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Prophylactic Pedicle Clipping Before Hot Snare Polypectomy Is Associated With Lower Immediate Bleeding Risk in Pedunculated Colorectal Polyps: A Propensity Score–Matched Retrospective Cohort Study

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Abstract

Background

Immediate bleeding during hot snare polypectomy (HSP) of pedunculated colorectal polyps remains common. Most prophylactic measures protect the defect after transection; whether pre-resection pedicle clipping adds benefit when post-resection clipping is routine remains unresolved.

Methods

This single-center retrospective cohort included 423 consecutive pedunculated polyps treated with HSP: 342 with post-resection defect clipping alone and 81 with pre-resection pedicle clipping plus post-resection clipping. Propensity scores based on 19 baseline variables were used for 1:2 nearest-neighbor matching. The primary outcome was immediate bleeding requiring intraprocedural hemostasis; secondary outcomes were delayed bleeding and post-polypectomy syndrome. Robustness was assessed using Firth's logistic regression and patient-clustered generalized estimating equations (GEE).

Results

After matching, 71 clipped and 136 control polyps were analyzed; all standardized mean differences were < 0.10 (mean 0.053). Immediate bleeding occurred in 2.8% versus 14.7% (OR = 0.204; 95% CI 0.053–0.786; P = 0.008), with consistent Firth (OR = 0.204) and GEE (OR = 0.165) estimates. Delayed bleeding and post-polypectomy syndrome did not differ significantly. In exploratory analyses, polyp head size accounted for approximately 56% of machine-learning feature importance. Absolute bleeding rate reduction for control versus clipped polyps was most significant in the 10–20 mm subgroup (12.6% vs. 1.7%; number needed to treat ≈ 9). Cutoff analyses suggested approximately 16 mm. Resource utilization analysis showed that procedure time increased modestly for small and intermediate polyps, hospital stay was similar between groups, and clip use was numerically lower in the pre-resection clipping group for large polyps.

Conclusions

When post-resection clipping was routine, pre-resection pedicle clipping was associated with lower immediate bleeding, supporting staged hemostasis. The size-based signals and resource-utilization patterns are hypothesis-generating and warrant prospective validation.

Trial registration

The study was approved by the Peking University Shenzhen Hospital Research Ethics Review Committee (MR-44-26-026120) and retrospectively registered on the Chinese Clinical Trial Registry (ChiCTR2600123659) at May 1, 2026. Because the study used retrospective de-identified data, the requirement for written informed consent was waived.

Background

Hot snare polypectomy (HSP) remains a standard endoscopic treatment for appropriately selected pedunculated colorectal polyps. The technique is efficient, widely available, and endorsed by international guidance for lesions suitable for endoscopic resection (1, 2). Its principal procedural hazard is bleeding (3, 4). Immediate bleeding occurs at transection, can obscure the endoscopic field, prolong the procedure, require rescue hemostasis, and increase technical complexity. Delayed bleeding, which arises hours to days later, can trigger repeat endoscopy, hospital readmission, and additional resource use. Larger polyp size, thick stalk morphology, proximal colonic location, antithrombotic exposure, and comorbidity burden have all been linked to post-polypectomy bleeding risk (1, 5, 6).

Most preventive strategies address bleeding risk after transection. Post-resection clipping closes the mucosal defect and compresses exposed vessels, with the clearest evidence of benefit for delayed bleeding after resection of large or proximal lesions (1, 7, 8). Pedunculated polyps pose a distinct hemostatic problem because their vascular supply is concentrated within the stalk. Controlling inflow before transection therefore has a direct anatomic rationale: it targets the vascular pedicle before electrosurgical cutting exposes the vessel lumen. Guidelines therefore support pre-resection mechanical prophylaxis in selected pedunculated lesions with large heads or thick stalks, but the evidence remains inconsistent (1). Some studies report reduced immediate bleeding with pre-resection clipping or ligation, whereas others have raised concern that mechanical pretreatment may not improve, or may even worsen, selected delayed outcomes (5, 9, 10).

The clinically relevant question differs from that addressed by most prior studies. In many contemporary endoscopy units, operators already close the post-resection defect after removing higher-risk pedunculated lesions. The key question is therefore not whether pre-resection clipping is better than no prophylaxis, but whether adding pre-resection pedicle clipping to routine post-resection defect clipping reduces immediate bleeding without increasing delayed complications. This practice separates two temporally distinct interventions—pre-transection control of pedicle inflow and post-transection protection of the mucosal defect—that address different phases of bleeding risk.

This study addressed that question in a real-world cohort of pedunculated colorectal polyps removed by HSP. We compared post-resection clipping alone with pre-resection pedicle clipping followed by post-resection clipping, using propensity-score matching across 19 baseline variables and robustness analyses with Firth logistic regression and patient-clustered generalized estimating equations. We also performed exploratory machine-learning, SHAP, restricted cubic spline, and size-stratified analyses to generate hypotheses about the risk architecture of immediate bleeding. The conceptual framework was

staged hemostasis: pre-resection clipping controls vascular inflow at the moment of transection, whereas post-resection clipping protects the residual wound during healing.

Methods

Study design, setting, and ethics

This single-center retrospective cohort study included patients who underwent HSP for pedunculated colorectal polyps at Peking University Shenzhen Hospital between August 15, 2020, and September 15, 2025. The study was approved by the institutional ethics review board and registered as ChiCTR2600123659. Because the study used retrospective de-identified data, the requirement for written informed consent was waived. This study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting guideline for cohort studies.

Study population

Inclusion criteria were colonoscopically diagnosed pedunculated colorectal polyp treated by HSP; complete perioperative records, pathological results, and postoperative follow-up data; and availability of bleeding and complication assessment. Exclusion criteria were lesions highly suspicious for submucosal invasive carcinoma or requiring surgical treatment; intraoperative perforation, uncontrollable active bleeding, or major cardiovascular or cerebrovascular events; American Society of Anesthesiologists physical status class V or higher; continued anticoagulant or antiplatelet therapy within 5 days before the procedure; and conditions known to substantially increase bleeding risk, including inflammatory bowel disease, autoimmune disease, and coagulation disorders.

All patients underwent routine preoperative evaluation, including a complete blood count, a coagulation profile, and a comorbidity assessment. Management of antithrombotic medications was guided by published endoscopic guidelines and institutional protocols. Bowel preparation used polyethylene glycol electrolyte powder. Procedures were performed by three endoscopists with extensive experience in therapeutic colonoscopy; each had completed more than 1,000 cases. Colonoscopy was performed using the Olympus 290 series endoscopic system with carbon dioxide insufflation. Lesion size, location, morphology, and surface structure were evaluated under white-light and narrow-band imaging. Lesions with overt signs of deep submucosal invasion were excluded from endoscopic resection.

