Research Square

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From fragile anastomosis to safer reconstruction: fishhook suture technique enhances anastomotic safety after transanal endoscopic intersphincteric resection: a propensity score-matched cohort study

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Abstract

Background

Anastomotic leakage (AL) is a major complication after sphincter-preserving surgery for low and ultra-low rectal cancer, significantly impairing postoperative recovery and quality of life. Although transanal endoscopic intersphincteric resection (taE-ISR) has emerged as a novel sphincter-preserving procedure for ultra-low rectal cancer, its AL rate remains relatively high because hand-sewn coloanal anastomosis is technically demanding in the narrow transanal workspace. In this retrospective study, Fishhook suture was used in place of the conventional 3 − 0 Vicryl suture for coloanal anastomosis, and its efficacy in reducing AL and improving perioperative outcomes was evaluated.

Methods

Patients who underwent taE-ISR were retrospectively analyzed. After 1:1 propensity score matching (PSM), patients were stratified into Fishhook (n = 62) and Vicryl (n = 62) groups. Baseline characteristics, perioperative outcomes, pathological outcomes, anastomotic leakage rates and follow-up were compared. A nomogram model was established based on logistic regression to predict AL risks.

Results

After PSM, the Fishhook group demonstrated shorter operative time (135 min vs. 152.5 min, P < 0.001), reduced postoperative hospital stay (6 vs. 7 days, P < 0.001) and lower AL rate (8/62, 12.9% vs. 19/62, 30.6%, P = 0.030). Clinical AL was also reduced (3/62, 4.8% vs. 11/62, 17.7%, P = 0.044). No significant differences were observed in overall survival (P = 0.970) or disease-free survival (P = 0.660). Suture type, hypoproteinemia, body mass index, T stage, and diabetes were factors influencing AL. The area under the curve (AUC) for the nomogram reached 0.910.

Conclusion

The Fishhook suture was safe and effective in reducing AL rates and improved perioperative outcomes after taE-ISR. It conferred significant clinical value for coloanal anastomosis in ultra-low rectal cancer.

Introduction

Transanal endoscopic intersphincteric resection (taE-ISR) has emerged as a promising technique conducive to anal preservation, combining the advantages of transanal total mesorectal excision with intersphincteric resection to achieve precise dissection under magnified laparoscopic vision [1]. However, the coloanal anastomosis following ISR is positioned below the anorectal ring, where the neorectum and its mesentery are constrained within the anal canal, and is exposed to considerable longitudinal tension,

as well as transverse tension derived from the contraction of the anal sphincter [2]. Accordingly, the risk of anastomotic leakage after conventional ISR surgery still remains high, with reported incidence rates ranging from 8.9% to 18.0% [3–5]. AL leads to significant morbidity, prolonged hospitalization, increased permanent enterostomy rates, failure of anal preservation and potentially compromised oncological outcomes [6].

Currently, the management of ultra-low rectal cancer involves complex multidisciplinary strategies. With the optimization of neoadjuvant treatment regimens, an increasing proportion of patients with locally advanced rectal cancer are undergoing sphincter-preserving surgery [7]. Nevertheless, neoadjuvant therapy induces tissue oedema and fibrosis, rendering precise anastomosis more challenging [6, 8]. In this context, the conventional 3 – 0 Vicryl suture technique, which employs absorbable sutures with repetitive knot-tying, remains technically challenging within the confined transanal workspace. Due to the geometric constraints of standard needles, achieving stable needle passage in the deep pelvic cavity is often difficult. This is not only time-consuming but also may result in uneven tension distribution along the anastomotic line [9, 10], further exacerbating this predicament.

Several strategies have been proposed to address these limitations. Barbed sutures, with their self-anchoring properties that eliminate knot-tying, have demonstrated reduced operative time without increasing complications in gastrointestinal anastomosis [11–13]. Intraoperative reinforcement sutures have been associated with reduced AL risk in laparoscopic rectal cancer surgery [14]. The fishhook needle (Fig. 1), denominated by its needle configuration (27-mm 5/8 circle taper needle), was also introduced as a solution with its unique structure and has also been employed in anal anastomosis in narrow operative fields [11, 15]. However, the application of fishhook suture in taE-ISR has not been systematically validated. Furthermore, existing AL prediction models have focused exclusively on patient-related factors, without integrating modifiable surgical techniques [16, 17].

Therefore, on the premise of ensuring oncological safety, we seminally employed the fishhook suture technique in the process of bowel reconstruction during taE-ISR. This study aimed to compare perioperative outcomes, AL rates, long-term oncological outcomes between the Fishhook suture and conventional 3 – 0 Vicryl interrupted sutures in low and ultra-low rectal cancer patients receiving taE-ISR procedure.

Methods

Study Design and Patients

This study was designed as a retrospective investigation and carried out at Ruijin Hospital. All surgeons involved in the study were proficient in performing taE-ISR. Patients who underwent taE-ISR for primary rectal cancer between 2020 and September 2025 were enrolled in this study.

Patients met all of the following criteria were eligible for inclusion: (1) Age: 18–75 years old; (2) Histologically confirmed rectal cancer; (3) The tumor was confirmed to be less than or equal to 5 cm from the anal verge by preoperative digital rectal examination, colonoscopy, and imaging; (4) Preoperative CT or MRI were used to rule out distant metastasis; (5) Preoperative staging was confirmed as (y)cT0-3N0-2M0; (6) Patients with stage T4 disease achieved tumor downstaging following neoadjuvant therapy.

Patients met any of the following criteria were excluded: (1) Emergency surgery; (2) Patients did not undergo R0 resection; (3) Patients who underwent concurrent resection of other abdominal or pelvic organs during surgery; (4) Patients with a history of other malignant tumors within the 5 years before surgery.

The study was approved by the Ethics Committee of Ruijin Hospital (Approval number: 2019-82) and informed consent was waived due to the retrospective design.

