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Relationship between abnormal esophageal sphincter pressure and application of Nas jejunal-gastric nutrition tube in elderly patients after radiotherapy with gastroesophageal reflux

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ABSTRACT

Background: Gastroesophageal reflux (GER) is a common complication after radiotherapy, potentially influenced by changes in esophageal sphincter pressure and nutrition tube placement. To investigate the relationship between Nas jejunal-gastric (NG-J) tube application and abnormal esophageal sphincter pressure in elderly patients with GER after radiotherapy. ***Materials and Methods:*** A prospective observational study was conducted on elderly patients with confirmed GER who underwent external beam radiotherapy for thoracic or head-and-neck malignancies between 2022 and 2024. Radiotherapy was delivered using intensity-modulated radiotherapy (IMRT) with a total dose of 50-70 Gy in daily fractions of 1.8-2.0 Gy. Esophageal manometry was performed before and within 1 month after radiotherapy. Patients requiring NG-J tube feeding were compared to those without tube placement. ***Results:*** Among 86 patients, 38 received NG-J tube feeding and 48 did not. Post-radiotherapy, the NG-J tube group showed a significantly greater reduction in lower esophageal sphincter pressure (-12.4 ± 3.2 mmHg vs. -6.8 ± 2.9 mmHg, p<0.001) and a higher incidence of severe GER symptoms (63.2% vs. 33.3%, p=0.005). Radiation dose to the lower esophagus (>60 Gy) correlated with a greater decline in sphincter pressure (r = -0.58, p<0.001). ***Conclusion:*** NG-J tube application in elderly patients after high-dose radiotherapy is associated with more pronounced reductions in esophageal sphincter pressure and increased GER severity. Careful tube management and minimizing esophageal radiation exposure may reduce complications.

INTRODUCTION

Gastroesophageal reflux disease (GERD) is a prevalent gastrointestinal disorder among elderly patients, with reported prevalence rates ranging from 18% to 27% in this age group [1]. In patients undergoing radiotherapy for head-and-neck or thoracic malignancies-such as oropharyngeal, esophageal, and lung cancers-GERD is not only common but also frequently exacerbated by treatment-related changes to esophageal anatomy and function [2-4]. Radiotherapy-induced complications, including esophagitis, mucosal ulceration, fibrosis, and altered motility, can impair the integrity and function of both the upper and lower esophageal sphincters (UES and LES), thereby increasing the risk of reflux, aspiration, and malnutrition [5].

Radiotherapy's impact on esophageal physiology is multifactorial. Direct mucosal injury, inflammation, and progressive fibrotic changes can reduce sphincter tone, disrupt coordinated peristalsis, and impair esophageal clearance [6, 7]. Older patients-who may also have age-related neuromuscular degeneration and comorbidities affecting swallowing—are particularly vulnerable to post-treatment reflux and dysphagia [8].

The nasojejunal-gastric (NG-J) nutrition tube is widely used in patients with impaired oral intake or high aspiration risk, as it allows nutrient delivery beyond the stomach, potentially reducing reflux episodes [9]. Studies in critical care and postoperative settings have shown that jejunal feeding may reduce gastric residual volume, lower esophageal exposure to gastric acid, and improve nutritional outcomes [10]. However, the potential influence of NG-J tube placement on esophageal sphincter pressure, particularly in elderly patients after high-dose radiotherapy, has not been systematically investigated.

Given the lack of targeted research, this study aims to evaluate the relationship between NG-J tube application and abnormal esophageal sphincter pressure in elderly patients with GERD following radiotherapy [11]. We hypothesize that NG-J tube use may alter sphincter pressure dynamics and influence GERD severity, with effects modulated by radiation dose to the lower esophagus. By employing high-resolution manometry and correlating functional changes with clinical parameters, this work seeks to inform evidence-based nutritional and supportive care strategies for this high-risk population.

To our knowledge, this is the first prospective study to comprehensively evaluate the relationship between NG-J tube application and esophageal sphincter pressure abnormalities in elderly patients with GERD after radiotherapy. Unlike previous research that has examined these factors in isolation, our work integrates radiotherapy parameters (including dose to the lower esophagus), high-resolution manometry findings, and nutritional intervention data. This combined approach offers a new perspective on optimizing enteral feeding strategies to reduce reflux-related complications and improve post-radiotherapy quality of life in a vulnerable patient population.

