

Perioperative Nasogastric Decompression Strategies in Laparoscopic Pancreaticoduodenectomy: A Propensity Score-Matched Retrospective Cohort Study

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Abstract

Purpose: Routine postoperative nasogastric tube (NGT) decompression is increasingly questioned after open pancreaticoduodenectomy, but evidence on complete perioperative omission during laparoscopic pancreaticoduodenectomy (LPD) remains limited. This study aimed to assess whether NGT maintenance was associated with better outcomes than both omission strategies and whether complete omission was safe and feasible compared with postoperative omission in LPD.

Methods: This single-centre retrospective cohort included 957 consecutive adults undergoing LPD from April 2016 to April 2025. Patients were classified according to perioperative NGT management as routine placement (RP), postoperative omission (PO), or routine omission (RO). The primary outcomes were clinically relevant delayed gastric emptying (CR-DGE) and the in-hospital Comprehensive Complication Index (CCI). Pairwise 1:1 propensity score matching was performed.

Results: A total of 957 patients were included: 324 in the RP group, 102 in the PO group, and 531 in the RO group. After matching, RO was associated with lower CR-DGE than RP (19.8% vs 35.7%; $P=0.007$) and a lower CCI (23.87 vs 33.85; $P<0.001$). PO was also associated with a lower CCI than RP (27.07 vs 39.21; $P<0.001$), whereas CR-DGE did not differ significantly (27.3% vs 41.6%; $P=0.081$). CR-DGE and CCI did not differ significantly between RO and PO, whereas rescue NGT insertion was less frequent with RO (13.0% vs 29.0%; $P=0.024$). NGT strategy remained associated with both CR-DGE and CCI in exploratory multivariable analyses.

Conclusion: Routine postoperative NGT placement was not associated with improved postoperative outcomes after LPD. Complete perioperative NGT omission appears safe and feasible, with CR-DGE and CCI outcomes comparable to postoperative omission and fewer rescue NGT insertions.

Introduction

Pancreaticoduodenectomy (PD) is the standard curative procedure for malignant tumours of the pancreatic head and periampullary region, but it is associated with substantial postoperative morbidity [1]. Although early safety concerns limited the adoption of laparoscopic pancreaticoduodenectomy (LPD), technique standardization and maturation have been accompanied by accumulating evidence from high-volume centres suggesting that LPD can achieve perioperative safety comparable to open pancreaticoduodenectomy (OPD), with potential advantages in postoperative recovery [2, 3]. Accordingly, as surgical techniques have continued to evolve, attention has increasingly turned to optimizing perioperative care, including NGT management, to further improve perioperative safety and postoperative recovery [4].

Because PD requires multiple gastrointestinal reconstructions and anastomoses, and manoeuvres under pneumoperitoneum may alter anastomotic tension in LPD, NGT decompression is often intended to reduce anastomotic tension and facilitate gastrointestinal motility, thereby lowering the risk of anastomotic leakage and delayed gastric emptying [5]. On this rationale, some centres continue to

routinely maintain NGTs after LPD. However, this practice is supported more by convention than by high-quality evidence, and prolonged NGT use may conversely delay gastrointestinal motility [6], increase gastroesophageal reflux [7] and the risk of pulmonary aspiration [8]. The true clinical effect of routine NGT use in the specific setting of LPD therefore remains uncertain.

The emergence of enhanced recovery after surgery (ERAS) protocols has challenged the traditional paradigm of NGT use in abdominal surgery [9]. Randomized controlled trials across major abdominal procedures have shown that omitting postoperative NGT placement is safe and feasible and is associated with faster return of bowel function and reduced discomfort [10–12]. Studies in OPD have similarly supported postoperative omission [13–15], which has been incorporated into ERAS recommendations for PD [16]; however, most OPD studies involve intraoperative NGT placement rather than complete perioperative avoidance. High-quality evidence on omitting NGT decompression throughout the perioperative period remains limited, particularly for LPD.

Therefore, this study aimed to compare three perioperative NGT management strategies in patients undergoing LPD. First, routine placement (RP) was compared with postoperative omission (PO) and routine omission (RO) to assess whether postoperative NGT maintenance was associated with better outcomes. Second, RO was compared with PO to evaluate the safety and potential benefits of complete perioperative omission. Third, exploratory analyses examined factors associated with clinically relevant delayed gastric emptying (CR-DGE), the Comprehensive Complication Index (CCI), and postoperative rescue NGT insertion.