Treatment groups and procedural technique

Polyps were classified according to the actual treatment received as the conventional HSP group or the pre-resection pedicle-clipping group. In the conventional HSP group, HSP was performed directly, followed by post-resection defect clipping for prophylaxis. In the pre-resection pedicle-clipping group, the procedural sequence was as follows (Figure 1). After confirming that the lesion was suitable for endoscopic resection, the pedicle and its vascular supply were examined under white-light and narrow-band imaging (Figure 1A). A hemostatic clip was then placed across the pedicle near the bowel wall to

occlude arterial and venous inflow before transection (Figure 1B). HSP was performed on the distal side of the deployed clip (Figure 1C). After complete polyp removal, the residual mucosal defect was closed with additional clips in the same manner as the conventional HSP group (Figure 1D). Active bleeding, when present, was managed with endoscopic hemostasis at the treating endoscopist's discretion. All resected specimens were submitted for histopathological evaluation. Because the decision to perform pre-resection pedicle clipping was based on the endoscopist’s integrated judgment of polyp size, pedicle morphology, location, and estimated bleeding risk, treatment assignment was regarded as nonrandomized exposure. Propensity-score matching and robustness analyses were used to reduce measured confounding.

Outcomes

The primary outcome was immediate bleeding, defined as persistent active hemorrhage during the procedure requiring intraprocedural endoscopic hemostasis. Secondary outcomes were delayed bleeding and post-polypectomy syndrome. Resource-utilization outcomes included procedure time, postoperative length of stay, and number of clips used.

Propensity-score matching

Propensity scores were estimated from a logistic regression model that included 19 preoperative baseline variables: age, weight, height, body mass index, preoperative hemoglobin level, polyp head size, sex, family history of colorectal cancer, smoking history, diabetes mellitus, hypertension, personal history of malignancy, hyperlipidemia, other gastrointestinal diseases, history of colorectal polyps, anticoagulant or antiplatelet drug exposure, polyp location, histological type, and number of polyps. Continuous variables were standardized by z-score transformation, and categorical variables were dummy-coded. Records with missing baseline variables were excluded before analysis; the propensity-score model was therefore fit on complete-case data. A 1:2 nearest-neighbor matching without replacement was performed with a caliper width of 0.2 standard deviations of the logit of the propensity score. Procedure time, postoperative length of stay, and number of clips used were considered intraoperative or postoperative process variables and were not included in the propensity-score model. Post-matching balance was assessed using standardized mean differences (SMDs), with SMD <0.10 indicating adequate balance.

Primary and robustness analyses

The primary analysis compared immediate bleeding in the matched cohort using Fisher’s exact test, with odds ratios (ORs), 95% confidence intervals (CIs), and P values reported. To address the limited number of immediate bleeding events, Firth's penalized-likelihood logistic regression was used to reduce small-sample bias in maximum-likelihood estimation. To account for within-patient clustering due to multiple polyps, generalized estimating equations (GEE) were fitted with patient identity as the clustering variable, an exchangeable correlation structure, a logit link function, and robust sandwich standard errors. Conventional logistic regression models were summarized as supplementary analyses.

Exploratory risk-architecture and resource-utilization analyses

Exploratory analyses of the risk architecture of immediate bleeding and potential treatment-benefit subgroups were conducted using machine learning, restricted cubic splines, and subgroup analyses. For the machine-learning component, the control-group data were split into training and validation sets at a 7:3 ratio. Feature selection was performed using the Boruta algorithm in conjunction with baseline clinical characteristics, retaining four variables: polyp head size, body weight, diabetes mellitus, and hyperlipidemia. Twelve predictive models were constructed: logistic regression with L2 regularization, logistic regression with isotonic calibration, logistic regression with sigmoid calibration, random forest, XGBoost, LightGBM, support vector machine with a linear kernel, Balanced Random Forest, Balanced Bagging, EasyEnsemble, Soft Voting, and Stacking. SHAP values were used to characterize the relative contribution of each variable to model output. Model performance was evaluated using receiver operating characteristic curves with area under the curve (AUC), precision–recall curves with average precision, Brier score, balanced accuracy, F1 score, and Youden index.

Restricted cubic splines were used to examine the continuous relationship between polyp head size and immediate bleeding risk. For subgroup analyses, polyps were stratified using clinically conventional thresholds: <10 mm, 10–20 mm, and >20 mm. To determine the optimal cutoff value for polyp head size in discriminating immediate bleeding, receiver operating characteristic curve analysis was performed. The Youden index, calculated as sensitivity + specificity - 1, identified 16.0 mm as the optimal threshold. The sensitivity–specificity intersection method yielded a cutoff of 15.5 mm, and the balanced accuracy approach supported a clinically consistent threshold in the approximate range of 15–16 mm. These exploratory methods collectively suggested an optimal cutoff of approximately 16 mm for polyp head size in this cohort.

Resource utilization, including procedure time, postoperative length of stay, and number of clips used, was compared between groups using the Mann–Whitney U test and visualized with box plots. All statistical analyses were performed in Python, using Scikit-learn, Statsmodels, Imbalanced-learn, SHAP, SciPy, Matplotlib, and Seaborn. Graphical outputs were saved at 600 DPI for publication. Two-sided P values <0.05 were considered statistically significant.

Results

Cohort assembly and baseline characteristics

During the study period, 457 pedunculated colorectal polyps underwent HSP. After excluding 22 polyps with missing baseline variables, 8 without follow-up outcomes, 2 with pathologically confirmed invasive cancer, and 2 from patients with severe underlying disease, 423 polyps were included in the analysis (Fig. 2). Of these, 342 were treated with conventional HSP followed by post-resection defect clipping, and 81 were treated with pre-resection pedicle clipping followed by HSP and post-resection defect clipping.

Before matching, the groups did not differ significantly in age, body mass index, preoperative hemoglobin level, hypertension, diabetes mellitus, smoking history, or most chronic disease variables. The sigmoid colon was the most common polyp location, and tubular adenoma and tubulovillous adenoma were the dominant histologic types. Compared with the control group, the pre-resection pedicle-clipping group had larger polyp heads, more frequent antithrombotic drug exposure, and longer procedure times, consistent with operator selection of pre-resection clipping for lesions judged to be higher risk or more technically complex. Baseline categorical and continuous variables are summarized in Tables 1 and 2.