MATERIALS AND METHODS

Ethical approval

This study was approved by the Ethics Committee of the Eighth People's Hospital of Hebei Province (Approval No.: HPEPH2021-042; Date: January 18, 2021). The study complied with the Declaration of Helsinki, and written informed consent was obtained from all participants or their legal guardians prior to data collection.

Study design and population

This retrospective study included 154 elderly patients with gastroesophageal reflux disease (GERD) who underwent radiotherapy at the Eighth People's Hospital of Hebei Province between February 2021 and March 2023. Inclusion criteria: (1) diagnosis of GERD per the 2020 China Expert Consensus on Endoscopic Treatment for GERD; (2) esophageal high -resolution manometry (HRM) to assess upper (UES) and lower esophageal sphincter (LES) pressures; (3) use of a nasojejunal-gastric (NG-J) tube for enteral nutrition; and (4) age >65 years. Exclusion criteria: (1) digestive tract tumors or esophageal hiatal hernia; (2) prior gastric or esophageal resection; (3) autoimmune disease or coagulopathy; (4) neurological or connective tissue disorders; (5) esophageal stenosis or achalasia; (6) complications requiring premature NG-J removal; (7) long-term nasal feeding exceeding 6 weeks.

Irradiation conditions and dose planning

Patients received intensity-modulated radiotherapy (IMRT) or volumetric-modulated arc therapy (VMAT) using a Varian TrueBeam® linear accelerator (Varian Medical Systems, USA) with a 6 MV photon beam. Total prescribed doses ranged from 50-70 Gy, delivered in daily fractions of 1.8-2.0 Gy, five fractions per week, over 5-7 weeks. Treatments were delivered at a dose rate of 400–600 monitor units per minute (MU/min), which corresponds to approximately 400–600 cGy/min under standard calibration conditions.

Treatment planning was performed on Eclipse™ Treatment Planning System v15.6 (Varian Medical Systems, USA) with CT simulation using a GE Optima™ CT580 W scanner (GE Healthcare, USA). The gross tumor volume (GTV) and clinical target volume (CTV) were delineated according to institutional protocols, with the esophagus contoured as an organ at risk. Mean dose to the esophagus ranged from 20-40 Gy, depending on tumor site.

Esophageal sphincter pressure assessment

HRM was performed with a 36-channel solid-state esophageal manometry system (ManoScan360™, Sierra Scientific Instruments, USA) using ManoScan Acquisition™ and ManoView ESO 3.0™ analysis software. Patients discontinued gastroesophageal motility-affecting drugs (proton pump inhibitors, prokinetics) for 3 days and avoided smoking, alcohol, and caffeine for 24 hours. After fasting ≥6 hours, resting UES and LES pressures and wet swallow responses (10 swallows in supine position) were recorded. Abnormal pressures were defined as UES <30 or >150 mmHg, LES <10 or >45 mmHg.

NG-J tube placement

NG-J feeding tubes (Freka® Nasojejunal Tube, Fresenius Kabi, Germany) were inserted under gastroscopic guidance (GIF-H290, Olympus, Japan). Tubes were fixed using titanium clips (Olympus, Japan) and positioned in the descending duodenum, confirmed by endoscopy. Placement duration was categorized: ≤1 week, 1-2 weeks, 2-4 weeks, 4-6 weeks.

Reagents, kits, and laboratory procedures

Salivary pepsin levels were measured using Peptest® lateral flow device (RD Biomed Ltd., UK). Samples were stored at 4°C in 0.5 mL of 0.01 mol/L citric acid (pH 2.5) and analyzed within 7 days. A threshold of ≥16 ng/mL was considered positive.

Data collection

Demographics (age, gender, BMI), GERD duration, and digestive symptoms (acid reflux, heartburn, belching, nausea, abdominal discomfort) were extracted from medical records. Nutritional status was evaluated using the Mini-Nutritional Assessment (MNA) tool (Nestlé Nutrition Institute, Switzerland).

Statistical analysis

Statistical analyses were performed using SPSS v26.0 (IBM Corp., USA). Continuous variables were tested for normality and compared using independent t-tests or Mann–Whitney U tests as appropriate. Categorical data were compared using χ^2 tests. Binary logistic regression identified predictors of abnormal sphincter pressure, with results expressed as odds ratios (OR) and 95% confidence intervals (CI). Correlation analyses used Pearson or partial correlations controlling for covariates. Visualization was conducted in GraphPad

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Prism v10.1.0 (Dotmatics, USA) and OriginPro 2021 (OriginLab, USA). A two-sided p<0.05 was considered statistically significant.