Methods

Study design

We conducted a single-centre retrospective cohort study at Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology. Consecutive adult patients undergoing LPD between April 2016 and April 2025 were included. Hybrid procedures were excluded because they did not represent a fully laparoscopic approach. Patients with preoperative gastrointestinal obstruction were excluded because NGT placement is mandatory in this setting. Data were obtained from a prospectively maintained pancreatic surgery database. This retrospective study was approved by the Medical Ethics Committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology (approval no. TJ-IRB202601095), and the requirement for written informed consent was waived in accordance with the Chinese Administrative Measures for the Ethical Review of Biomedical Research Involving Humans.

Surgical procedure

All LPD procedures were performed by senior pancreatic surgeons with extensive experience in OPD. During the early study period, LPD was in an exploratory phase; the technique was progressively refined and ultimately standardized into a uniform workflow (TJDBPS01 [17]). A classic Whipple procedure was

performed in all patients. Reconstruction generally followed the Child method, with pancreaticogastrostomy used in a few cases during the early study period. The pancreaticojejunostomy technique was selected according to pancreatic texture, main pancreatic duct diameter, and the operating surgeon's judgement, including imbedding [18], invagination, Chen's [19], or duct-to-mucosa pancreaticojejunostomy. Gastrointestinal reconstruction was preferentially performed through the retrocolic route, and intraperitoneal drains were routinely placed. Operative year period was included in the propensity score analysis to account for temporal changes.

Postoperative management

All patients were routinely transferred to the surgical intensive care unit after surgery, and those with stable clinical conditions were generally moved to the general surgical ward on postoperative day (POD) 3. Abdominal drain output and characteristics were assessed daily, and drain fluid amylase and bilirubin levels were measured on POD 3. Routine computed tomography was performed on POD 5 to evaluate the thoracic and abdominal cavities. In patients without evidence of postoperative pancreatic fistula or clinical signs of infection and with drain output < 20 mL/day, intraperitoneal drains were generally removed on PODs 6–7. Patients routinely received total parenteral nutrition during the early postoperative period, with a gradual transition to oral intake as tolerated. Postoperative analgesia followed a multimodal regimen centered on intravenous patient-controlled analgesia, with adjunct opioids and non-steroidal anti-inflammatory drugs as needed.

NGT management

Perioperative NGT management followed real clinical practice rather than a standardized protocol, with decisions left to the discretion of the operating surgeon. For analysis, patients were retrospectively classified into three groups based on NGT status at the time of surgical incision and postoperative tube retention: (1) routine omission (RO), with no prophylactic NGT in place at surgical incision; (2) postoperative omission (PO), with a prophylactic NGT in place at surgical incision for intraoperative decompression and removed before emergence from anaesthesia; and (3) routine placement (RP), with a prophylactic NGT in place at surgical incision and retained postoperatively, typically until PODs 3–5. In the RP group, the NGT was removed once the output during the preceding 24 hours was < 500 mL and the patient had no clinically significant abdominal distension, nausea, or vomiting. In all three groups, when no NGT was in place, rescue NGT insertion was performed if the patient developed persistent abdominal distension, nausea, or vomiting, or if imaging was suggestive of gastrointestinal obstruction, and the tube was maintained until symptom resolution or radiologic improvement. Rescue NGT insertion did not lead to reclassification.

Outcomes

The primary outcomes were clinically relevant delayed gastric emptying (CR-DGE) and the Comprehensive Complication Index (CCI). DGE was defined and graded according to the International Study Group of Pancreatic Surgery (ISGPS) criteria, with CR-DGE defined as grade B or C[20]. The CCI

was calculated from all postoperative complications occurring during the index hospitalization and summarizes cumulative morbidity by integrating the number and severity of complications based on the Clavien–Dindo classification [21].