Surgical Technique

All procedures were performed by the same experienced colorectal surgical team, with each surgeon having accrued more than 100 taE-ISR cases before initiation of this study. For taE-ISR,

after specimen excision, the proximal colon was fully mobilized to reach the anal canal without tension, followed by coloanal anastomosis under direct vision. Patients were divided into two groups according to the type of suture needle used: the fishhook suture group and the conventional 3 − 0 Vicryl suture group. For the conventional approach, 8–12 interrupted absorbable sutures were utilized (3 − 0 Vicryl, 26-mm 1/2 circle taper needle). Each suture took full-thickness bites of the colonic wall with 3–4 mm from the resection margin, as well as the internal sphincter complex. Sutures were placed circumferentially at 3–4 mm intervals. The fishhook suture group adopted the same single-layer, full-thickness suturing technique as the conventional group (Fig. 2) [9, 10].

All sutures were evenly tied in both groups, with an air-leak test routinely performed after anastomosis to verify the integrity and watertightness of the anastomotic stoma. A protective loop ileostomy was routinely constructed in all patients and reversed 3–6 months postoperatively after confirmation of anastomotic integrity.

Definition of AL

AL was defined and graded according to the criteria proposed by the International Study Group of Rectal Cancer (ISREC). Briefly, AL was defined as a defect of intestinal wall integrity at the anastomotic site, resulting in communication between the intraluminal and extraluminal compartments [18].

AL was classified as grade A, B, or C according to the required level of intervention. grade A (radiological finding requiring no intervention), grade B (requiring therapeutic intervention but not reoperation), and grade C (requiring reoperation). Clinical AL was defined as grade B or C leakage.

Assessment of defecation dysfunction

After ileostomy reversal, a standardized anal function questionnaire was utilized to evaluate patients' anal function. The questionnaire employed the Wexner Incontinence Score (WIS), which assesses five domains: gas incontinence, liquid stool incontinence, solid stool incontinence, pad usage, and lifestyle changes. Regarding the scoring system, each domain was rated on a scale from 0 to 4, yielding a total score of 20. A score of more than or equal to10 was classified as severe incontinence, 5 to 9 as moderate incontinence, and 0 to 4 as normal anal function, among which those with a score of more than or equal to 10 were considered positive.

Data Collection

Patient baseline characteristics, perioperative outcomes, pathological results, and long-term follow-up data were retrospectively recorded. Postoperative complications within 30 days were evaluated according to the Clavien-Dindo classification [19]. Hypoproteinemia was defined as serum total protein less than 60 g/L or albumin less than 35 g/L.

Follow-up

Patients were followed up every 3 months for the first 2 years and every 6 months thereafter. Overall survival (OS) was defined as the time from surgery to death from any cause. Disease-free survival (DFS) was defined as the time from surgery to local recurrence, distant metastasis, or death.

Propensity Score Matching

To mitigate the impact of baseline characteristic differences, PSM was conducted based on the following factors: age, gender, BMI, diabetes, hypertension, ASA grade, hypoproteinemia, neoadjuvant chemotherapy, neoadjuvant radiotherapy, neoadjuvant immunotherapy, tumour distance, hemoglobin. These factors have been identified in prior literature as well-validated confounders or prognostically relevant factors correlated with the study outcomes in rectal cancer surgical cohorts. Their inclusion was intended to harmonize the covariate distribution between the fishhook suture and 3 – 0 Vicryl suture groups, thereby mitigating potential confounding bias and approximating the design of a randomized controlled trial as closely as feasible. Nearest-neighbor matching (1:1) with a caliper of 0.25 was utilized to balance the dual aims of identifying eligible matches for as many subjects as feasible and ensuring that matched counterparts were truly comparable in terms of propensity score distribution.

Establishment of Nomogram Model

A nomogram model was established based on logistic regression analysis. Each variable had its own score scale. Given the limited sample size, multivariate analysis was not performed. The predictive accuracy was assessed through calibration plots. The receiver operating characteristic (ROC) curves were plotted using “pROC” package. The AUC was used to assess the predictive ability.

Statistical Analysis

A two-sided P value of less than 0.05 was considered statistically significant. Continuous data were presented as median [interquartile range], while categorical data were expressed as percentages. Categorical variables were analyzed using chi-square test or Fisher’s exact test. Continuous variables were analyzed using Mann-Whitney U test. Survival curves were estimated using the Kaplan-Meier method and compared using log-rank test. All statistical analyses were performed using R (version 4.5.2).

Results

Baseline characteristics

A total of 161 patients were included in the study, with 84 cases in the Fishhook group and 77 cases in the Vicryl group. Table 1 displayed the baseline characteristics. Before PSM, no significant differences were observed between groups except for a trend toward higher female proportion (39.3% vs. 24.7%, P = 0.070) and lower hemoglobin concentration (120.5 g/L vs. 126 g/L, P = 0.081) in the Fishhook group.

After 1:1 PSM, 124 patients (62 per group) were included for analysis. All standardized mean differences were less than 0.1, indicating a satisfactory balance. The two groups were well-matched for gender (male 64.5% vs. 71.0%, P = 0.564), and hemoglobin (125.5 [115.0, 135.0], P = 0.994) (Table 1).

