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Important Role of Pharyngeal Constrictors in Carcinoma of Head and Neck Radiotherapy: Dose Assessment

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ABSTRACT

Introduction: Late-onset impaired swallowing is a frequent clinically significant outcome of irradiation for head and neck malignancies. Accumulating evidence indicates that radiation exposure of the pharyngeal constrictor musculature contributes substantially to post-treatment dysphagia.

Objective: This study evaluated the incidence of late dysphagia and explored associations between dosimetric parameters of pharyngeal constrictor muscles and impaired swallowing in patients receiving definitive irradiation.

Material And Methods: In this cohort study, 50 patients were included with oropharyngeal, hypopharyngeal, or laryngeal carcinoma (any T, any N, M0) treated between December 2020 and April 2022. All patients underwent CT-based planning and were treated with intensity-modulated radiotherapy (IMRT) with or without concurrent chemotherapy. Pharyngeal constrictors were delineated as organs at risk. Swallowing function was assessed using the EORTC QLQ-H&N35 questionnaire and graded according to RTOG criteria. Dosimetric parameters correleation was done with impaired swallowing grades at 6 months following irradiation completion.

Results: 23 patients were evaluable at 6 months. Grade I, II, and III dysphagia were observed in 60.87%, 30.43%, and 8.7% of patients, respectively. Increasing dysphagia severity demonstrated a consistent trend with higher maximum dose and high-dose volume exposure (V65) to the superior and middle pharyngeal constrictor muscles. Mean and Dmax of SPCM increased from 68.46 Gy in Grade I to 69.21 Gy in Grade III dysphagia, while V65 increased from 28.58% to 63.38%. Similar dose–volume escalation was noted for the MPCM. These differences did not reach statistical significance.

Conclusion: Higher dose and volume exposure of the superior and middle pharyngeal constrictor muscles shows direct association with worsening of impaired swallowing. IMRT planning strategies that prioritize sparing of these structures may reduce long-term swallowing morbidity. Larger prospective studies with extended follow-up are needed to define robust dose constraints.

Keywords: Carcinoma of head and neck; radiation-induced impaired swallowing; pharyngeal constrictor muscles; intensity-modulated radiotherapy; dose–volume parameters; late toxicity.

INTRODUCTION

Cancers of the head and neck originate from inner epithelial cells of upper aerodigestive tract and represents substantial global health problems, predominantly in lower resourced nations [1,2]. Radiotherapy, delivered alone or combined with systemic therapy, remains a fundamental component of curative treatment for locally advanced disease [3–5]. While establishment of intensity-modulated radiotherapy has refined dose conformity and reduced toxicity to several critical structures, long-term functional complications continue to affect survivorship outcomes [6].

Among late toxicities, dysphagia represents paramount disabling consequences of head and neck radiotherapy. Patients may experience persistent difficulty swallowing solids or liquids, aspiration events, prolonged meal times, and, in severe cases, long-term dependence on enteral feeding [7,12]. Such impairments are associated with malnutrition, recurrent respiratory infections, and marked deterioration in health-related quality of life [15,22]. Importantly, swallowing dysfunction often manifests months after treatment completion and may progress over time, underscoring its relevance as a late toxicity endpoint [16].

Radiation-associated dysphagia arises through multiple biological mechanisms, including mucosal injury, chronic inflammation, fibrosis, neuromuscular dysfunction, and impaired coordination of the swallowing apparatus [17,18]. Pharyngeal constrictors comprising the superior, middle, inferior constrictors—play a pivotal role in bolus propulsion and airway protection during deglutition [23]. Due to their anatomical proximity to primary tumors and elective nodal regions, these muscles frequently receive substantial radiation doses during definitive treatment.

Multiple dosimetry studies have demonstrated a relationship between pharyngeal constrictors irradiation and subsequent difficulty in deglutition. Higher mean doses and volumes of the superior and middle constrictors have been linked to increased rates of dysphagia, aspiration, and feeding tube dependence [7–10,14,24]. As a result, contemporary radiotherapy planning increasingly emphasizes delineation and sparing of swallowing-related structures. The present study prospectively evaluates late dysphagia incidence and examines dose–volume correlations involving pharyngeal constrictors in patients having treatment with definitive raditherapy.