Secondary outcomes were categorized as postoperative complications, postoperative recovery, NGT-related outcomes, and mortality. Postoperative complications during the index hospitalization included PD-specific complications: DGE [20] and postoperative pancreatic fistula (POPF) [22], for which both overall and clinically relevant events were assessed, with clinically relevant events defined as grade B or C according to the corresponding ISGPS criteria; postpancreatectomy hemorrhage (PPH) [23] and chyle leak [24], defined according to the corresponding ISGPS criteria; and bile leak [25], defined according to the International Study Group of Liver Surgery criteria. Other postoperative complications included intra-abdominal infection, pleural effusion, atelectasis, pneumonia, arrhythmia, and renal failure. Major complications were defined as Clavien–Dindo grade IIIa or higher. Postoperative recovery outcomes included time to tolerate a liquid diet, time to tolerate a semi-solid diet, and postoperative length of stay. The NGT-related outcome was rescue NGT insertion, and mortality outcomes included 30-day and 90-day all-cause mortality.

Statistical analysis

Continuous variables are presented as mean (SD) or median (IQR), and categorical variables as n (%). For three-group comparisons, Welch's ANOVA or the Kruskal–Wallis test was used for continuous variables and the χ^2 test or Fisher's exact test for categorical variables; pairwise comparisons used Games–Howell or Dunn tests for continuous variables and χ^2 /Fisher tests for categorical variables, with Holm adjustment.

Primary comparisons were RP versus PO and RP versus RO, followed by RO versus PO. For each contrast, 1:1 nearest-neighbour propensity score matching was performed without replacement using a calliper of 0.1 SD of the estimated propensity score. Propensity scores were estimated by logistic regression including age, sex, BMI, benign/malignant pathology, ASA class, preoperative biliary drainage, pancreatic anastomosis type, and vascular resection as a categorical variable; exact matching was imposed on operative year period. Covariate balance was assessed using the absolute standardized mean difference (ASMD), with ASMD < 0.1 indicating adequate balance. In matched cohorts, categorical and continuous outcomes were analyzed using logistic and linear regression, respectively, with robust standard errors clustered by matched set. Exact McNemar tests were used for matched binary outcomes with zero events in one group or sparse discordant pairs. Criterion-based CR-DGE comparisons were also performed using exact McNemar tests. A sensitivity analysis restricted to 2020–2025, when the TJBDSPO1 trial [26] marked standardization of surgical and perioperative management at our centre, repeated the same propensity score matching for CR-DGE and CCI.

Exploratory univariable regression analyses were performed for CCI, CR-DGE, and postoperative rescue NGT insertion. Variables with $P < 0.05$ in univariable analysis were entered into the corresponding

multivariable model; for multi-level categorical variables, selection was based on the global P value. Effect estimates and 95% confidence intervals were emphasized because these models were exploratory. Propensity score analyses used complete cases without imputation. All tests were two-sided, with $P < 0.05$ considered statistically significant. Analyses were conducted in R 4.4.3 (R Foundation for Statistical Computing) using *MatchIt* for propensity score matching, *lm* for linear regression, and *glm* for logistic regression.

Results

A total of 957 patients were included, comprising 324 in the RP group, 102 in the PO group, and 531 in the RO group (Fig.1). Propensity score analyses used 954 complete cases after excluding three RP patients with missing BMI; no other propensity score covariates were missing. Baseline and operative characteristics are shown in Table 1. The RP group had higher estimated blood loss and a lower rate of vascular resection; the RO group was older, had the highest proportion of ASA class III, and had the lowest transfusion rate. Soft pancreatic texture and imbedding pancreaticojejunostomy were more frequent in RO, whereas invagination pancreaticojejunostomy was more common in PO and RP. The use of RO increased over the study period while PO and RP decreased (Fig. 2).

Perioperative outcomes before propensity score matching are summarized in Table 2. In the unadjusted cohort, significant between-group differences were observed for both primary outcomes, CR-DGE and CCI, and for several secondary outcomes, including PPH, intra-abdominal infection, major complications, 30- and 90-day mortality, and time to tolerance of liquid and semi-solid diets. Most of these unadjusted comparisons favoured RO over RP.

After propensity score matching, all propensity score covariates were balanced across the RP-PO, RP-RO, and PO-RO cohorts, with after-match ASMDs < 0.1 (Supplementary Tables S1a–S1b; Supplementary Figs. S1–S2). Perioperative outcomes after matching are summarized in Table 3.