Table 1
Categorical characteristics and outcomes before propensity-score matching

	Category	Control group	Pre-resection pedicle clipping group	P-value
Total		**342**	**81**	
Immediate Bleeding	Yes	39	2	
	No	303	79	
Delayed Bleeding	Yes	12	2	
	No	330	79	
Post-polypectomy syndrome	Yes	11	0	
	No	331	81	
Gender	Male	241	66	0.063
	Female	101	15	
Family history of colon cancer	Yes	6	2	0.652
	No	336	79	
Smoking	Yes	51	13	0.958
	Cessation	5	1	
	No	286	67	
Hypertension	Yes	89	17	0.425
	No	253	64	
Diabetes mellitus	Yes	31	11	0.310
	No	311	70	
Cancer history	Yes	24	3	0.399
	No	318	78	
Hyperlipidemia	Yes	13	2	0.746
	No	329	79	
Other gastro-intestinal disease	Yes	25	3	0.355
	No	317	78	

	Category	Control group	Pre-resection pedicle clipping group	P-value
Total		**342**	**81**	
Anticoagulant/anti-platelet drug use	Yes	8	6	0.034
	No	334	75	
Polyp head size	< 10mm	115	9	< 0.001
	10-20mm	190	59	
Polyp number	> 20mm	37	13	
	1	263	62	0.374
	2	62	12	
	3	17	7	
Polyp location	Hepatic flexure	4	3	0.317
	Splenic flexure	3	1	
	Ileum and Cecum	5	1	
	Ascending colon	48	7	
	Transverse colon	39	8	
	Descending colon	26	12	
	Sigmoid colon	188	43	
	Rectum	29	6	
Pathology type	Non-neoplastic polyp	23	5	0.087
	Hyperplastic polyp	10	2	
	Hamartomatous polyp	11	7	
	Serrated lesion	4	4	
	Tubular adenoma, low/intermediate grade	147	25	
	Tubular adenoma, high grade	6	3	
	Tubulovillous adenoma, low/intermediate grade	114	29	

	Category	Control group	Pre-resection pedicle clipping group	P-value
Total		**342**	**81**	
	Tubulovillous adenoma, high grade	18	5	
	Precancerous lesion or carcinoma	9	1	

Table 2
Continuous characteristics and procedural variables before propensity-score matching

Age, years	**Control group**	**Pre-resection pedicle clipping group**	**P-value**
	53.5 ± 12.7	**52.8 ± 12.3**	**0.610**
Weight, kg	67.2 ± 11.3	68.7 ± 9.8	0.290
Height, cm	166.9 ± 7.6	168.2 ± 6.8	0.363
BMI, kg/m^2	24.3 ± 3.1	24.3 ± 2.8	0.840
Preoperative hemoglobin level, g/L	137.5 ± 16.2	138.6 ± 16.8	0.666
Time of operation, min	39.2 ± 20.8	49.1 ± 24.6	< 0.001
Polyp head size, mm	12.7 ± 6.5	16.0 ± 6.0	< 0.001
Number of clip	3.5 ± 2.0	3.5 ± 1.6	0.477

Propensity-score matching and covariate balance

After 1:2 nearest-neighbor propensity-score matching using all 19 preoperative variables, 71 polyps in the pre-resection pedicle-clipping group and 136 polyps in the conventional HSP group entered the matched cohort. The matching rate in the pre-resection clipping group was 87.7%. Baseline balance improved substantially after matching. All covariates had SMDs < 0.10, and the mean SMD decreased from 0.136 before matching to 0.053 after matching. Polyp head size, the most imbalanced variable before matching, had an SMD that decreased from 0.528 to 0.046. Propensity-score distributions showed markedly improved overlap after matching (Fig. 3B, C).

Primary and secondary outcomes

In the matched cohort, immediate bleeding occurred in 2 of 71 polyps (2.8%) in the pre-resection pedicle-clipping group and 20 of 136 polyps (14.7%) in the conventional HSP group. Fisher's exact test showed that pre-resection pedicle clipping was associated with lower immediate bleeding (OR = 0.204, 95% CI

0.053–0.786, P = 0.008) (Table 3; Fig. 3A). This association remained directionally consistent in robustness analyses, including Firth penalized-likelihood logistic regression (OR = 0.204, 95% CI 0.053–0.793) and patient-clustered GEE (OR = 0.165, 95% CI 0.037–0.734). Correction for within-patient clustering among patients contributing multiple polyps did not materially change the direction or magnitude of the association.

Table 3
Relationship between complications and operation method after matching

Immediate Bleeding	**OR**	**95% CI**	**P value**
	0.204	**0.053–0.786**	**0.008**
Delayed bleeding	0.722	0.163–3.196	0.718
Post-polypectomy syndrome	0.140	0.008–2.529	0.096

Secondary outcomes were infrequent. Delayed bleeding was numerically lower in the pre-resection clipping group after matching, but the difference was not statistically significant (OR = 0.722, 95% CI 0.163–3.196, P = 0.718). Post-polypectomy syndrome was not observed in the pre-resection clipping group and occurred in a small number of control lesions; the between-group difference was not statistically significant (OR = 0.140, 95% CI 0.008–2.529, P = 0.096). These secondary-outcome analyses were underpowered to exclude smaller or moderate true differences.

Exploratory machine-learning and polyp-size analyses

In the exploratory risk model built from control-group data, 39 immediate bleeding events occurred, corresponding to an event rate of 11.4%. Feature selection retained four variables: polyp head size, body weight, diabetes mellitus, and hyperlipidemia. Among the 12 predictive models evaluated, the EasyEnsemble model performed well on class-imbalance-sensitive metrics, with an AUC of 0.801, and was used for SHAP interpretation. SHAP analysis showed that polyp head size was the dominant contributor to model output, accounting for approximately 56% of total feature importance (Fig. 4). Body weight also contributed positively. Diabetes mellitus and hyperlipidemia showed inverse model contributions; given the limited event count, these findings should be interpreted as potentially reflecting selection bias, perioperative management differences, or model instability rather than biological protection.

Restricted cubic spline analysis showed a nonlinear increase in immediate bleeding risk with increasing polyp head size in the conventional HSP group. Risk rose most clearly above 10 mm and remained elevated among larger polyps (Fig. 5A). In size-stratified analyses, bleeding rates for control versus pre-resection clipped polyps were 7.0% (8/115) versus 0.0% (0/9) for < 10 mm, 12.6% (24/190) versus 1.7% (1/59) for 10–20 mm, and 18.9% (7/37) versus 7.7% (1/13) for > 20 mm (Fig. 5B). The largest absolute risk reduction was observed in the 10–20 mm subgroup: 10.9 percentage points, corresponding to a number needed to treat of approximately 9. However, the small number of clipped lesions in the < 10 mm

and > 20 mm strata and the absence of statistically significant treatment-effect heterogeneity limit subgroup inference. These findings are hypothesis-generating.

Optimal cutoff analysis identified a Youden-index threshold of 16.0 mm and a sensitivity–specificity intersection of 15.5 mm; balanced accuracy supported the same approximate range (Fig. 5C). These exploratory cutoff analyses suggest that a polyp head size of approximately 16 mm may be useful for future risk-stratified trial design, but the threshold should not be treated as practice-changing without prospective validation.