MATERIALS AND METHODS

Study Design and Patient Selection

This single-institution cohort study was conducted in Radiotherapy department of Valavadi Narayanaswamy Cancer Centre, G. Kuppuswamy Naidu Memorial Hospital. Fifty patients with biopsy proven carcinoma of the oropharynx, hypopharynx, or larynx (any T, any N, M0) planned for definitive radiotherapy were included.

Pretreatment Evaluation

All patients underwent comprehensive clinical assessment, including endoscopic evaluation and contrast-enhanced CT imaging of the neck. Baseline performance status was documented using the ECOG scale. Prior approval was taken from institutional ethics committee. Participants provided their written approval before enrollment in this research.

Radiotherapy Planning and Delivery

Patients were immobilized using thermoplastic masks and underwent CT simulation with 3-mm slice thickness. Target delineations were performed according to ICRU and RTOG recommendations. IMRT

using a simultaneous integrated boost technique was employed, delivering 66 Gy in 33 fractions to high-risk planning target volumes with 6 MV photons.

Spinal cord, brainstem, parotid glands, mandible, and pharyngeal constrictors were included as organ at risk. Dosimetric variables analyzed comprised organ volume, V40–V65, maximum dose, and mean dose.

Chemotherapy

Eligible patients with locally advanced disease received concurrent cisplatin-based chemotherapy. Chemotherapy administration was recorded but not used for stratified analysis.

Assessment of Dysphagia

Swallowing function was assessed using the EORTC QLQ-H&N35 questionnaire and graded according to RTOG toxicity criteria. Assessments were performed weekly during radiotherapy and at follow-up visits, with the 6-month post-treatment evaluation used for late dysphagia analysis.

Primary and Secondary Outcomes

The primary outcome of the study was the incidence and severity of late dysphagia at 6 months following completion of definitive radiotherapy, graded according to RTOG criteria.

The secondary outcome was the association between dose–volume parameters of the pharyngeal constrictor muscles and the severity of swallowing impairment.

Inclusion and Exclusion Criteria

Inclusion Criteria

Newly diagnosed patients with histologically confirmed carcinoma of the oropharynx, hypopharynx, or larynx with any primary tumor (T) stage and nodal (N) stage with no evidence of distant metastasis (M0) with planned treatment with definitive radiotherapy, with or without concurrent chemotherapy.

Exclusion Criteria

Patient with early-stage glottic carcinoma (T1–T2, N0), Prior treatment for head and neck cancer, including radiotherapy, chemotherapy, surgery, or alternative therapeutic modalities, History of surgical resection of the primary tumor before initiation of radiotherapy, Presence of distant metastatic disease (M1), Diagnosis of a second primary malignancy involving the head and neck region, Inability or unwillingness to provide written informed consent were excluded from the study.

STATISTICAL ANALYSIS

Descriptive facts were used to summarize patient and therapeutic approach characteristics. Quantitative variables were described as mean ± standard deviation. Comparisons across dysphagia grades were piloted using one-way ANOVA, with statistical significance defined as $p < 0.05$.

ETHICAL GUIDELINES

This research had done according to Declaration of Helsinki and having formal ethics approval by Ethics Committee of G. Kuppuswamy Naidu Memorial Hospital. All Included participants had given their written assent.

RESULTS

Patient Characteristics

Mean age of patients were 62.4 ± 11.25 years, with a predominance of male patients (82%). Majority of patients presented with advanced disease. Main malignancy site was oropharynx subsequently larynx and hypopharynx. 76% patients were treated with definitive chemoradiation.

Incidence of Late Dysphagia

Among the 23 patients evaluable at 6 months, Grade I dysphagia was documented in 14 patients (60.87%), Grade II in 7 patients (30.43%), and Grade III in 2 patients (8.7%). No significant associations were observed between dysphagia grade and tumor site, stage, histology, or treatment modality.

Dosimetric Correlation

A progressive increase in high-dose exposure of the superior and middle pharyngeal constrictor muscles was observed along worsening of impaired swallowing. SPCM V65 increased from 28.58% in Grade I to 63.38% in Grade III dysphagia, while MPCM V65 increased from 80.47% to 99.99% (Figure 2). Dose parameters for the inferior constrictor did not demonstrate consistent trends (Figure 3). None of the observed differences reached statistical significance.

