins in the duodenum is not always possible; margins of fewer than 5 mm after resection of duodenal tumors are not uncommon.[9] We found that only 84 % of LR were R0 resections versus 100 % in the pancreaticoduodenectomy group. This may be relevant as there was a trend favoring RpFS for the pancreaticoduodenectomy group ($p = 0.05$), despite the pancreaticoduodenectomy group having larger tumors. However, this did not translate to a difference in RFS or OS between the 2 groups. These similar outcomes may be related to the use of effective adjuvant therapy such as imatinib, especially in patients with high-risk tumors.

Different techniques of LR and reconstruction for DGIST have been described according to the site and the size of the tumor.[9,10,12,23,24] The various procedures and types of reconstruction are illustrated in Fig. 1b. A surgical algorithm based on the site and size of the tumor is outlined in Fig. 3. Currently, there is no established consensus or algorithm guiding the type of resection for DGIST. For tumors in D1/D2 proximal to the ampulla, distal gastrectomy with a loop or Roux-en-Y gastrojejunostomy is an option (Fig. 1bi). Wedge resection with primary closure can be performed for small tumors, especially those on the antimesenteric border regardless of location, if preservation of the ampulla is possible and the remnant bowel lumen is adequate (Fig. 1bii).[9,22] For larger tumors where the

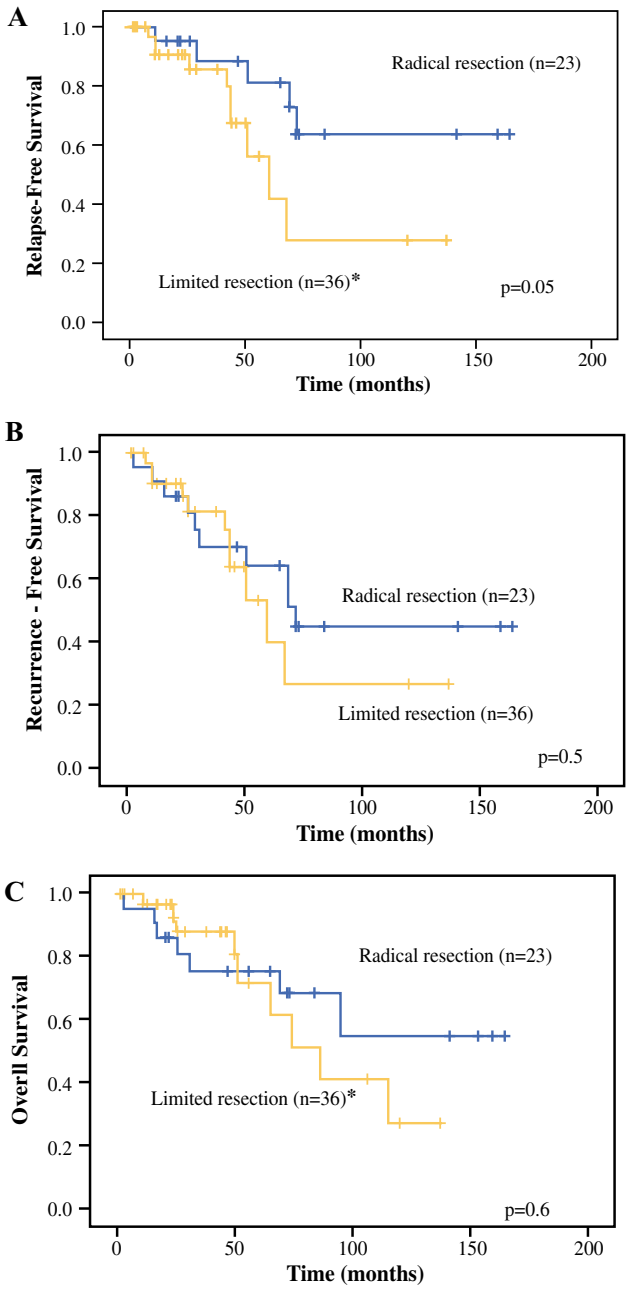


FIG. 2 Outcomes after surgery. **a** Relapse-free survival. **b** Recurrence-free survival. **c** Overall survival. *Asterisk* one patient in limited resection group was excluded from survival analysis because of missing follow-up data

resultant defect cannot be approximated without tension or compromising the bowel lumen, a Roux-en-Y duodenojejunostomy can be performed (Fig. 1bii).[9,10] Segmental duodenectomy with side-to-end or end-to-end duodenojejunostomy for larger tumors located distal to ampulla at D3/4 has also been described (Fig. 1biii).[9]