Resource utilization

Resource-utilization analyses showed that procedure time was longer in the pre-resection pedicle-clipping group among small and intermediate lesions but not among large lesions (Fig. 6). Median procedure time was 40 versus 30 minutes for < 10 mm polyps (P = 0.027), 50 versus 35 minutes for 10–20 mm polyps (P = 0.007), and 43 versus 44 minutes for > 20 mm polyps (P = 0.924), comparing pre-resection clipping with conventional HSP. Postoperative length of stay did not differ significantly between the two groups, either overall or within any size stratum (all P > 0.05). The median length of stay was 1 day for polyps ≤ 20 mm and 2 days for polyps > 20 mm, irrespective of treatment assignment. Clip count did not differ in the smaller strata, whereas the pre-resection clipping group descriptively used fewer clips in the > 20 mm subgroup (median 3 versus 6; P = 0.022). Because clip purpose was not systematically recorded, these resource-utilization findings should be interpreted descriptively.

Discussion

This study addresses a practical question that has remained unresolved in the management of pedunculated colorectal polyps: Does pre-resection pedicle clipping add value when operators already close the post-resection defect? In a real-world cohort treated with hot snare polypectomy, pre-resection pedicle clipping followed by post-resection defect clipping was associated with a substantial reduction in immediate bleeding compared with post-resection clipping alone. After propensity-score matching, immediate bleeding decreased from 14.7% to 2.8%, and the association remained directionally consistent in Firth logistic regression and patient-clustered GEE analyses. These findings support the staged-hemostasis concept: pre-resection clipping controls stalk inflow at the moment of transection, whereas post-resection clipping protects the wound during healing.

The main contribution of this study is its temporal framing of hemostasis. Post-resection clipping and pre-resection pedicle clipping do not solve the same problem at the same moment. Post-resection clipping closes the residual defect after the stalk has been transected and is biologically aligned with delayed bleeding prevention (11, 12). Pre-resection pedicle clipping acts earlier by compressing the stalk near the bowel wall before the snare cuts across the vascular pedicle. This upstream control plausibly lowers arterial and venous inflow at the moment of electrosurgical transection, reduces bleeding pressure at the cut vessel end, and allows coagulation in a more controlled field (13–17). The present results are consistent with this temporal complementarity: the strongest signal was for immediate

bleeding, whereas delayed bleeding and post-polypectomy syndrome did not differ significantly. This distinction matters because prior studies have often evaluated prophylactic clipping as a single intervention rather than as part of a sequenced hemostatic strategy (5, 9, 10, 18). By holding post-resection clipping constant across both groups, this study isolates the clinically actionable incremental question more directly than comparisons against no prophylaxis. The findings therefore support a procedural principle: bleeding prevention should be timed to the biology of bleeding.

The exploratory risk analyses refine this principle but do not establish a definitive treatment threshold. Polyp head size was the dominant predictor of immediate bleeding and accounted for approximately 56% of model feature importance in the SHAP analysis. This finding is clinically coherent: larger pedunculated heads generally require greater stalk vascular supply, create larger transection surfaces, and increase the chance that a sizable vessel will be exposed during hot snare resection. Restricted cubic spline analysis further showed that risk did not rise linearly from the smallest lesions; it increased more clearly above 10 mm and remained elevated among larger polyps. This pattern explains why the 10–20 mm subgroup showed the largest absolute risk reduction. These lesions sit in a clinically important transition zone: they are not uniformly treated as high-risk lesions, yet their bleeding risk is no longer trivial. The observed number needed to treat of approximately 9 in this subgroup is therefore provocative and practice-relevant, although it requires further prospective validation. The 16 mm cutoff signal derived from exploratory receiver operating characteristic analyses is likewise useful for designing prospective studies, but it should not be used as a stand-alone practice rule without validation.

The machine-learning analyses also require cautious interpretation. Body weight showed a positive contribution to predicted bleeding risk, which may reflect body habitus, positioning difficulty, intra-abdominal pressure, procedural complexity, or metabolic vascular risk (19, 20). The inverse model contributions of diabetes mellitus and hyperlipidemia should not be interpreted as biological protection. More plausibly, these variables may reflect more intensive preoperative assessment, medication management, operator caution, or unstable estimates in a small event set (21–24). Prediction models can identify reproducible patterns, but they can also encode care pathways, confounding by indication, and hidden clinical behaviors (25–28). These findings should therefore guide hypothesis generation rather than clinical decision-making.

The resource-utilization analysis supports a similarly nuanced interpretation. Pre-resection pedicle clipping increased overall procedure time, particularly in small and intermediate lesions, but it did not prolong postoperative hospitalization. In larger lesions, procedure time did not clearly increase, and clip use was descriptively lower in the pre-resection clipping group. These patterns are consistent with a procedural trade-off: planned vascular control may add a deliberate step but reduce the need for unpredictable rescue hemostasis after active bleeding begins. The present data cannot support cost-effectiveness claims because clip purpose, rescue hemostasis time, anesthesia time, reintervention, and total cost were not systematically recorded. They do, however, justify prospective resource-utilization studies that distinguish prophylactic, closure, and rescue clips.

Several limitations define the boundaries of interpretation. First, this was a single-center, retrospective cohort study. The treatment assignment reflected operator judgment rather than randomization, potentially introducing indication bias. Propensity-score matching across 19 baseline variables improved measured balance, and Firth and GEE analyses produced concordant estimates, but residual confounding remains possible. Second, key anatomic variables—including stalk diameter, stalk length, and visible stalk vessels—were not systematically documented. These features likely influenced both clipping decisions and bleeding risk. Endoscopic stalk-width estimation is inherently difficult and operator-dependent; future studies should therefore incorporate standardized, photographically documented measurement protocols. Third, all procedures were performed by three experienced endoscopists. Their expertise improves technical consistency but limits generalizability and restricts assessment of operator-level heterogeneity. Fourth, the machine-learning, restricted cubic spline, cutoff, and subgroup analyses were exploratory and limited by the number of immediate bleeding events. These analyses should guide trial design, not replace confirmatory inference.

Despite these constraints, the study provides a coherent and clinically useful signal. In a setting where post-resection defect clipping was already routine, pre-resection pedicle clipping was associated with markedly less immediate bleeding after hot snare polypectomy of pedunculated colorectal polyps. The findings support a staged hemostasis framework: control the vascular stalk before transection, then protect the residual defect after transection. Polyp head size emerged as the dominant risk feature, and 10–20 mm lesions appeared to offer the clearest opportunity for selective incremental benefit. The next step is a prospective, multicenter study that standardizes stalk measurements, electrosurgical settings, operator factors, bleeding-severity grading, and resource accounting. Such a trial could determine whether risk-stratified pre-resection pedicle clipping should become a routine component of the resection of pedunculated colorectal polyps.