Table 1
Baseline characteristics before and after propensity score matching

Variable	Before PSM			After PSM		
	Fishhook (n = 84)	Vicryl (n = 77)	P	Fishhook (n = 62)	Vicryl (n = 62)	P
Gender, n (%)			0.070			0.564
Female	33 (39.3)	19 (24.7)		22 (35.5)	18 (29.0)	
Male	51 (60.7)	58 (75.3)		40 (64.5)	44 (71.0)	
Age (years)	58.5 [49.8, 66.2]	60.0 [53.0, 67.0]	0.203	59.0 [51.0, 66.8]	59.5 [53.0, 63.8]	0.946
BMI (kg/m²)	22.9 [21.5, 24.6]	23.7 [20.8, 25.7]	0.696	23.1 [22.0, 25.0]	23.9 [20.8, 25.8]	0.849
Diabetes, n (%)			0.644			0.464
No	71 (84.5)	62 (80.5)		54 (87.1)	50 (80.6)	
Yes	13 (15.5)	15 (19.5)		8 (12.9)	12 (19.4)	
Hypertension, n (%)			0.832			0.848
No	58 (69.0)	51 (66.2)		41 (66.1)	43 (69.4)	
Yes	26 (31.0)	26 (33.8)		21 (33.9)	19 (30.6)	
ASA grade, n (%)			0.501			1.000
I-II	73 (86.9)	63 (81.8)		53 (85.5)	52 (83.9)	
III	11 (13.1)	14 (18.2)		9 (14.5)	10 (16.1)	
Hypoproteinemia, n (%)			0.641			0.825
No	70 (83.3)	61 (79.2)		50 (80.6)	48 (77.4)	
Yes	14 (16.7)	16 (20.8)		12 (19.4)	14 (22.6)	
Neoadjuvant chemotherapy, n (%)			0.313			0.439
No	3 (3.6)	6 (7.8)		2 (3.2)	5 (8.1)	
Yes	81 (96.4)	71 (92.2)		60 (96.8)	57 (91.9)	
Neoadjuvant radiotherapy, n (%)			0.154			0.439
No	2 (2.4)	6 (7.8)		2 (3.2)	5 (8.1)	

Variable	Before PSM			After PSM		
	Fishhook (n = 84)	Vicryl (n = 77)	P	Fishhook (n = 62)	Vicryl (n = 62)	P
Yes	82 (97.6)	71 (92.2)		60 (96.8)	57 (91.9)	
Neoadjuvant immunotherapy, n (%)			0.312			0.363
No	79 (94.0)	68 (88.3)		58 (93.5)	54 (87.1)	
Yes	5 (6.0)	9 (11.7)		4 (6.5)	8 (12.9)	
Tumor distance (cm)	4.0 [3.5, 5.0]	4.0 [3.5, 5.0]	0.631	4.0 [3.5, 5.5]	4.0 [3.4, 4.8]	0.147
Hemoglobin (g/L)	120.5 [115.0, 133.0]	126.0 [115.0, 135.0]	0.081	122.5 [115.2, 134.8]	125.5 [115.0, 135.0]	0.994

Data are presented as median [IQR] or n (%). PSM, propensity score matching; BMI, body mass index; ASA, American Society of Anesthesiologists; IQR, interquartile range.

Perioperative outcomes

Perioperative outcomes are detailed in Table 2. It is noteworthy that the Fishhook group demonstrated superior surgical efficiency. The median operative time was significantly shorter in the Fishhook group compared to the Vicryl group (135.0 min [100.0-155.0] vs. 152.5 min [136.2-178.8]; P < 0.001). Additionally, intraoperative blood loss was aslo reduced in the Fishhook group (50.0 mL [20.0–80.0] vs. 50.0 mL [50.0-100.0]; P = 0.012).

In terms of safety, significant differences were observed in postoperative hospital stay (6.0 vs. 7.0 days, P < 0.001), and the incidence of major postoperative complications (Clavien-Dindo III-V: 4.8% vs. 21.0%, P = 0.014). However, the drain removal time revealed no statistical significance (9.0 vs. 9.0 days, P = 0.480) between the Fishhook and Vicryl groups.

Table 2
Perioperative outcomes in the propensity score-matched cohort

Variable	Fishhook (n = 62)	Vicryl (n = 62)	P
Operative time (min)	135.0 [100.0, 155.0]	152.5 [136.2, 178.8]	< 0.001
Intraoperative blood loss (mL)	50.0 [20.0, 80.0]	50.0 [50.0, 100.0]	0.012
Postoperative hospital stay (days)	6.0 [6.0, 7.0]	7.0 [6.0, 8.8]	< 0.001
Drain removal time (days)	9.0 [9.0, 11.0]	9.0 [8.0, 12.0]	0.480
Time to semi-liquid diet (days)	3.0 [3.0, 3.0]	3.0 [3.0, 4.0]	0.262
Postoperative complications, n (%)			0.014
I-II	59 (95.2)	49 (79.0)	
III-V	3 (4.8)	13 (21.0)	
Anastomotic leakage, n (%)			0.030
No	54 (87.1)	43 (69.4)	
Yes	8 (12.9)	19 (30.6)	
Clinical anastomotic leakage (B + C), n (%)			0.044
No	59 (95.2)	51 (82.3)	
Yes	3 (4.8)	11 (17.7)	
Abdominal/pelvic abscess, n (%)			0.244
No	62 (100.0)	59 (95.2)	
Yes	0 (0.0)	3 (4.8)	
Defecation dysfunction, n (%)			0.231
No	48 (77.4)	41 (66.1)	
Yes	14 (22.6)	21 (33.9)	
Data are presented as median [IQR] or n (%). CD, Clavien-Dindo; IQR, interquartile range.			

AL and defecation dysfunction

The impact of suture technique on AL was presented in Table 2. The overall AL rate was significantly lower in the Fishhook group (12.9% vs. 30.6%; P = 0.030). Furthermore, clinical AL requiring therapeutic intervention was also reduced (4.8% vs. 17.7%; P = 0.044). By ISREC grade, grade A leakage occurred in 8.1% vs. 12.9% (P = 0.559), grade B in 3.2% vs. 12.9% (P = 0.095), and grade C in 1.6% vs. 4.8% (P = 0.619) in the Fishhook vs. Vicryl groups, respectively. Furthermore, no abdominal or pelvic abscesses were observed in the Fishhook group, compared to 4.8% in the Vicryl group, although this specific

difference did not reach statistical significance (P = 0.244). Besides, regarding defecation function at 12 months postoperatively, the Fishhook group showed a trend toward a lower rate of dysfunction compared to the Vicryl group (22.6% vs. 33.9%), although this difference was not statistically significant in the overall cohort (P = 0.231).