In the RP-RO matched cohort, 126 patients were included in each group. Compared with the RP group, the RO group had a lower rate of CR-DGE (19.8% vs 35.7%; OR=0.45, 95% CI 0.25–0.80; $P=0.007$) and a lower mean CCI (23.87 vs 33.85; mean difference [MD]=−9.98, 95% CI −14.60 to −5.35; $P<0.001$). The RO group also had a lower rate of DGE (65.1% vs 80.2%; OR=0.46, 95% CI 0.27–0.78; $P=0.004$) and PPH (2.4% vs 8.7%; OR=0.26, 95% CI 0.07–0.88; $P=0.030$). A criterion-based decomposition of CR-DGE events in the matched RP–RO cohort is provided in Supplementary Table S2.

In the RP-PO matched cohort, 77 patients were included in each group. Compared with RP, PO had a lower mean CCI (27.07 vs 39.21; MD=−12.1, 95% CI −18.5 to −5.78; $P<0.001$), whereas CR-DGE was numerically lower but did not reach statistical significance (27.3% vs 41.6%; OR=0.53, 95% CI 0.26–1.08; $P=0.081$). 30-day mortality (0% vs 7.8%; $P=0.031$) and 90-day mortality (0% vs 10.4%; $P=0.008$) were also lower in PO.

In the PO-RO matched cohort, 69 patients were included in each group. Compared with the PO group, the RO group had a similar incidence of CR-DGE (21.7% vs 26.1%; OR=0.79, 95% CI 0.38–1.63; P=0.519) and a comparable CCI (26.01 vs 25.92; MD=0.09, 95% CI –5.62 to 5.80; P=0.975). The RO group had a lower rate of rescue NGT insertion (13.0% vs 29.0%; OR=0.37, 95% CI 0.15–0.88; P=0.024), but a higher rate of pleural effusion (82.6% vs 63.8%; OR=2.70, 95% CI 1.23–5.92; P=0.013).

In the 2020–2025 sensitivity analysis, RO remained associated with a lower CCI than RP (MD=–10.97, 95% CI –16.91 to –5.03; P<0.001), whereas the lower CR-DGE rate with RO did not reach statistical significance (22.9% vs 36.1%; OR=0.52, 95% CI 0.27–1.02; P=0.056). No statistically significant differences were observed between RO and PO, while the PO–RP comparison was considered exploratory because of residual post-match imbalance (maximum ASMD=0.205; Supplementary Table S3).

In exploratory multivariable models, NGT strategy remained associated with CR-DGE, CCI, and rescue NGT insertion (global P=0.018, P<0.001, and P=0.034, respectively). Compared with RP, RO was associated with lower odds of CR-DGE; both PO and RO were associated with lower CCI values; and PO was associated with higher odds of rescue NGT insertion. Older age was also associated with all three outcomes, whereas BMI >24 kg/m² was associated with CR-DGE, and diabetes, creatinine >104 µmol/L, and pancreatic anastomosis type were associated with CCI (Supplementary Tables S4–6).

Discussion

This study compared three perioperative NGT strategies in 957 patients undergoing LPD. After matching, RP was associated with a higher CCI than both omission strategies and a higher incidence of CR-DGE than RO, whereas RO and PO had comparable CR-DGE and CCI outcomes. Rescue NGT insertion was less frequent with RO than PO. These findings do not support routine postoperative NGT maintenance as the default strategy after LPD and suggest that complete perioperative omission is feasible.

A key finding was the higher incidence of CR-DGE in the RP group. However, interpretation of this endpoint requires caution because the ISGPS definition incorporates both NGT use (ongoing use or reinsertion on or after POD 8) and delayed oral intake, while NGT exposure itself differed by study group [20]. Routine tube maintenance and conservative removal in RP could therefore increase CR-DGE classification without necessarily reflecting greater physiological impairment of gastric emptying. The criterion-based decomposition supported this concern: exclusion of events qualifying solely through the NGT criterion reduced the absolute RP–RO difference from 15.9 to 8.7 percentage points (Supplementary Table S2), indicating that the NGT component of the definition amplified the observed difference. Nevertheless, CR-DGE meeting the intake criterion remained numerically more frequent in RP than in RO after exclusion of NGT-only events (23.8% vs 15.1%), although the paired comparison was not statistically significant (P = 0.126), leaving uncertainty as to whether a true difference in postoperative gastric recovery remained. The similar direction of the CR-DGE association in the 2020–2025 sensitivity analysis (RO 22.9% vs RP 36.1%; 95% CI 0.27–1.02; P = 0.056) suggests that the main finding may not be

