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·临床研究·

86例头颈癌放疗后住院患者发生抢救事件的回顾性分析

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【摘要】 目的　总结头颈癌放疗后住院患者发生抢救事件的相关情况，为临床决策提供参考。**方法**　本研究经医院医学伦理委员会批准。回顾性分析2015年至2023年收治的86例头颈癌放疗后因口腔颌面疾病住院患者的临床资料，根据是否发生抢救事件分为抢救组（n=20）与非抢救组（n=66）；并纳入20例年龄、性别与抢救组匹配的健康受试者作为对照组。首先比较抢救组与非抢救组的基线特征差异；其次对抢救组患者的临床特征与抢救事件进行描述性分析；然后比较抢救组与非抢救组2组患者的实验室炎症与营养指标及气管切开情况的差异。最后，利用Dolphin Imaging软件测量抢救组、非抢救组及对照组的锥形束计算机断层扫描（cone beam computed tomography，CBCT）图像，测量上气道指标，包括鼻咽段、腭咽段、舌咽段及喉咽段的矢状径与冠状径。**结果**　①抢救组和非抢救组基线比较结果显示，2组年龄、性别及身体质量指数（body mass index，BMI）的差异无统计学意义，但抢救组患者合并肺部疾病比例高于非抢救组（P<0.05）。②抢救组患者放疗原因主要为鼻咽癌（65%）和舌癌（25%），平均年龄为（54.75±11.59）岁，男女比例为3∶1；本次入院主要原因包括下颌骨放射性骨髓炎（55%）以及口腔颌面肿瘤复发或口腔颌面新发肿瘤（40%）；住院期间抢救原因以呼吸困难为主（55%），其次为急性大出血（15%）和心脏骤停（15%）等；抢救事件多发生于术后（65%），中位发生时间为术后5 d，另有30%发生于术前，5%为术中。③实验室指标与气管切开情况：抢救组患者术前及术后中性粒细胞计数、气管切开占比均高于非抢救组，而术后白蛋白水平较低（P<0.05）。④上气道测量：抢救组与非抢救组的鼻咽段冠状径、矢状径以及舌咽段冠状径均小于对照组（P<0.001）。**结论**　本研究数据表明，头颈癌放疗后住院发生抢救的患者常合并肺部疾病或肿瘤复发/新发，且多表现为呼吸困难；呈现出更高的炎症状态、更差的营养状况及更高的紧急气道干预需求，且共同存在上气道狭窄这一呼吸困难的解剖学基础。临床应对具有此类特征的高危患者给予充分重视。

【关键词】 头颈癌；　口腔癌；　鼻咽癌；　放射治疗；　放射性颌骨骨髓炎；　抢救事件；　呼吸困难；　大出血；　心脏骤停；　气管切开术；　上气道；　锥形束CT
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A retrospective analysis of rescue events among 86 inpatients following radiotherapy for head and neck cancer

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【Abstract】 Objective　To summarize the circumstances of rescue events in hospitalized patients after radiotherapy for head and neck cancer in order to provide a reference for clinical decision-making. **Methods**　This study was ap-