Pathological outcomes

In terms of pathological results (Table 3), no significant differences were observed in tumor size (2.5 vs. 2.8 cm, P = 0.583), perineural invasion (8.1% vs. 4.8%, P = 0.717), or lymphovascular invasion (4.8% vs 6.5%, P = 1.000). No significant differences were observed in the proportion of advanced pT stage (pT3-4: 33.9% vs. 33.9%, P = 1.000) and lymph node positivity (pN1-2: 14.5% vs. 14.5%, P = 1.000) between the two groups.

Table 3
Pathological outcomes in the propensity score-matched cohort

Variable	Fishhook (n = 62)	Vicryl (n = 62)	P
Tumor size (cm)	2.5 [2.0, 3.0]	2.8 [1.9, 3.5]	0.583
pT stage, n (%)			1.000
T0-2	41 (66.1)	41 (66.1)	
T3-4	21 (33.9)	21 (33.9)	
pN stage, n (%)			1.000
N0	53 (85.5)	53 (85.5)	
N1-2	9 (14.5)	9 (14.5)	
Positive DRM, n (%)			1.000
No	61 (98.4)	62 (100.0)	
Yes	1 (1.6)	0 (0.0)	
Perineural invasion, n (%)			0.717
No	57 (91.9)	59 (95.2)	
Yes	5 (8.1)	3 (4.8)	
Lymphovascular invasion, n (%)			1.000
No	59 (95.2)	58 (93.5)	
Yes	3 (4.8)	4 (6.5)	
Positive CRM, n (%)			0.126
No	59 (95.2)	53 (85.5)	
Yes	3 (4.8)	9 (14.5)	

Data are presented as median [IQR] or n (%). DRM, distal resection margin; CRM, circumferential resection margin; IQR, interquartile range.

Survival outcomes

The median follow-up duration was 2.8 years for the Fishhook group and 3.2 years for the Vicryl group. Kaplan-Meier analysis revealed no significant difference in OS (P = 0.970) or DFS (P = 0.660) between groups (Fig. 3), suggesting that the Fishhook technique does not compromise oncological safety.

Correlation between AL and clinical characteristics

The logistic regression revealed several factors which significantly impacted AL (Table 4, Fig. 4), including the Fishhook suture [OR: 0.25 (0.10–0.56), P = 0.001], hypoproteinemia [OR: 8.77 (3.67–21.73), P < 0.001], BMI [OR: 1.28 (1.13–1.46), P < 0.001], diabetes [OR: 3.09 (1.26–7.45), P = 0.012], and T stage [OR: 2.63 (1.22–5.77), P = 0.014].

Table 4
Logistic regression analysis for anastomotic leakage

Variable	OR (95% CI)	P
Fishhook suture (vs Vicryl)	0.25 (0.10–0.56)	0.001
Age (per year)	1.01 (0.97–1.04)	0.740
Male sex	2.65 (1.08–7.51)	0.045
BMI (per kg/m²)	1.28 (1.13–1.46)	< 0.001
Diabetes	3.09 (1.26–7.45)	0.012
Hypertension	1.64 (0.74–3.57)	0.215
ASA grade III	2.50 (0.96–6.23)	0.052
Neoadjuvant chemotherapy	0.51 (0.13–2.53)	0.363
Neoadjuvant radiotherapy	0.42 (0.10–2.15)	0.257
Neoadjuvant immunotherapy	3.19 (0.98–9.91)	0.045
Tumor distance (per cm)	0.88 (0.61–1.25)	0.481
Operative time (per min)	1.02 (1.00-1.03)	0.007
Blood loss (per mL)	1.00 (1.00-1.01)	0.258
Hypoproteinemia	8.77 (3.67–21.73)	< 0.001
Hemoglobin (per g/L)	0.99 (0.96–1.01)	0.356
pT stage T3-4	2.63 (1.22–5.77)	0.014
pN stage N1-2	3.86 (1.54–9.60)	0.004
OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists.		

Based on these findings, we employed a nomogram model incorporating these five factors to predict AL risk (Fig. 5a). The AUC value for the nomogram reached 0.910 (Fig. 5b), and the calibration plot demonstrated satisfactory agreement between predicted and observed probabilities (mean absolute error = 0.035) (Fig. 5c).

Outcomes in neoadjuvant therapy patients

In this subgroup of patients who received neoadjuvant therapy (Fishhook, n = 82; Vicryl, n = 72), the advantages of the Fishhook technique were even more evident. Compared with the Vicryl group, the Fishhook group showed significantly lower rates of both overall AL (11.0% vs. 30.6%, P = 0.005) and clinical AL (3.7% vs. 16.7%, P = 0.012). Moreover, in contrast to the findings in the overall cohort, the Fishhook group in this subgroup also demonstrated a statistically significant improvement in defecation function (18.3% vs. 37.5%, P = 0.013) (Table 5).

Table 5
Subgroup analysis among patients receiving any neoadjuvant therapy

Variable	**Fishhook (n = 82)**	**Vicryl (n = 72)**	**P**
Anastomotic leakage (any), n (%)			0.005
No	73 (89.0)	50 (69.4)	
Yes	9 (11.0)	22 (30.6)	
Clinical anastomotic leakage (B + C), n (%)			0.012
No	79 (96.3)	60 (83.3)	
Yes	3 (3.7)	12 (16.7)	
Abdominal/pelvic abscess, n (%)			0.419
No	80 (97.6)	68 (94.4)	
Yes	2 (2.4)	4 (5.6)	
Severe complications (CD III-V), n (%)			0.023
No	77 (93.9)	58 (80.6)	
Yes	5 (6.1)	14 (19.4)	
Defecation dysfunction, n (%)			0.013
No	67 (81.7)	45 (62.5)	
Yes	15 (18.3)	27 (37.5)	
Postoperative hospital stay (days)	6.0 [6.0, 6.8]	7.0 [6.0, 9.0]	< 0.001
Drain removal time (days)	9.5 [9.0, 12.0]	9.0 [8.0, 12.0]	0.162
Time to semi-liquid diet (days)	3.0 [3.0, 3.0]	3.0 [3.0, 4.0]	0.030
Data are presented as median [IQR] or n (%). CD, Clavien-Dindo; IQR, interquartile range.			