fully attributable to temporal changes in perioperative practice (Supplementary Table S3). NGT strategy also remained associated with CR-DGE in the exploratory multivariable analysis, providing complementary support for the observed association. These findings are broadly consistent with meta-analytic [5] and observational [15] evidence reporting more CR-DGE with routine nasogastric decompression, but the NGT-dependent ISGPS definition complicates comparisons between strategies that directly determine NGT exposure. Differences in surgical approach, perioperative pathways, and event frequency may also contribute to the discrepancy with the randomized IPOD trial [14], in which CR-DGE was infrequent and similar between groups (6.8% vs 7.7%; $P > 0.99$).

The other primary endpoint, CCI, provided a complementary assessment of overall postoperative morbidity. Unlike binary complication endpoints, CCI captures the number and severity of all postoperative complications on a 0–100 scale and is widely used in pancreatic surgery outcomes research [27–29]. This is particularly relevant to NGT management, whose effects may be reflected in the cumulative burden of multiple complications rather than in any single event. In this study, RP was associated with a heavier overall morbidity burden, with a significantly higher mean CCI than both omission strategies. In the overall RP cohort, the mean CCI was 32.87, comparable in magnitude to values reported in the previous PD randomized trial using CCI as a primary endpoint (34.02 and 36.45) [30]. NGT strategy remained associated with CCI after multivariable adjustment, with both PO and RO showing lower CCI than RP. The lower CCI with RO also persisted in the 2020–2025 standardized-care sensitivity analysis (RO vs RP: MD – 10.97, $P < 0.001$), supporting the consistency of this finding after restriction to standardized surgical and perioperative management. Although severe complications (Clavien–Dindo $\geq$ IIIa) were more frequent with RP before PSM, as also reported by Kunstman et al. [31], the difference was not statistically significant after matching. This absence of a significant difference after matching was also observed in the randomized IPOD trial [14], using Clavien–Dindo $\geq$ II complications as the endpoint. However, direct comparison is limited because we defined severe complications as Clavien–Dindo grade $\geq$ IIIa. This threshold captures complications requiring procedural intervention and may be more reliably identified retrospectively than grade II complications, whose classification depends on pharmacological treatment [32]. Consistent with the heavier overall morbidity burden reflected by CCI, RP was also associated with an approximately 1-day delay in progression to liquid and semi-solid diets, although these differences were not statistically significant.

Given the less favourable CR-DGE and CCI profiles observed with RP, the next practical question is how the two omission strategies compare. RO and PO showed similar CCI and CR-DGE rates, but RO was associated with fewer rescue NGT insertions and a higher rate of pleural effusion. The lower rescue rate suggests that complete perioperative omission did not increase the need for subsequent decompression and may even reduce it compared with PO. Previous PD studies have reported related but not identical findings. In the randomized IPOD trial [14], routine NGT placement was associated with a lower NGT replacement rate than postoperative omission (6.8% vs 23.1%). Wu et al. [33] directly compared immediate intraoperative NGT removal with complete perioperative omission, and found similar insertion rates after immediate intraoperative removal and complete omission (2.6% vs 2.8%; $P = 0.840$). Direct comparison of rescue NGT rates is limited because the period during which reinsertion could occur

differed across strategies: in RP, the tube remained in place during the early postoperative period, making reinsertion generally unnecessary while providing the intended benefit of continued decompression. In the present study, the multivariable logistic model further showed that NGT strategy remained associated with rescue NGT insertion after multivariable adjustment, with older age also emerging as a risk factor. Taken together, these findings suggest that rescue NGT insertion is influenced by both perioperative tube strategy and postoperative gastric recovery, and that patients managed with NGT omission, particularly older patients, may require careful postoperative monitoring.