Conclusions

In this single-center propensity score–matched retrospective cohort study of pedunculated colorectal polyps, pre-resection pedicle clipping combined with routine post-resection defect clipping was associated with a substantially lower risk of immediate bleeding compared with post-resection clipping alone (OR = 0.204; 95% CI 0.053–0.786). The association remained consistent across Firth penalized-likelihood logistic regression and patient-clustered generalized estimating equations. Delayed bleeding and post-polypectomy syndrome did not differ significantly between groups, although the number of events was small. Exploratory machine learning and SHAP analyses identified polyp head size as the dominant contributor to immediate bleeding risk, accounting for approximately 56% of model feature importance, and support a staged-hemostasis framework in which pre-resection clipping controls vascular inflow at transection while post-resection clipping protects the healing defect. Restricted cubic spline analysis revealed a nonlinear risk increase above 10 mm. Size-stratified bleeding rates for control versus clipped polyps were 7.0% versus 0.0% for < 10 mm, 12.6% versus 1.7% for 10–20 mm, and 18.9% versus 7.7% for > 20 mm; the largest absolute risk reduction was observed in the 10–20 mm subgroup (10.9 percentage points; NNT ≈ 9). An approximate risk-discrimination cutoff of 16 mm was identified;

this exploratory threshold is hypothesis-generating. Procedure time increased modestly for small and intermediate lesions but did not differ for polyps larger than 20 mm, while postoperative length of stay was similar between groups, and descriptive trends suggested fewer clips were used in the pre-resection clipping group among larger polyps. These resource utilization patterns are consistent with a procedural trade-off in which planned pre-resection vascular control may reduce the burden of unplanned rescue hemostasis. The study is limited by its retrospective, single-center design and by the absence of systematically recorded stalk-dimensional variables. Prospective, multicenter studies with standardized measurement of stalk diameter, operator-level variables, and complete resource accounting are required to validate these findings and to define the population most likely to benefit from selective pre-resection pedicle clipping.

Abbreviations

AUC
area under the curve
CI
confidence interval
DPI
dots per inch
GEE
generalized estimating equations
HSP
hot snare polypectomy
NNT
number needed to treat
OR
odds ratio
PSM
propensity-score matching
RCS
restricted cubic spline
SHAP
SHapley Additive exPlanations
SMD
standardized mean difference
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology.

Declarations

Ethics approval and consent to participate

This retrospective cohort study was conducted using de-identified patient data. The study was reviewed and approved by the Peking University Shenzhen Hospital Research Ethics Review Committee (approval no. MR-44-26-026120). The requirement for written informed consent to participate was waived by the same committee because of the retrospective nature of the study and the use of de-identified data. All methods were carried out in accordance with the Declaration of Helsinki and relevant institutional guidelines.

Consent for publication

Not applicable. All patient data were de-identified, and the endoscopic images presented in Figure 1 contain no information that could identify any individual participant.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JL: Conceptualization, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Writing - Original Draft, Writing - Review & Editing

YS: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing - Original Draft, Writing - Review & Editing

MY: Data Curation, Investigation, Validation, Writing - Review & Editing

JW: Data Curation, Investigation, Validation, Visualization

ZL: Data Curation, Formal Analysis, Visualization, Writing - Review & Editing

PT: Investigation, Resources, Validation

SY: Investigation, Formal Analysis, Writing - Review & Editing

MZ: Investigation, Validation

GL(corresponding author): Funding Acquisition, Investigation, Project Administration, Resources, Supervision.

ZS(corresponding author): Funding Acquisition, Investigation, Project Administration, Resources, Supervision.

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Figures

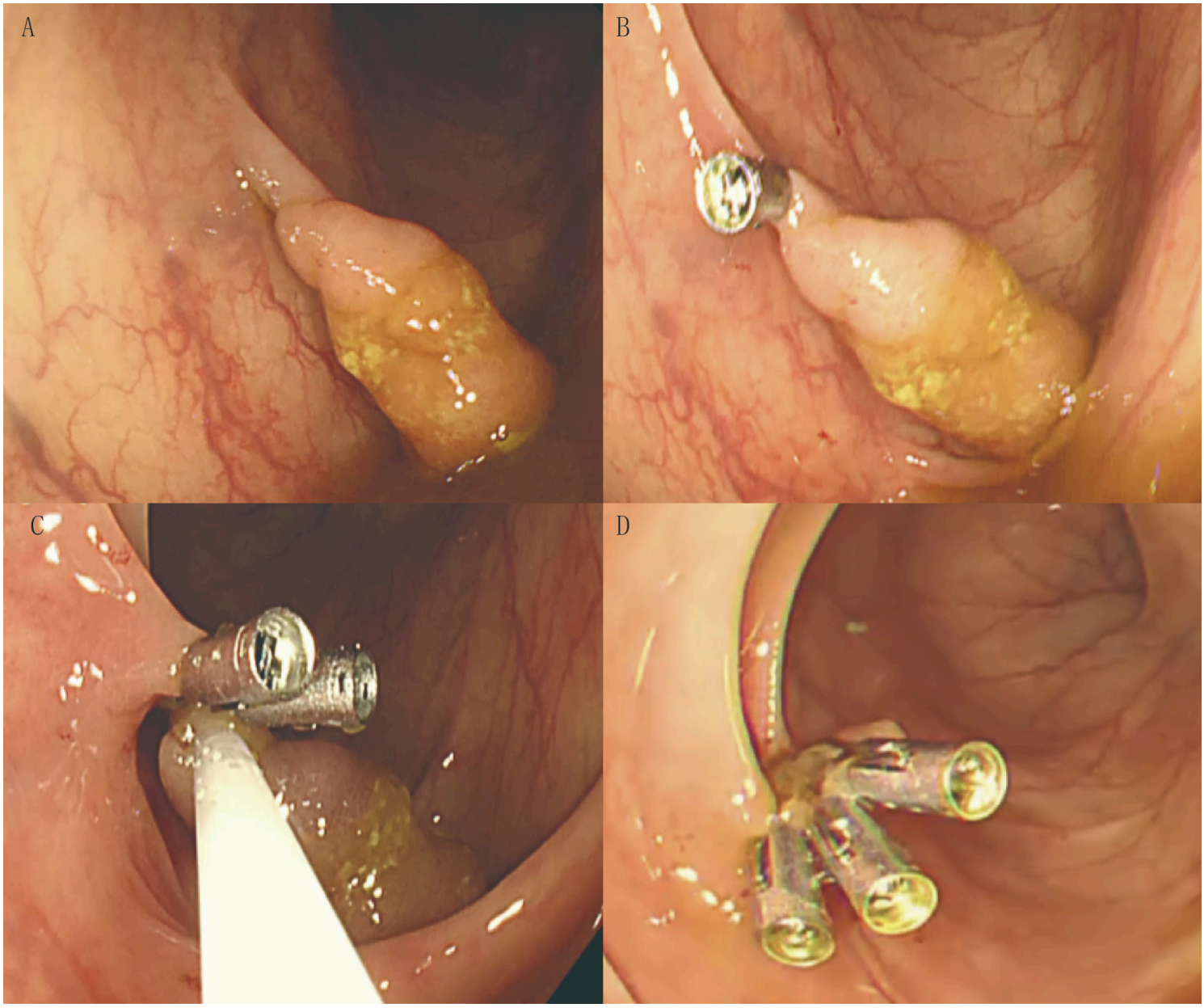


Figure 1

Surgical technique of pre-resection pedicle clipping followed by hot snare polypectomy and post-resection defect clipping. (A) Endoscopic assessment of the pedunculated polyp and stalk vasculature. (B) Prophylactic clip placement across the pedicle to occlude inflow before transection. (C) Hot snare polypectomy distal to the deployed clip. (D) Post-resection defect closure with additional clips.