Discussion

This study demonstrates that the modified Fishhook suture technique significantly improved perioperative outcomes for patients undergoing taE-ISR for ultra-low rectal cancer. The notable improvements observed in the Fishhook group highlighted the advantages of this technique in reducing operative time, postoperative hospital stay, AL rates, and potentially defecation dysfunction, without compromising oncological outcomes, particularly in high-risk patients receiving neoadjuvant therapy.

The AL rate in our Vicryl group was 30.6%, which falls at the upper limit of the 8.9%-18.0% range reported in previous literature on ISR and taE-ISR [1–4]. This elevated rate is not unexpected, in a systematic review using an international grading system after rectal cancer surgery, substantial heterogeneity in reported leakage rates was observed across studies [20]. In more technically demanding settings, for example, a randomized clinical trial of ultra-low rectal resection with hand-sewn coloanal anastomosis reported an AL rate of 23.9% in the standard coloanal anastomosis group [21, 22]. A similar reconstructive challenge was present in our cohort, since all included patients had low or ultra-low rectal cancer requiring hand-sewn coloanal anastomosis in a deep and narrow operative space. In addition, 88.7% of our cohort underwent neoadjuvant therapy, which is known to induce tissue fibrosis, edema and impair healing. Consistent with this, a total leakage burden of 28.2% has been reported after neoadjuvant chemoradiotherapy in rectal cancer patients undergoing sphincter-preserving surgery [8]. Therefore, the leakage rate observed in our control group remains clinically plausible for a population with an ultra-low hand-sewn anastomosis after intensive multimodal treatment. Crucially, this finding underscores the limitations of conventional Vicryl anastomosis in complex scenarios. The deep, confined transanal workspace inherently [3] complicates precise knot-tying, repeated needle repositioning, and when compounded by radiation-induced tissue rigidity [23, 24], uneven tension distribution becomes a critical failure point for interrupted sutures. In contrast, the Fishhook technique reduced the AL rate to 12.9%, suggesting that this modified technique effectively overcomes the technical bottlenecks posed by the neoadjuvant therapy, ultra-low pelvic anatomy.

Importantly, our regression analysis identified suture type as factors associated with AL alongside hypoproteinemia, BMI, T stage, and diabetes, suggesting that leakage risk in this setting is shaped not only by baseline patient vulnerability but also by modifiable technical factors. The strong association with hypoproteinemia reinforces the importance of perioperative nutritional optimization. Based on these variables, we constructed an exploratory nomogram with an AUC of 0.910. Existing AL scores and nomograms are heterogeneous, and most are dominated by demographic characteristics, comorbidities, tumor height, and broad operative variables. Of note, our model is a practical tool for high-risk patients requiring perioperative counseling, nutritional optimization, surveillance intensity, and selection of a lower-risk anastomotic strategy.

A dedicated subgroup analysis in neoadjuvant-treated patients was clinically justified, because this population represents a substantial proportion of patients undergoing sphincter-preserving surgery for ultra-low rectal cancer while also presenting greater reconstructive challenges. In our neoadjuvant subgroup, the Fishhook suture technique was associated not only with lower overall and clinical AL

rates, but also with better defecatory function. This finding is clinically relevant, beyond anatomical integrity, functional preservation is paramount, whereas nCRT-treated cohorts may carry a substantial burden of delayed leakage [8], particularly in patients with a protective ileostomy. In addition, AL and subsequent pelvic sepsis may aggravate fibrosis and adversely affect long-term pelvic and bowel function [25, 26], while neoadjuvant therapy itself may negatively influence postoperative functional outcomes and other anastomotic complications such as stenosis may further compromise recovery [27, 28]. The functional benefit observed in our study may therefore be secondary to the lower leakage rate, because AL and pelvic sepsis have been associated with major LARS, peri-anastomotic fibrosis, and impaired neorectal function [29]. The superior performance of the Fishhook suture can be attributed to three synergistic mechanisms. Firstly, from a biomechanical perspective, the fishhook suture distributes tension satably and uniformly along the anastomotic line. This avoids the focal stress concentration and potential ischemia associated with individual manual knots [11, 15]. Second, the ergonomic curvature of the fishhook suture technique significantly streamlined the procedure, saving approximately 17.5 minutes of operative time. This efficiency is consistent with meta-analyses on barbed sutures in GI surgery and reduces the duration of pelvic exposure [12, 13]. Third, the specific fishhook needle was designed to optimize tissue purchase within the narrow operative tunnel, its special curved shape facilitated stable and accurate needle insertion and extraction in the deep pelvic space, effectively reducing excessive tissue traction during suturing, minimizing mucosal and muscular layer injury [30, 31]. Collectively, this approach results in a more uniform, tension-free anastomosis while guaranteeing full-thickness bites in restricted spaces.

This study has several noteworthy innovative aspects. First, to our knowledge, this was the first study focused on the reconstructive step most directly linked to leakage in taE-ISR, namely hand-sewn coloanal anastomosis and compared the Fishhook and Vicryl suture procedure. Secondly, our study confirmed that the Fishhook suture technique can reduce the AL rate, providing guidance for clinical practice. Third, PSM was performed in this study to minimize the bias in retrospective research.

The limitations of this study should not be overlooked. Firstly, the evidence level was limited due to its retrospective nature. Second, the sample size of this study is small. Third, the clinical value of the nomogram still needed external validation.

In conclusion, Fishhook suture procedure was associated with shorter operative time and postoperative hospital stay, lower AL rates, and potential better functional outcomes. Low and ultra-low rectal cancer patients, especially receiving neoadjuvant therapy, can benefit from the Fishhook suture procedure during taE-ISR and achieve a higher quality of life.

Declarations

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Competing Interests:

All authors declare no conflicts of interest.

Ethics Approval:

This study was approved by the Ethics Committee of Ruijin Hospital (Approval No. 2019-82).

Informed Consent:

The requirement for informed consent was waived due to the retrospective nature of the study.