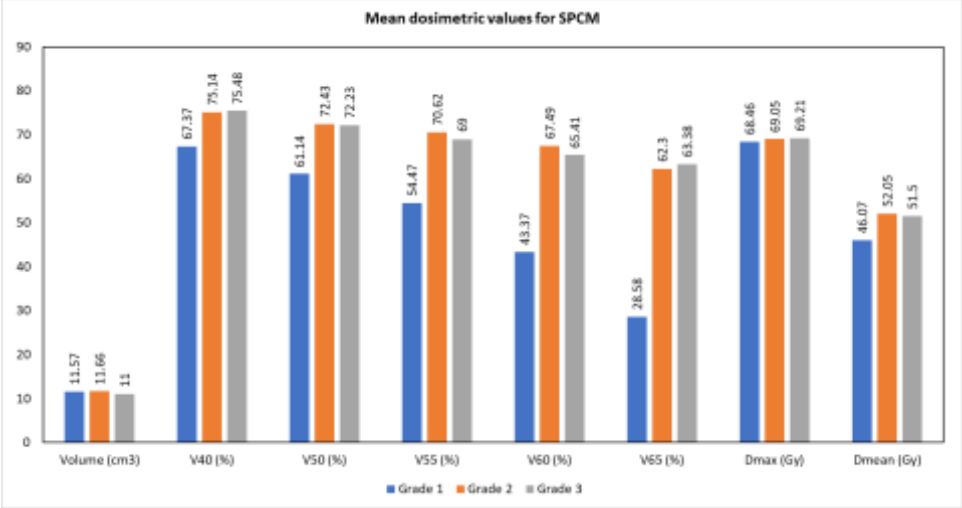

Figure 1: Mean dosimetric values for SPCM

Figure 1- SPCM V65 increased from 28.58% in Grade I to 63.38% in Grade III dysphagia.

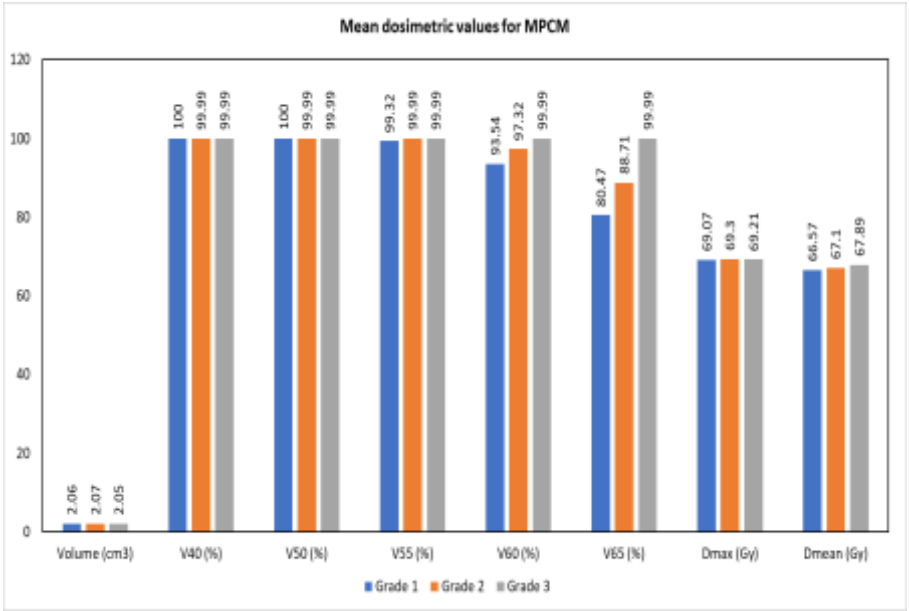

Figure 2: Mean dosimetric values for MPCM

Figure 2- MPCM V65 increased from 80.47% to 99.99%.