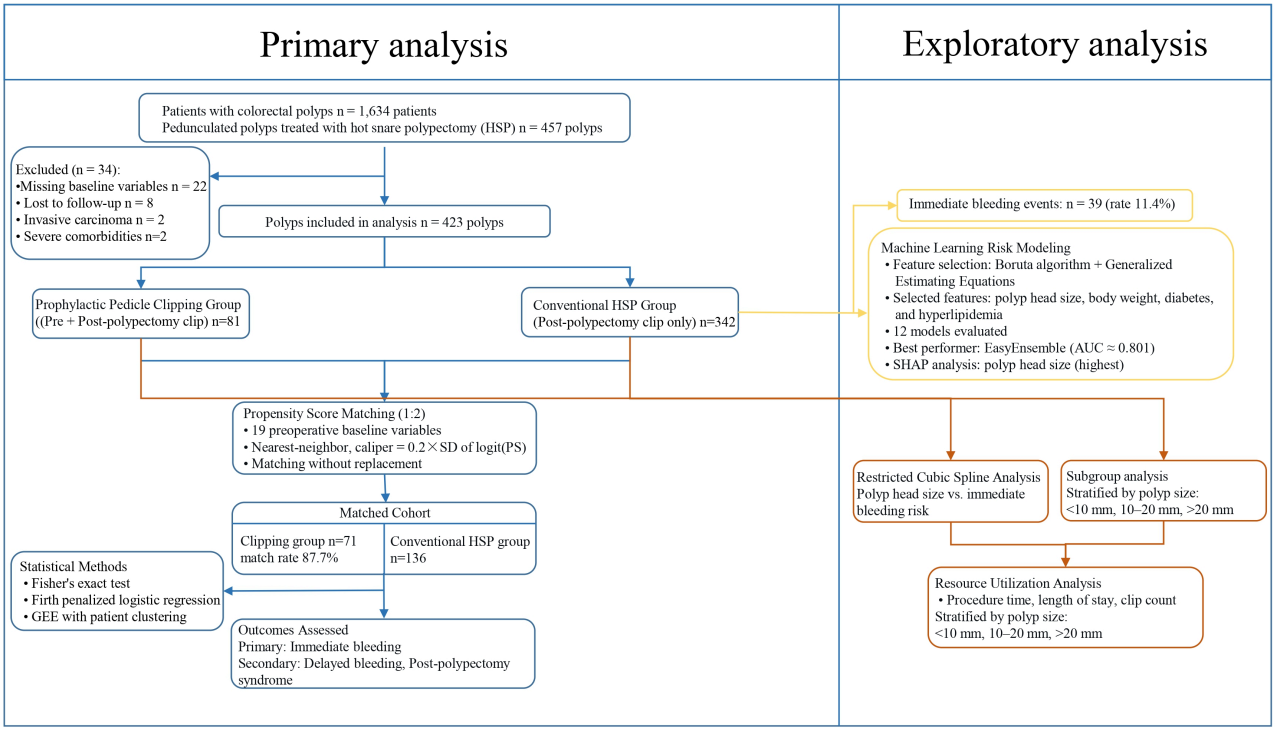


Figure 2

Study flow diagram. A total of 457 pedunculated polyps treated by hot snare polypectomy were screened; 423 were included after exclusions. After 1:2 propensity-score matching, 71 pre-resection clipping and 136 conventional HSP polyps were analyzed. Exploratory analyses were conducted using control-group data (n = 342). HSP, hot snare polypectomy; PSM, propensity-score matching.