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Figures

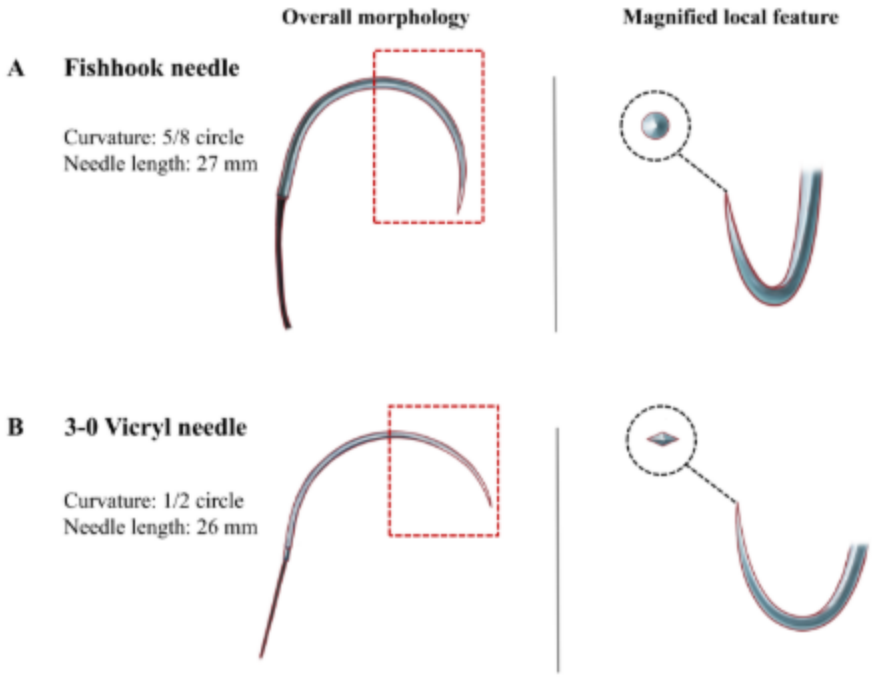

Figure 1

Morphological comparison of the needle design used in the conventional Vicryl and Fishhook groups. (A) Overall configuration of the fishhook suture needle and enlarged structural view of the distal needle body-tip segment. (B) Overall configuration of the conventional 3-0 Vicryl suture needle and enlarged structural view of the corresponding distal needle body-tip segment