For tumors in D2/D3, located at the mesenteric or medial aspect involving the ampulla or the pancreas, major resection via a pancreaticoduodenectomy or a pancreas-sparing duodenectomy may be necessary.[28,29] In our combined experience, the majority ($n = 38$, 63 %) of the patients have tumors at D2/3, of which approximately half ($n = 18$, 47 %) are amenable to LR. The remaining 20 patients (53 %) with tumors located at D2/3 had involvement of the mesenteric border, thus requiring a pancreaticoduodenectomy (Fig. 1biv). Overall, we achieved an overall negative margin rate of 90 % (Table 1). In this study, patients who underwent pancreaticoduodenectomy tended to have larger tumors and tumors located at D2/3 compared to patients who underwent LR. This tendency was not statistically significant.

Role of Neoadjuvant Therapy

Neoadjuvant imatinib has been utilized when an extended procedure is necessary, such as a pancreaticoduodenectomy for DGIST or abdominoperineal resection for rectal GIST is required. There is uncertainty whether residual microscopic disease at the resection margin will affect outcome, particularly if the patient is treated with postoperative imatinib.[30] Repeat resection is recommended when the site of remnant microscopic disease can be identified and when the oncologic benefits of repeat resection outweigh surgical morbidity. Prospective, nonrandomized studies have been conducted to evaluate preoperative imatinib for treatment of locally advanced GIST.[31–33] In these studies, most GISTs became smaller and less vascular with 2–6 months of preoperative imatinib; these results might facilitate a LR and allow organ-sparing surgery.[34] In our series, only 6 (10 %) patients received neoadjuvant imatinib, one of whom went to sunitinib as second-line therapy, with 67 % having stable disease and 23 % with a partial response. Three members of the neoadjuvant group (50 %) required pancreaticoduodenectomy and 3 (50 %) received LR. Of the two patients with partial responses, one required a pancreaticoduodenectomy and the other a LR; all 6 had an R0 resection. We recommend neoadjuvant therapy to be used selectively in locally advanced GISTs that are not amenable to LR or preservation of the pancreas, although clinical judgment is necessary to estimate the likelihood of conversion to a LR.

This study's retrospective, nonrandomized design, with its inherent biases in areas such as patient selection, is its biggest limitation. The details of the decision making in each case were not well captured due to the retrospective nature of the study (e.g., the precise reasons why LR was chosen over a radical resection or why neoadjuvant or adjuvant therapy was administered). In general, this was primarily based on the attending surgeon's assessment and consensus at a multidisciplinary disease management conference. Due to the limited numbers and the retrospective nature of the study, we are not able to