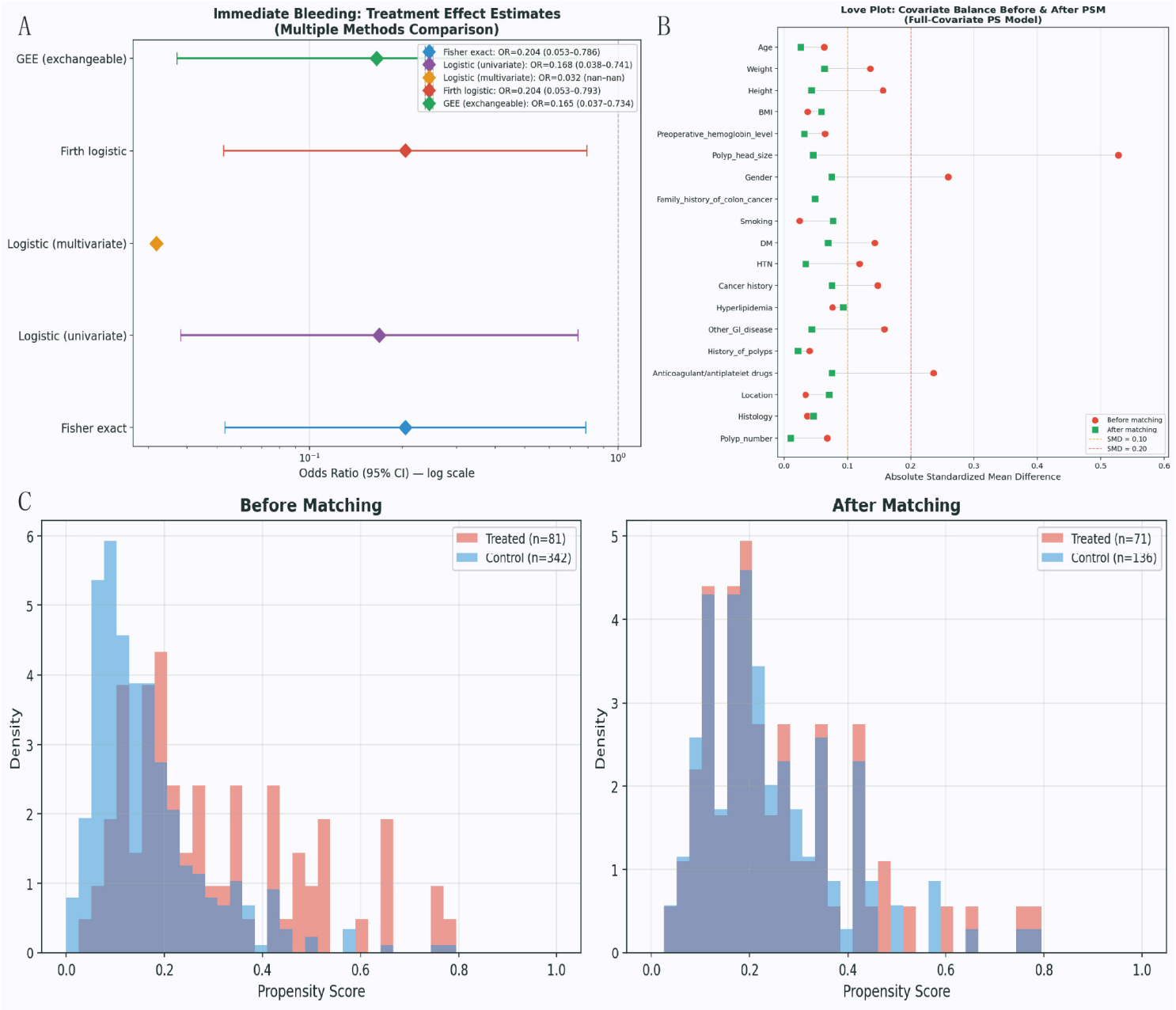


Figure 3

Outcome comparison after propensity-score matching. (A) Forest plot of odds ratios for immediate bleeding across five analytic methods in the matched cohort. (B) Love plot of standardized mean differences for 19 covariates before and after matching; all post-matching SMDs <0.10. (C) Propensity-score distributions showing improved overlap. GEE, generalized estimating equations; SMD, standardized mean difference.

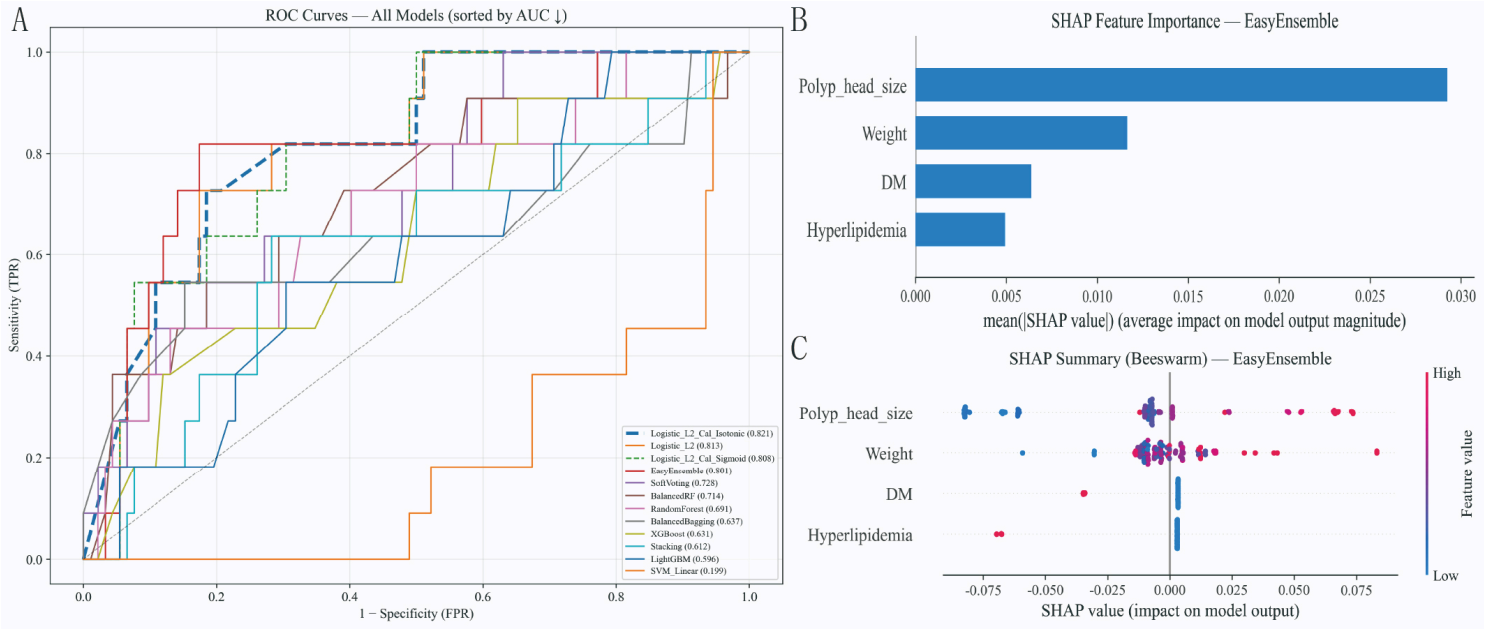


Figure 4

Exploratory machine-learning model performance and SHAP interpretation. (A) Receiver operating characteristic curves for 12 models; AUC values in parentheses. (B) Mean SHAP values from EasyEnsemble. (C) SHAP beeswarm plot. Color indicates feature value (red = high, blue = low); higher SHAP values indicate greater predicted risk. AUC, area under the curve.