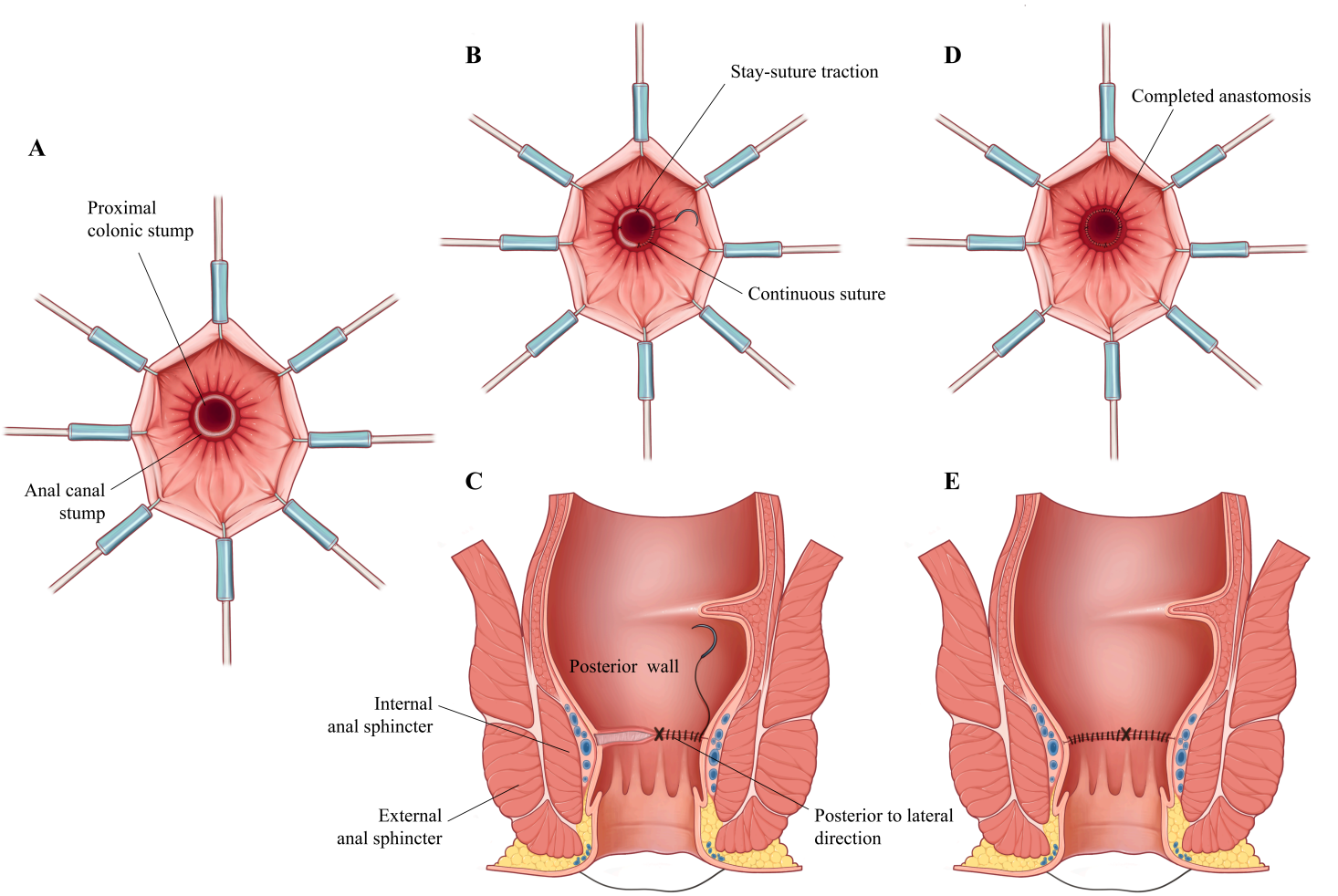

Figure 2

Fishhook suture for coloanal anastomosis

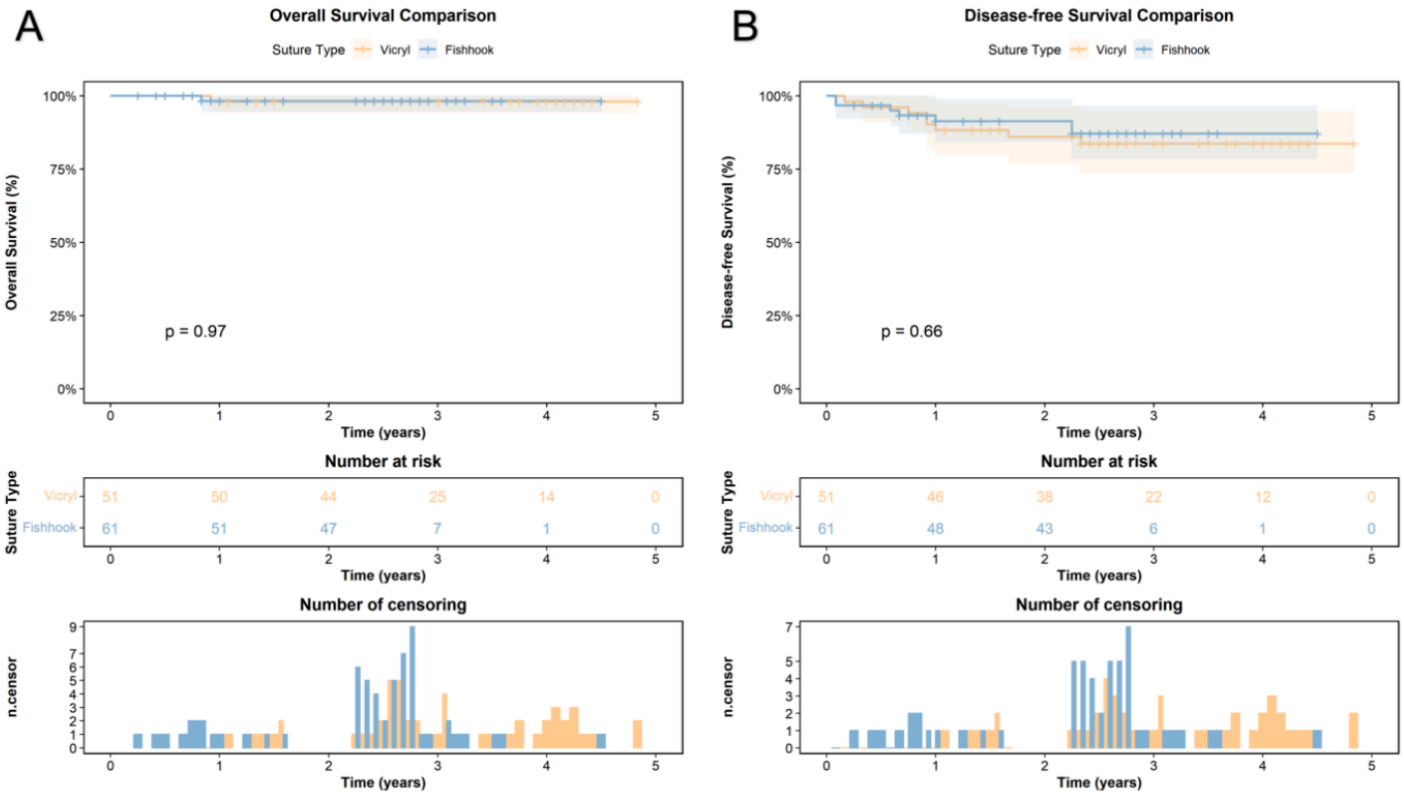

Figure 3

Survival outcomes in the Fishhook and Vicryl groups

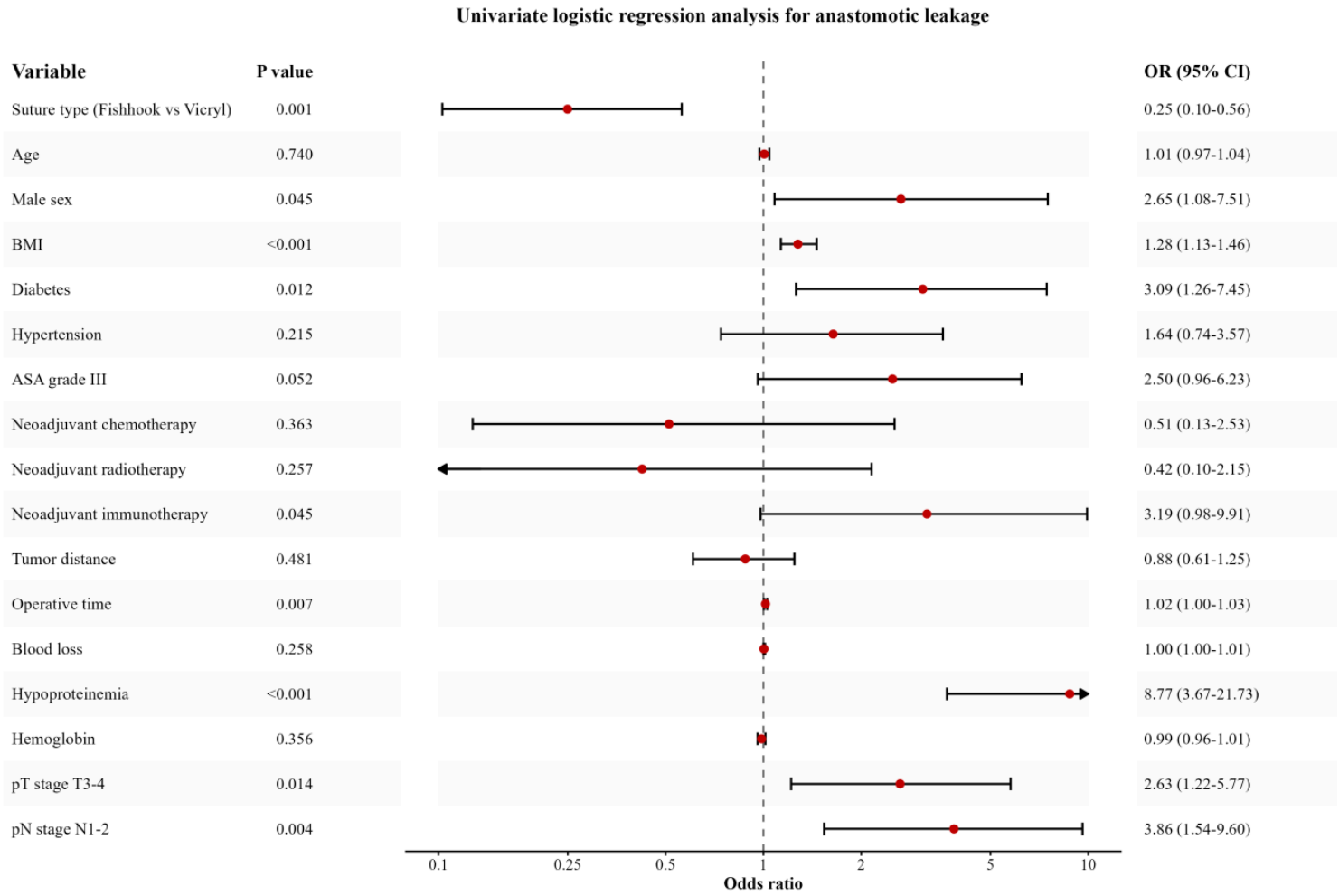