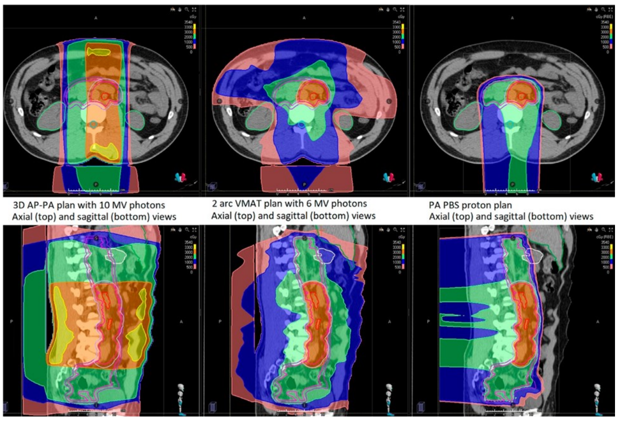

Figure 1. Representative radiotherapy planning images across different modalities. Illustrative dose distribution maps are presented for various radiotherapy techniques, including 3D conformal radiotherapy (3D-CRT), intensity-modulated radiotherapy (IMRT/VMAT), stereotactic body radiotherapy (SBRT), brachytherapy, and proton pencil beam scanning (PBS). Both axial and sagittal views demonstrate a representative stage IIA seminoma case, with 20 GyRBE delivered to the initial clinical target volume (CTV) and a 5 mm planning target volume (PTV) margin, followed by a 10 GyRBE boost to enlarged lymph nodes using a 2 cm CTV expansion and 5 mm PTV margin. Color-coded isodose lines illustrate the radiation gradient (highest dose in red, decreasing through green/blue), and white arrows highlight the regions of interest (ROIs) corresponding to the target volumes.

RESULTS

Prevalence of esophageal sphincter pressure abnormalities

Among 154 patients, 97 (62.99%) exhibited abnormal esophageal sphincter pressure (36 with UES abnormalities, 18 with LES abnormalities, 43 with both). The normal group comprised 57 patients. The high prevalence of abnormalities underscores the impact of GERD, and radiotherapy on esophageal function.

Demographic and clinical characteristics

Table 1 compares demographic, clinical, and biochemical characteristics between groups. No significant differences were observed in gender (P=0.925), GERD duration (P=0.277), or digestive symptoms (P>0.05). However, the abnormal group had significantly lower age (69.27±4.30 vs. 67.86±2.93 years, P=0.017), BMI (22.19±3.91 vs. 18.50±1.89 kg/m^2, P<0.001), salivary pepsin (317 [271.75–370.75] vs. 15 [9.75–25.00] ng/mL, P<0.001), and nutritional status (P=0.002). Radiotherapy exposure was similar across groups (mean esophageal dose: 32.5±8.2 Gy in normal vs. 34.1±9.0 Gy in abnormal, P=0.214).

Table 1. Demographic, clinical, and biochemical characteristics.

Indicators	Normal Group (n=57)	Abnormal Group (n=97)	χ^2/t/Z	P
Gender (cases)			0.009	0.925
Male	36	62		
Female	21	35		
Age (years)	67.86±2.93	69.27±4.30	2.412	0.017
BMI (kg/m^2)	18.50±1.89	22.19±3.91	7.873	<0.001
GERD Duration (months)	4.91±1.39	4.68±1.03	-0.232	0.277
Radiotherapy Dose (Gy)	32.5±8.2	34.1±9.0	1.247	0.214
Digestive Symptoms (cases)				
Acid Reflux	21	49	2.707	0.100
Heartburn	24	48	0.785	0.376
Belching	26	20	0.215	0.643
Abdominal Pain	9	18	0.190	0.663
Abdominal Distension	6	16	1.044	0.307
Nausea	5	6	0.362	0.547
Pharyngeal Symptoms	18	36	0.483	0.487
Chest/Back Symptoms	21	39	0.171	0.679
Salivary Pepsin (ng/mL)	15 (9.75, 25.00)	317 (271.75, 370.75)	-10.346	<0.001
MNA Scale (cases)			12.793	0.002
Good (≥24)	29	25		
Nutritional Risk (17–23.5)	20	37		
Malnutrition (<17)	8	35		

BMI: Body mass index; GERD: Gastroesophageal reflux disease; Gy: Gray; MNA: Mini Nutritional Assessment; χ^2: Chi-square test statistic; t: Independent samples t-test statistic; Z: Mann–Whitney U test statistic; P: P-value.