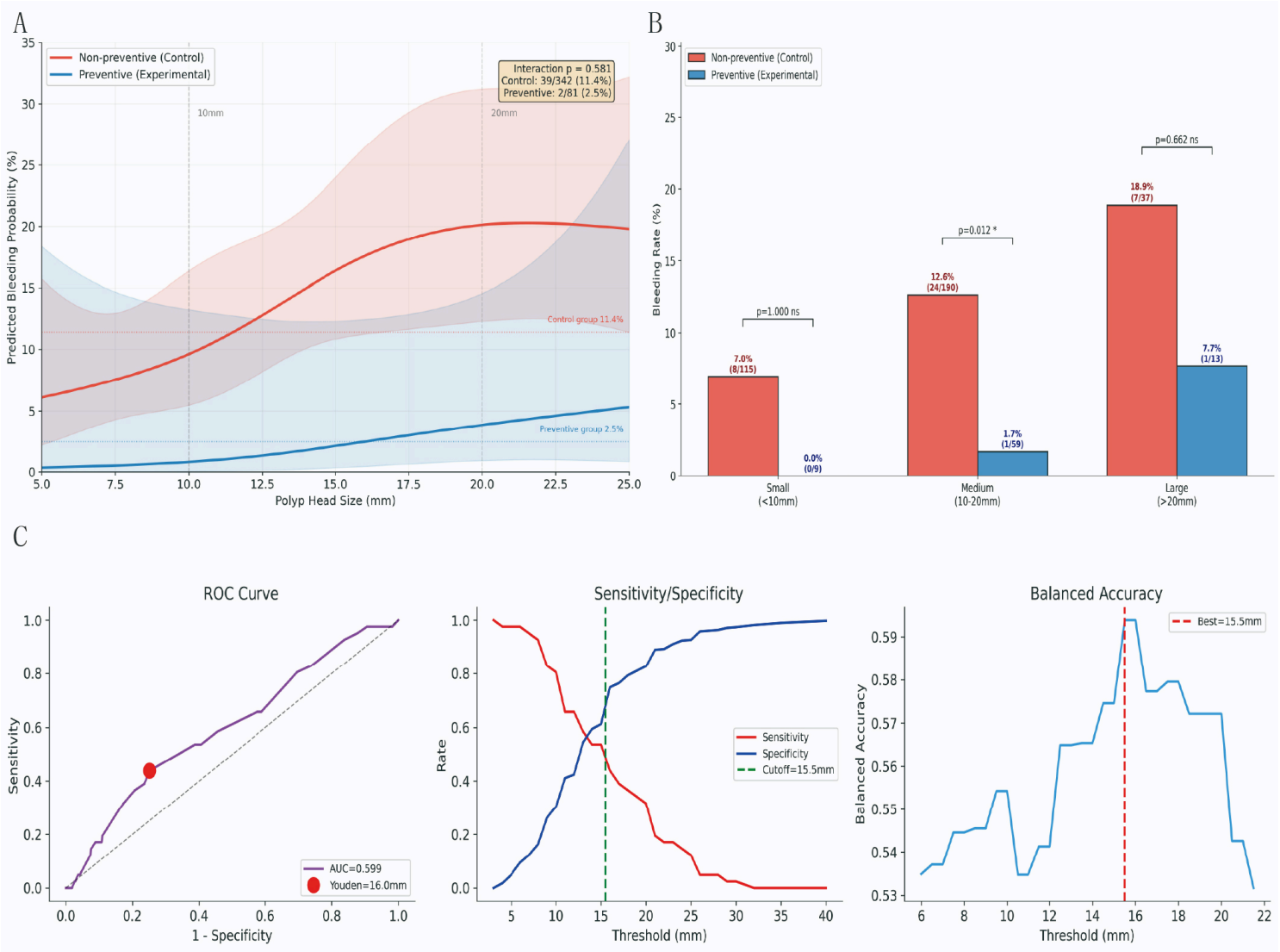


Figure 5

Restricted cubic spline and polyp-size subgroup analyses. (A) RCS curves for polyp head size and predicted immediate bleeding probability by treatment; shaded bands = 95% CIs. (B) Bleeding rates stratified by polyp size and treatment. (C) Optimal cutoff analysis: Youden index 16.0 mm, sensitivity–specificity intersection 15.5 mm, balanced accuracy supporting 15–16 mm. RCS, restricted cubic spline.

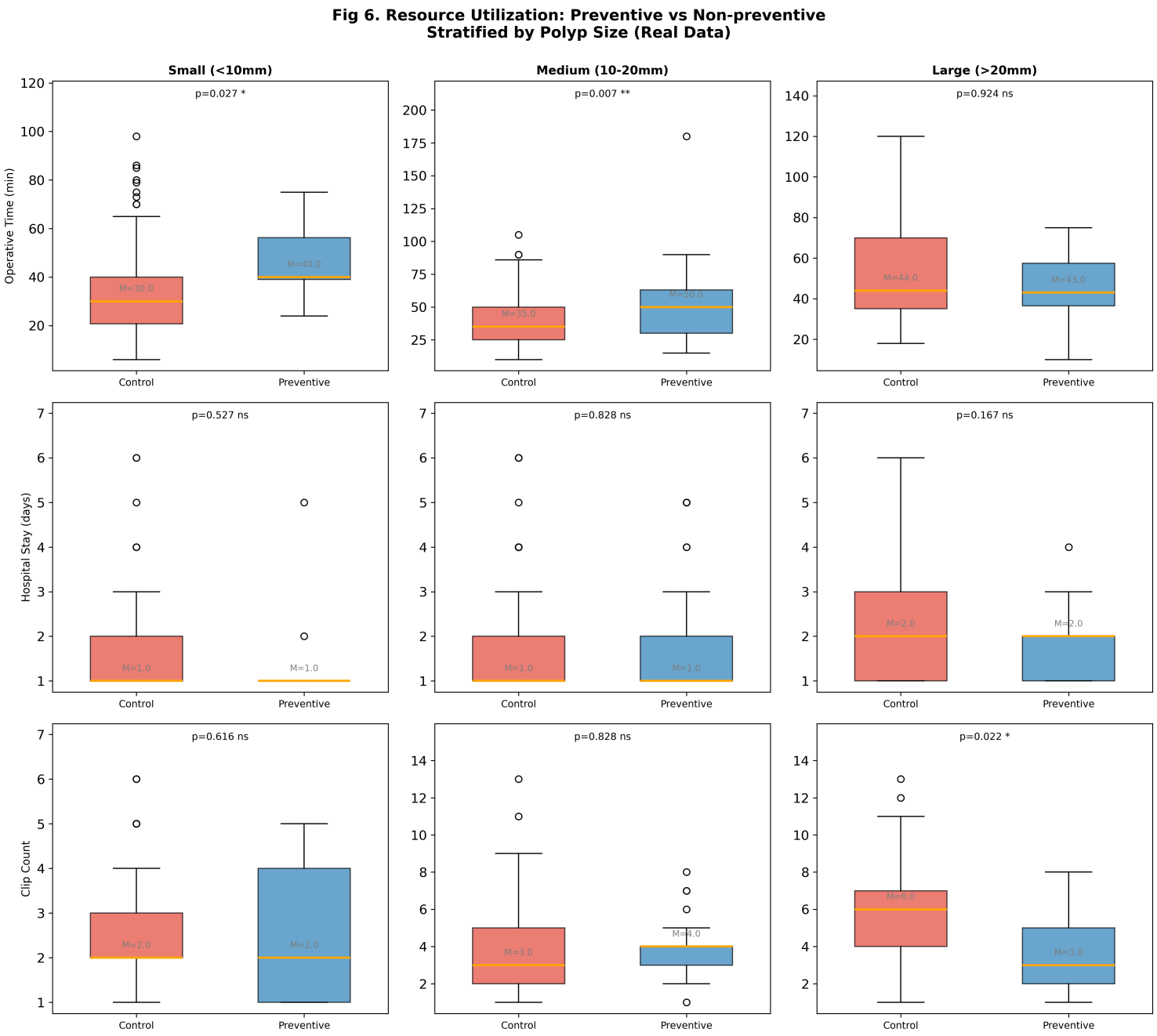


Figure 6

Resource utilization stratified by polyp size and treatment group. Box plots compare procedure time, postoperative length of stay, and clip count between the conventional HSP (control) and pre-resection clipping (preventive) groups. P values from Mann–Whitney U tests; *P ≤ 0.05, **P ≤ 0.01, ns, not significant. HSP, hot snare polypectomy.

Supplementary Files

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- Video1.mp4