The main trade-off observed with RO was a higher rate of pleural effusion in the matched comparison. This finding should be interpreted cautiously, as additional pleural ultrasonography on PODs 1–3 in some teams, beyond the routine POD 5 CT, may have increased the detection of small-volume pleural effusions. Moreover, in the unmatched overall cohort, the proportion of treatment-requiring pleural effusion was not higher in RO than in PO (51.2% vs 57.8%; $P = 0.220$), suggesting that the higher detected pleural effusion rate in RO did not translate into a higher treatment-requiring burden compared with PO (Supplementary Table S7). The overall high pleural effusion rate in our centre may also be partly related to relatively high intravenous fluid input associated with routine total parenteral nutrition.

Several limitations should be noted. First, the single-centre retrospective design limits generalizability, and confirmation in multicentre prospective randomized controlled trials is warranted. Second, the three strategies were unevenly distributed over time and may therefore be influenced by learning-curve effects and temporal improvements in surgical technique and perioperative care. Although propensity score matching and the 2020–2025 sensitivity analysis were used to mitigate temporal confounding, unmeasured changes in surgical and perioperative practice could not be fully accounted for, and observed benefits of RO may partly reflect temporal improvement and learning-curve effects. Third, group sizes were imbalanced, with a relatively small PO group, and event counts for some complications were low, which may have led to imprecise and potentially unstable estimates for rare outcomes, such as 30- and 90-day mortality, necessitating cautious interpretation.

Conclusion

Routine postoperative NGT placement was not associated with lower morbidity after LPD. Complete perioperative omission had CR-DGE and CCI outcomes comparable to postoperative omission and was not associated with a higher observed rate of rescue NGT insertion, supporting its feasibility as a perioperative strategy.

Statements and Declarations

Authors' contributions

JZ.Z and QL.L collected and analysed the data and drafted the manuscript. M.W. conceived and designed the study. TT.Q. contributed to the study design and supervised the statistical analyses. F.Z.

developed the manuscript structure and led its final revision. All authors reviewed and approved the final manuscript.

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Competing interests

The authors declare no competing interests.