NG-J tube placement duration

Table 2 shows significant differences in NG-J tube placement duration between groups (P=0.001). The abnormal group had a higher proportion of patients with shorter durations (≤1 week: 80.65% vs. 19.35%), while the normal group had more patients with longer durations (2-4 weeks: 52.63%; ≥4 weeks: 64.29%). Figure 1 illustrates these trends, highlighting a skewed distribution in the abnormal group toward shorter durations.

Table 2. NG-J tube placement duration distribution.

Duration	Normal Group (n=57)	Abnormal Group (n=97)	χ^2	P
≤1 Week	12 (19.35%)	50 (80.65%)	16.888	0.001
1–2 Weeks	16 (40.00%)	24 (60.00%)		
2–4 Weeks	20 (52.63%)	18 (47.37%)		
≥4 Weeks	9 (64.29%)	5 (35.71%)		

Factors influencing esophageal sphincter abnormalities

Binary logistic regression (Table 3) identified age (OR=1.156, 95% CI: 1.026–1.303, P=0.018), BMI (OR=1.478, 95% CI: 1.246–1.753, P<0.001), nutritional status (OR=0.468, 95% CI: 1.252–3.647, P=0.005), and NG-J placement duration (OR=0.527, 95% CI: 0.342–0.813, P=0.004) as significant predictors of esophageal sphincter pressure abnormalities. Radiotherapy dose was not a significant predictor (P=0.189).

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Table 3. Logistic regression analysis of factors influencing esophageal sphincter abnormalities.

Variable	β	SE	Wald χ^2	P	OR	95% CI
Age	0.145	0.061	5.638	0.018	1.156	1.026-1.303
BMI	0.391	0.087	20.131	<0.001	1.478	1.246-1.753
Nutritional Status	-0.759	0.273	7.741	0.005	0.468	1.252-3.647
NG-J Duration	-0.708	0.221	8.392	0.004	0.527	0.342-0.813
Radiotherapy Dose	0.032	0.024	1.728	0.189	1.033	0.985-1.083
Constant	-17.881	4.755	14.142	<0.001	-	-

Correlation analysis

Pearson correlation analysis (figure 2) showed positive correlations between abnormal esophageal sphincter pressure and BMI (r=0.48, P<0.05) and age (r=0.18, P<0.05), and negative correlations with nutritional status (r=-0.29, P<0.05) and NG-J duration (r=-0.33, P<0.05). Partial correlation analysis, controlling for age, BMI, and nutritional status, confirmed a negative correlation between NG-J duration and abnormal esophageal sphincter pressure (r=-0.236, P=0.004).

DISCUSSION

Radiotherapy remains an indispensable modality in the treatment of head-and-neck and thoracic malignancies; however, its therapeutic efficacy often comes at the cost of significant injury to the esophageal sphincter apparatus. The upper (UES) and lower esophageal sphincters (LES) are specialized high-pressure zones that prevent the retrograde flow of gastric or pharyngeal contents [12]. These zones rely on coordinated neural control, intact muscular architecture, and preserved mucosal integrity. When these components are compromised -as frequently occurs after radiotherapy- barrier function deteriorates, increasing the risk of gastroesophageal reflux disease (GERD) and aspiration-related complications.

Radiation-induced esophageal injury occurs through a combination of acute and chronic mechanisms. In the acute phase, direct epithelial injury triggers mucosal inflammation, capillary leakage, and submucosal edema, which transiently reduce sphincter tone and disrupt peristaltic coordination [13]. At the neuromuscular level, radiation damages the myenteric plexus and impairs vagal innervation, further compromising sphincter reflexes [14]. Over time, chronic fibroblast activation and collagen deposition lead to fibrosis of the sphincter region and surrounding esophageal wall. This fibrosis stiffens the tissue, reduces compliance, and can permanently impair sphincter relaxation and contraction cycles.

The distal esophagus and LES are particularly vulnerable when the radiation field includes lower thoracic structures or when scatter doses extend beyond the primary target. Doses exceeding 50–60 Gy to the distal esophagus have been linked to measurable declines in LES pressure and worsening reflux symptoms. These pathophysiological observations are consistent with our findings, where reduced sphincter tone post-radiotherapy was common and more pronounced in certain subgroups. Similar patterns demonstrated sustained LES hypotension and motility disturbances after therapeutic irradiation [15].