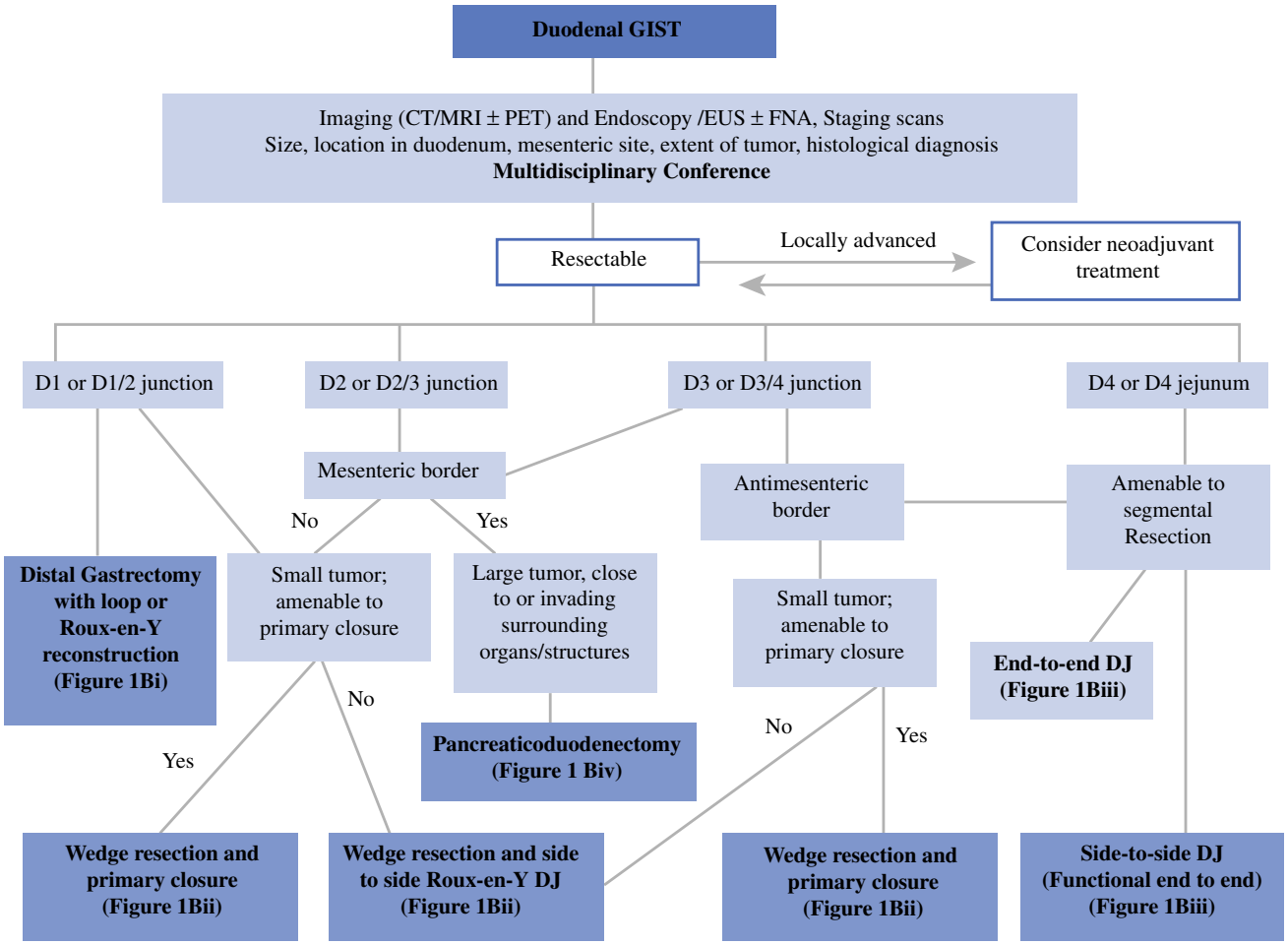


FIG. 3 Algorithm for surgical management of duodenal gastrointestinal stromal tumors. *Arrow* indicates possible option. *CT* computed tomography, *MRI* magnetic resonance imaging, *EUS* endoscopic ultrasound, *FNA* fine needle aspiration, *D1/2/3/4* first, second, third, fourth portion of duodenum, *DJ* duodenojejunostomy

meaningfully study important factors such as Eastern Cooperative Oncology Group (ECOG) performance status, Miettinen risk, and the role of imatinib therapy (neoadjuvant or adjuvant) on outcome. However, the proportion of patients in each group who received pre- or postoperative therapy was similar. The ASA class (as a surrogate of ECOG performance status) and the proportion of patients in each Miettinen risk group was also not significantly different (Table 1). Taking that information into consideration, the pattern of recurrence (local vs. distant), RFS, and OS were not significantly different in the 2 groups. The disease spectrum and management between the different institutions may also vary, but as DGIST is uncommon, the culmination of the experience of different institutions contributes to the knowledge base and clarifies the strategy of DGIST. There are limited data in the literature to unequivocally establish LR as the procedure of choice for amenable tumors, as the studies and the descriptive nature of the available data have inherent selection and publication biases as well, although LR seems to be appropriate in carefully selected patients.[11]

CONCLUSIONS

While LR may result in lower RpFS, in terms of RFS and OS it is a safe and oncologically comparable procedure for selected patients with DGIST compared to more radical resection, probably due to this tumor type's low propensity for lymphatic metastasis and limited submucosal spread. LR has the advantage of avoiding radical surgery and its potential complications if the tumor is in an anatomically advantageous location. Our proposed surgical strategy can help guide the procedure of choice for DGIST.

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