Data availability

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

Code availability

Not applicable

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Tables

Tables 1 to 3 are available in the supplementary files section

Figures

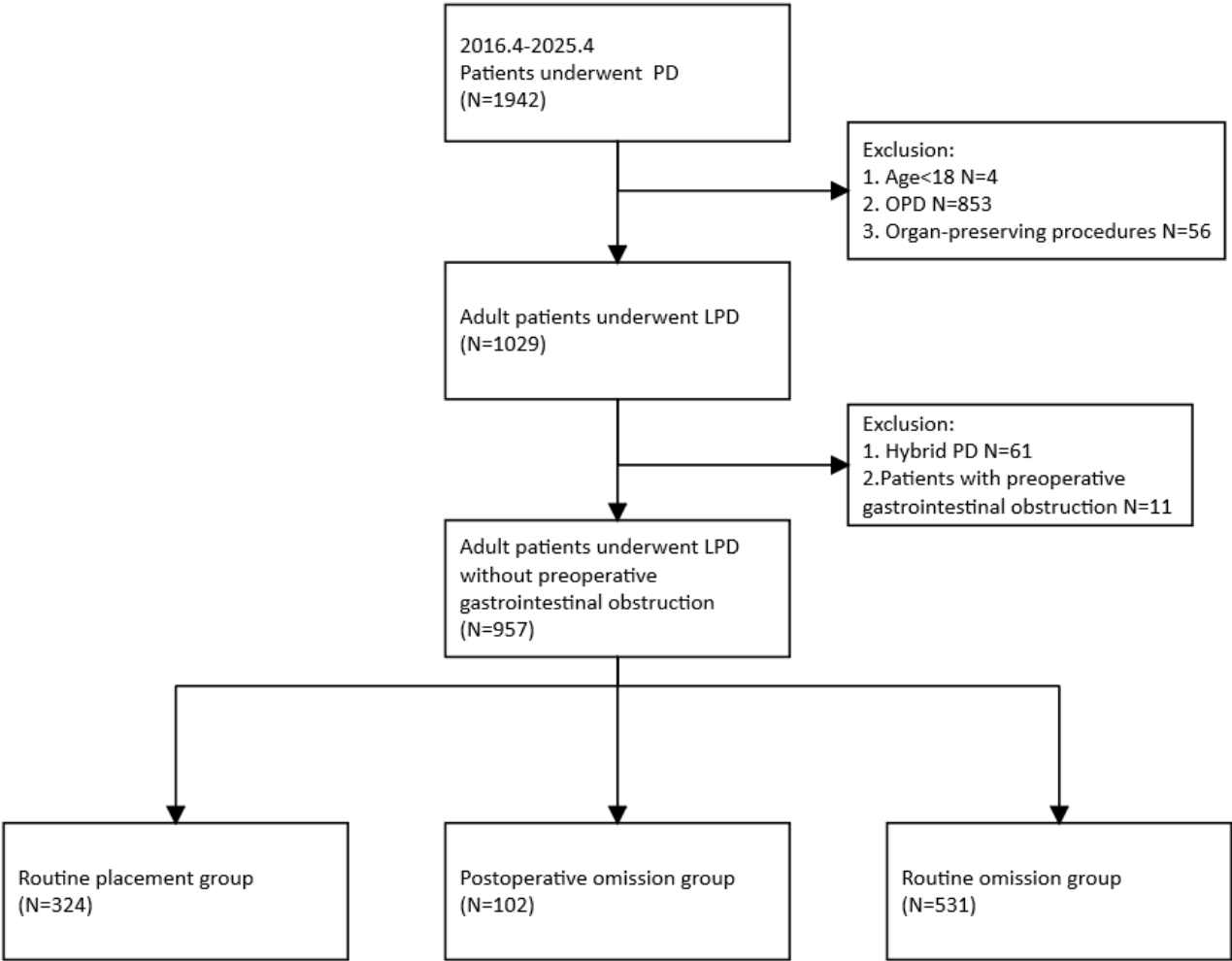


Figure 1

Flowchart

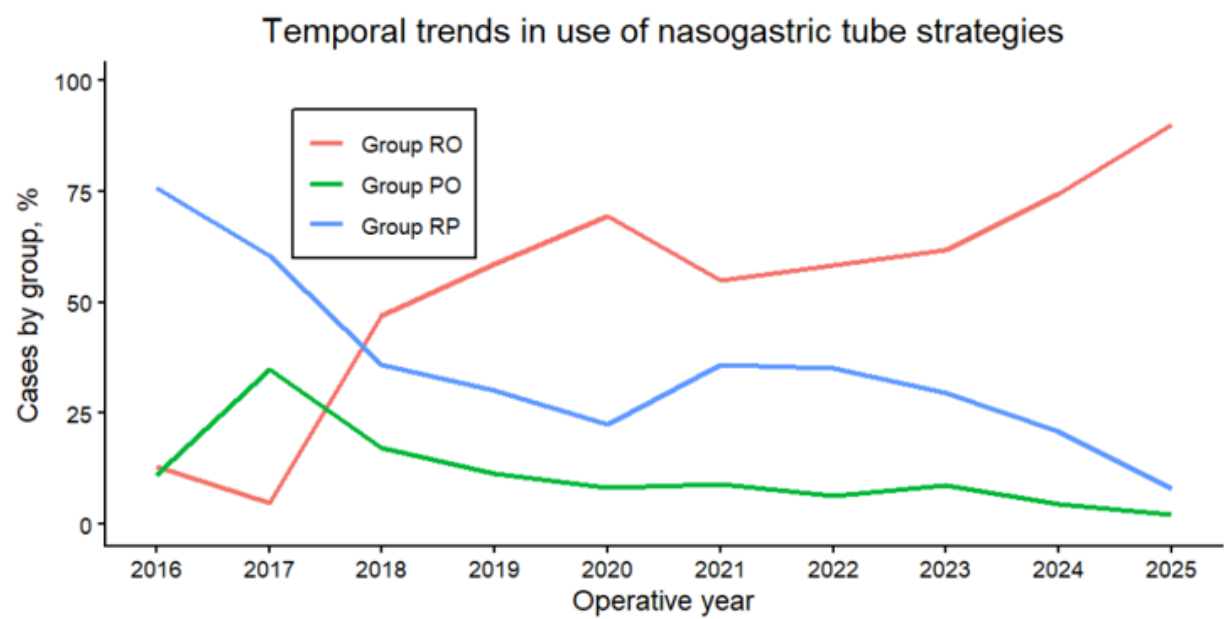


Figure 2

Temporal trends in perioperative NGT strategy use over the study period

Supplementary Files

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