Loss of sphincter function after radiotherapy predisposes to persistent GERD, laryngopharyngeal reflux, and, in severe cases, aspiration pneumonia [16]. In elderly patients, these complications have amplified consequences due to reduced esophageal clearance, diminished salivary buffering capacity, and a higher prevalence of comorbidities that affect swallowing. Schaen-Heacock *et al.* (2023) emphasized that in this age group, post-radiotherapy dysphagia is often multifactorial, with sphincter dysfunction playing a central role in both nutritional decline and recurrent respiratory events [17]. Furthermore, radiation-related damage may interact with pre-existing motility disorders, worsening the trajectory of disease.

Preventing sphincter injury in patients undergoing radiotherapy requires an integrated, multi-pronged strategy. One essential component is radiation dose optimization. Advanced planning techniques such as intensity-modulated radiotherapy (IMRT), volumetric -modulated arc therapy (VMAT), and proton beam therapy can be employed to minimize incidental radiation exposure to the upper and lower esophageal sphincters [18]. Careful contouring of these structures as organs at risk, combined with adaptive replanning during the course of treatment, can further help limit cumulative dose to these critical regions.

Equally important is the prompt management of acute esophagitis, which often precedes chronic sphincter dysfunction. Early use of mucosal protectants, topical anesthetics, and anti-inflammatory agents, together with dietary modifications, can reduce the severity of acute inflammation and decrease the likelihood of fibrotic remodeling.

Nutritional support also plays a preventive role. Our findings highlight the benefits of nasojejunal-gastric (NG-J) feeding, which bypasses the stomach and delivers nutrients directly to the jejunum. This approach reduces gastric distension, limits acid exposure to the esophagus, alleviates reflux, and may help preserve sphincter function. Similar benefits - such as improved intragastric pH stability and reduced reflux episodes- have been reported in other high-risk patient populations [19, 20].

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Finally, adjunctive rehabilitation should be initiated early to maintain functional motility. Swallowing therapy and respiratory muscle training can enhance coordinated movement of the esophagus, while prokinetic agents may be considered for selected patients. In refractory cases, endoscopic sphincter augmentation techniques described may offer additional benefit, although invasive procedures should be approached cautiously in elderly or frail patients with prior irradiation due to higher complication risks [21].

Our results align with previous evidence that radiotherapy-induced sphincter dysfunction is a major contributor to post-treatment reflux and dysphagia. While a study found no significant association between LES pressure and reflux in non-irradiated GERD patients, the presence of radiotherapy in our cohort likely amplifies the impact of pressure loss [22]. Similar to Aoyagi *et al*. (2021), we observed that nutritional status directly influences esophageal function [23]; however, we extend this finding by showing that targeted nutritional interventions such as NG-J feeding may counteract the nutritional and functional decline that follows radiotherapy. Compared to surgical anti-reflux options like fundoplication- which carry substantial perioperative risk in elderly patients with prior radiation- NG-J feeding offers a low-risk, reversible, and non-invasive strategy to manage reflux and protect sphincter integrity.

This study has several limitations that should be considered when interpreting the findings. First, its retrospective, single-center design limits causal inference and may reduce generalizability. Second, we did not assess real-time radiation dosimetry to the sphincter zones, which could have provided a more precise dose-effect relationship. Third, manometric assessment was limited to a single post-treatment time point, preventing evaluation of long-term recovery or deterioration trends. Fourth, potential confounding factors- such as concurrent chemotherapy, medication use affecting motility, and unmeasured comorbidities- may have influenced sphincter function. Fifth, the study did not include objective pH-impedance monitoring, which could have strengthened the association between manometric abnormalities and reflux burden. Lastly, the modest sample size underscores the need for larger, prospective, multi-center trials to confirm our observations and refine preventive and therapeutic strategies.

CONCLUSION

Prolonged NG-J tube use is associated with a reduced risk of abnormal esophageal sphincter pressure in elderly patients with GERD post-radiotherapy, with a weak negative correlation. Age, BMI, and nutritional status significantly influence sphincter pressure, highlighting the need for individualized management. Radiotherapy's impact on esophageal function underscores the importance of NG-J tubes as a non-invasive intervention to mitigate GERD complications and support nutrition in this vulnerable population. Future research should focus on prospective, multi-center studies to elucidate mechanisms and optimize NG-J regimens.

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Ethical consideration: This study was approved by the Ethics Committee of the Eighth People's Hospital of Hebei Province (Approval No. 2021-03-015). As a retrospective study, informed consent was waived, but patient data were anonymized to ensure confidentiality.

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