Figure 4

Forest plot of univariable logistic regression analyses of factors associated with anastomotic leakage

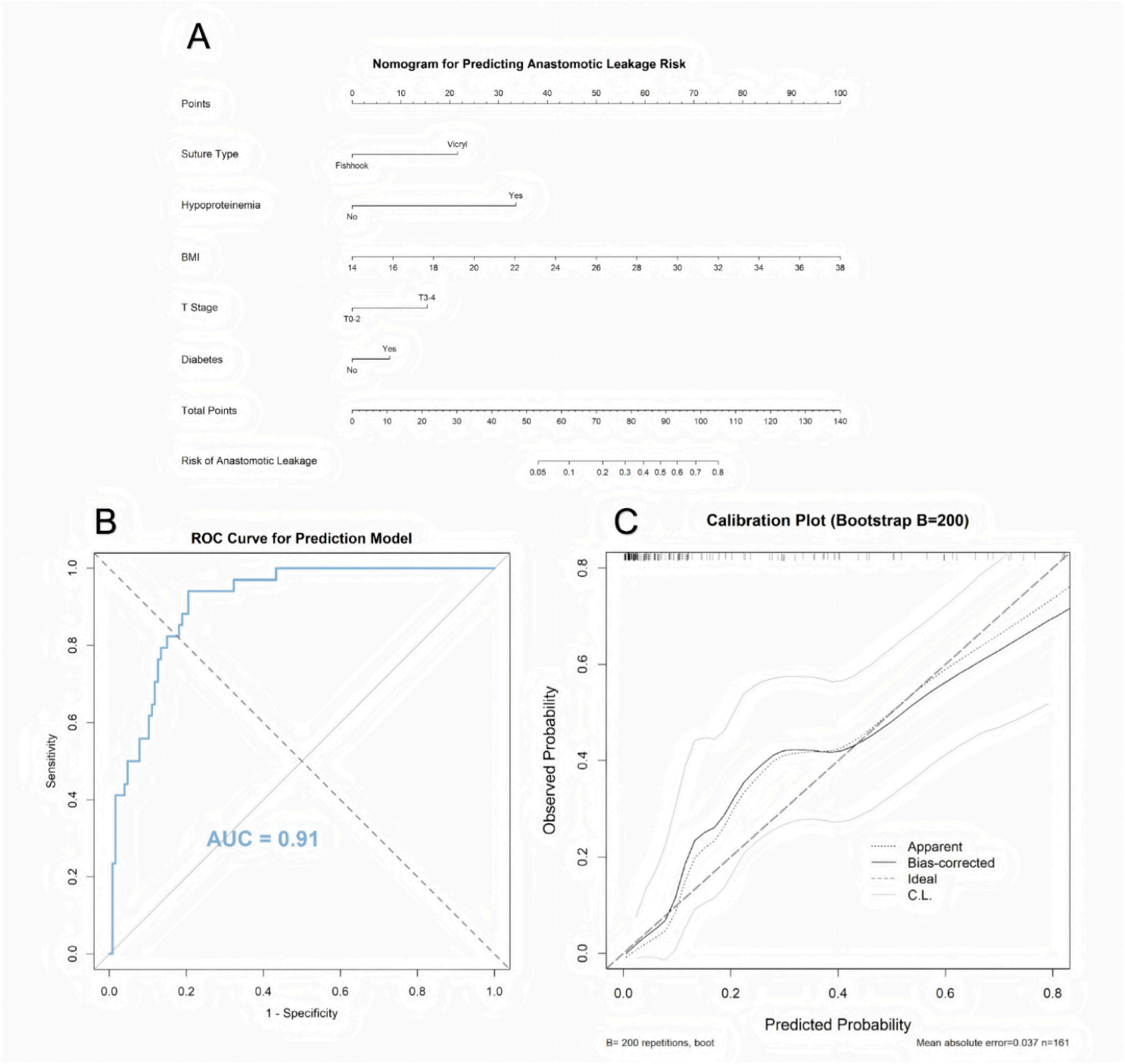

Figure 5

Nomogram model for predicting anastomotic leakage (AL)