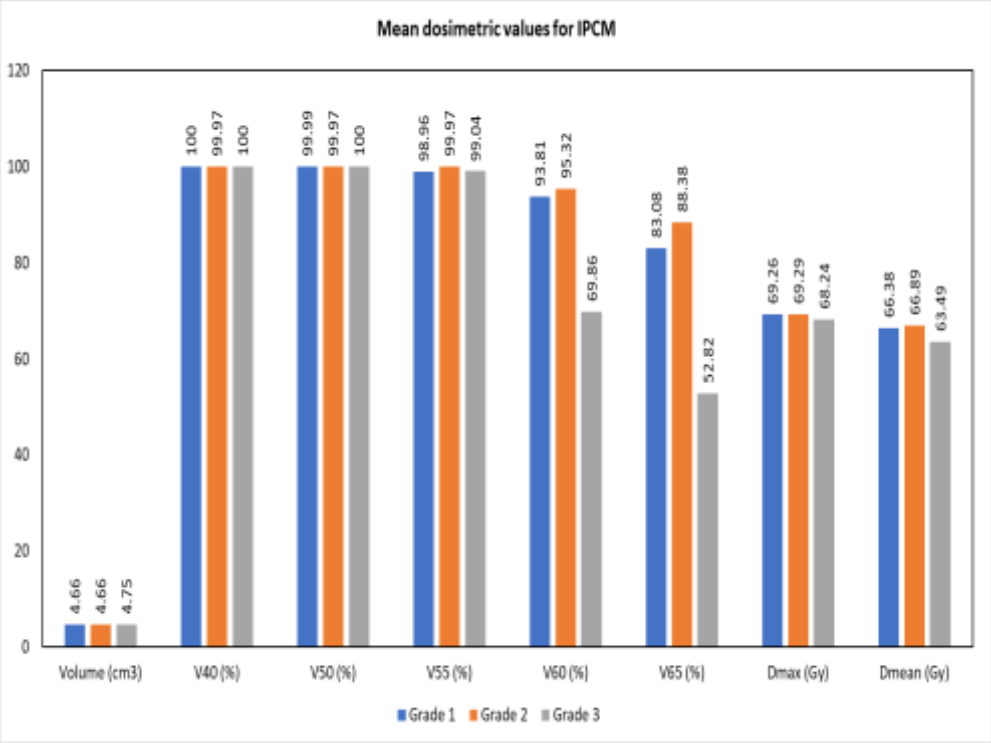

Figure 3: Mean dosimetric values for IPCM

Figure 3-Dose parameters constrictor for the inferior did not demonstrate consistent trends .

DISCUSSION

Despite advances in conformal radiotherapy, late dysphagia remains a prevalent functional complication following definitive treatment for head and neck cancers. This current research showed half patients having persistent swallowing difficulties at 6 months, underscoring the clinical relevance of this toxicity. Comparable rates have been reported in previous prospective and retrospective series [7,11,15].

Seminal dosimetric investigations have established the pharyngeal constrictor muscles as critical determinants of post-treatment swallowing outcomes. Eisbruch et al. identified high-dose exposure of swallowing structures as predictive of aspiration and long-term dysphagia [7], while Feng et al. described early dose–response relationships involving the superior and middle constrictors [9]. Levendag and colleagues further demonstrated correleation with increasing dose to these muscles and dysphagia severity [10]. Although statistical significance was not achieved in the present analysis, the observed dose–volume trends align with these foundational studies.

The lack of statistically significant correlations may be explained by limited sample size, relatively short follow-up duration, and heterogeneity in tumor subsites and treatment intensification. Concurrent chemotherapy, which can exacerbate mucosal injury and fibrosis, may also contribute to swallowing dysfunction independently of radiation dose [16,26].

In contrast, dose parameters of the inferior pharyngeal constrictor and cricopharyngeal muscle did not show a clear association with dysphagia severity, consistent with reports suggesting that superior and middle constrictors play a dominant role in pharyngeal clearance and bolus propulsion [19,24].

Clinically, these findings support routine delineation of pharyngeal constrictor muscles during IMRT planning. Strategies aimed at reducing high-dose exposure to the superior and middle constrictors, without compromising target coverage, may contribute to improved long-term swallowing outcomes [27–29].

Future multi-institutional studies incorporating objective swallowing assessments and patient-reported outcomes are needed to refine dose constraints and enhance functional preservation.

LIMITATIONS

Constraints of this research include small count of patients evaluable for late toxicity, limited follow-up duration, and potential treatment interruptions related to the COVID-19 pandemic. These factors may have reduced the statistical power to detect significant dose–response relationships.

CONCLUSION

This prospective dosimetric analysis demonstrates a consistent trend between increased radiation dose to the superior and middle pharyngeal constrictor muscles and worsening of impaired swallowing following definitive IMRT for head and neck cancer. Incorporation of pharyngeal constrictors as routine organs at risk and deliberate dose optimization may help mitigate long-term functional morbidity. Larger, multi-institutional studies with extended follow-up are warranted to establish validated dose constraints and guide swallowing-sparing radiotherapy strategies.

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