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proved by the hospital's medical ethics committee. A retrospective analysis was conducted on the clinical data of 86 hospitalized patients admitted between 2015 and 2023 for oral and maxillofacial diseases following radiotherapy for head and neck cancer. Based on the occurrence of rescue events, patients were divided into a rescue group (n=20) and a non-rescue group (n=66). In addition, 20 healthy subjects matched for age and gender with the rescue group were included as a control group. First, baseline characteristics were compared between the rescue and non-rescue groups. Second, a descriptive analysis of the clinical characteristics and rescue events of the rescue group patients was performed. Third, differences in laboratory inflammatory and nutritional indicators, as well as tracheostomy status, were compared between the rescue and non-rescue groups. Fourth, Dolphin Imaging software was used to measure cone beam computed tomography images of the rescue group, non-rescue group, and control group. Upper airway parameters were measured, including the sagittal and coronal diameters of the nasopharyngeal, palatopharyngeal, glossopharyngeal, and laryngopharyngeal segments. **Results** ① A comparison of baseline characteristics between the rescue and non-rescue groups showed no statistically significant differences in age, gender, or body mass index, but the proportion of patients with comorbid pulmonary diseases was higher in the rescue group (P<0.05). ② In the rescue group, the primary reasons for radiotherapy were nasopharyngeal carcinoma (65%) and tongue cancer (25%). The mean age was (54.75 ± 11.59) years, with a male-to-female ratio of 3:1. The main reasons for this admission included radio-osteomyelitis in the mandible (55%) and recurrence of oral and maxillofacial tumors or new primary tumors in the oral and maxillofacial region (40%). The primary reason for rescue during hospitalization was dyspnea (55%), followed by acute massive hemorrhage (15%) and cardiac arrest (15%). Rescue events occurred mostly postoperatively (65%), with a median time of occurrence at 5 days post-operatively; 30% occurred preoperatively, and 5% occurred intraoperatively. ③ Laboratory indicators and tracheostomy status: preoperative and postoperative neutrophil counts, as well as the proportion of patients undergoing tracheostomy, were higher in the rescue group compared to the non-rescue group, while postoperative albumin levels were lower (P<0.05). ④ Upper airway measurements: the coronal and sagittal diameters of the nasopharyngeal segment and the coronal diameter of the glossopharyngeal segment were smaller in both the rescue and non-rescue groups compared to the control group (P<0.001). **Conclusion** The data from this study indicate that hospitalized patients experiencing rescue events after radiotherapy for head and neck cancer often have comorbid pulmonary diseases or tumor recurrence/new primary tumors, and frequently present with dyspnea. They exhibit a higher inflammatory state, poorer nutritional status, a greater need for emergency airway intervention, and share a common anatomical basis for dyspnea--upper airway narrowing. Clinical attention should be fully given to high-risk patients with these characteristics.

【Key words】 head and neck cancer; oral cavity carcinoma; nasopharyngeal carcinoma; radiotherapy; osteoradionecrosis of the jaw; emergency rescue event; dyspnea; massive haemorrhage; cardiac arrest; tracheotomy; upper airway; cone beam CT

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放疗作为头颈癌的重要辅助治疗手段，目前已经广泛应用于约80%的相关患者，并改善了总体生存率[1-2]。以鼻咽癌为例，现代精准放疗技术与系统性治疗（包括化疗及新兴的免疫治疗）相结合的综合治疗模式，提升了局部晚期患者的生存率[3]。然而，放疗在杀灭肿瘤细胞的同时[4]，也难以避免地对周围正常组织造成损伤，进而引发一系列并发症。在急性期，患者常出现放射性黏膜炎、口干等症状[5-6]；而在远期，则可能出现放射性颌骨骨髓炎、吞咽功能障碍和组织纤维化等慢性并发症[7-8]，严重影响了患者的生活质量[9]。此外，研究显示放疗也是头颈癌围手术期死亡和术后住院时间延长的危险因素[10-11]。鼻咽部解剖结构复杂且毗邻重要血管与气道，放疗后可能诱发急性大出血、气道梗阻等危急事件[12-13]，临床处理难度大、风险高。

目前，研究多集中于头颈癌放疗后并发症的预防与管理，而对患者因口腔颌面疾病再次入院期间发生抢救事件的相关研究较为缺乏。由于危急事件具有突发性、进展快、死亡率高等特点[14]，若不能早期识别高风险患者并实施有效干预，将严重影响救治成功率。

因此，本研究基于笔者所在医院收治头颈癌放疗患者的临床资料，旨在分析该类患者住院期间发生抢救事件的规律。通过回顾性分析患者的临床特征与检查指标，为早期识别高危患者、及时采取针对性防治措施及抢救提供依据，从而优化患者管理策略，提升抢救成功率与患者整体预后。

1　资料和方法

1.1　研究对象

本研究经广西医科大学附属口腔医院伦理审查委员会批准（审批号：审2024083号）并因研究的回顾性性质获准豁免知情同意。所有患者数据均进行匿名化处理以保护隐私。纳入2015年1月至2023年4月在广西医科大学附属口腔医院口腔颌面外科收治的头颈癌放疗后因并发口腔颌面疾病入院发生抢救事件的患者，纳入流程见图1，本研究采用人工匹配方法为抢救组病例筛选非抢救及对照组病例。匹配基于预先设定的标准进行，按优先级依次为：放疗史、年龄（±5岁）、性别（精确匹配），对照组依次为年龄、性别。由两名研究员独立进行匹配，随后比对结果。若结果一致，则直接采纳；若存在分歧，则通过双方协商或由第三位研究员仲裁决定最终匹配对象。

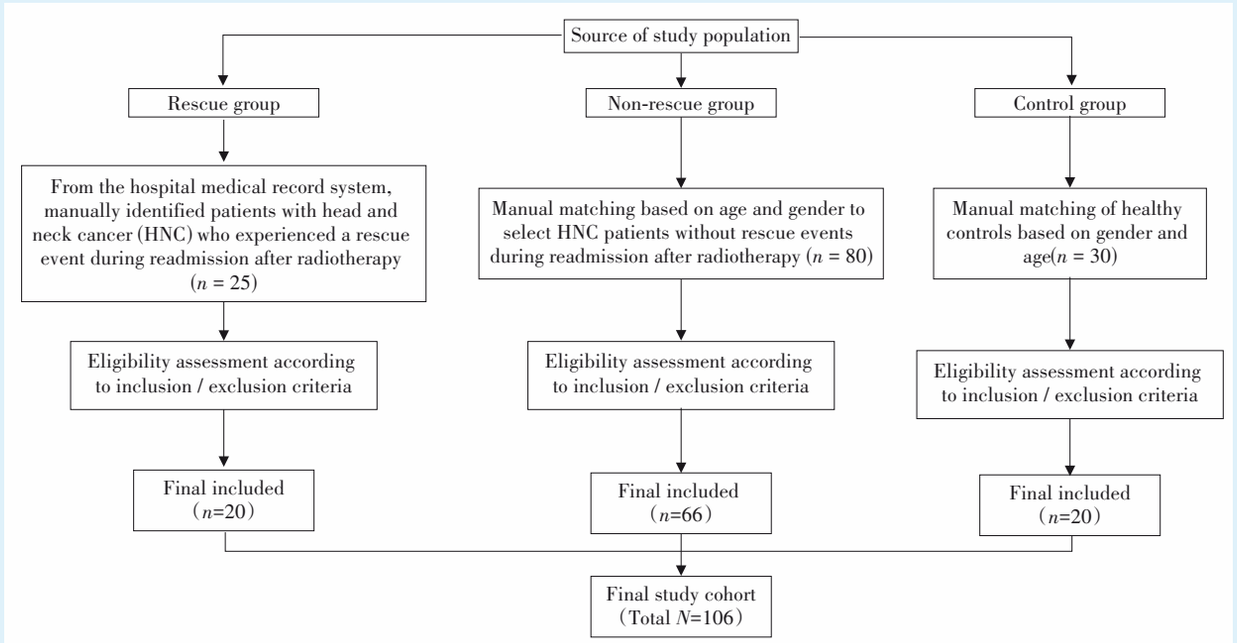


Figure 1　Flowchart of study population screening and enrollment

图1　研究人群筛选与纳入流程图

本研究中的“抢救事件”定义为：头颈癌患者接受放疗结束后，因并发口腔颌面疾病再次入院期间突发出现危及生命的、非计划性、需紧急医疗干预以维持生命体征或阻止器官功能衰竭的急性事件。主要包括：①循环系统衰竭：因心脏骤停需进行心肺复苏；②急性呼吸衰竭：因上呼吸道梗阻或呼吸功能不全，需进行紧急干预或气管切开术；③急性大出血：需进行紧急手术控制活动性出血；④其他：过敏性休克等需紧急干预的情况。

抢救措施：①呼吸困难：立即评估气道，针对病因进行处理，当出现分泌物阻塞呼吸道时，及时给予吸痰；对于咽喉部水肿，选择雾化肾上腺素，静脉推注地塞米松；保证呼吸道顺畅后行给氧等措施；无效则迅速行气管切开；②急性大出血：紧急压迫止血，快速扩容，并优先选择手术探查止血；③心脏骤停：立即启动高级生命支持流程；④过敏性休克：立即停用可疑药物，注射肾上腺素，必要时给予糖皮质激素及抗组胺药物，给予扩容及支持治疗。

抢救组纳入标准：①在住院期间发生了抢救事件；②有头颈癌放射治疗史；③住院病历资料和抢救记录完整；④已拍摄完整清晰的CBCT影像。

抢救组排除标准：①非头颈部肿瘤放射治疗后的患者；②未进行抢救的患者；③无CBCT影像。

非抢救组纳入标准：①有头颈癌放射治疗史；②在住院期间未曾发生过抢救事件；③病历资料完整；④已拍摄完整清晰的CBCT影像。非抢救组排除标准：①非头颈部肿瘤放射治疗后的患者；②无CBCT影像。

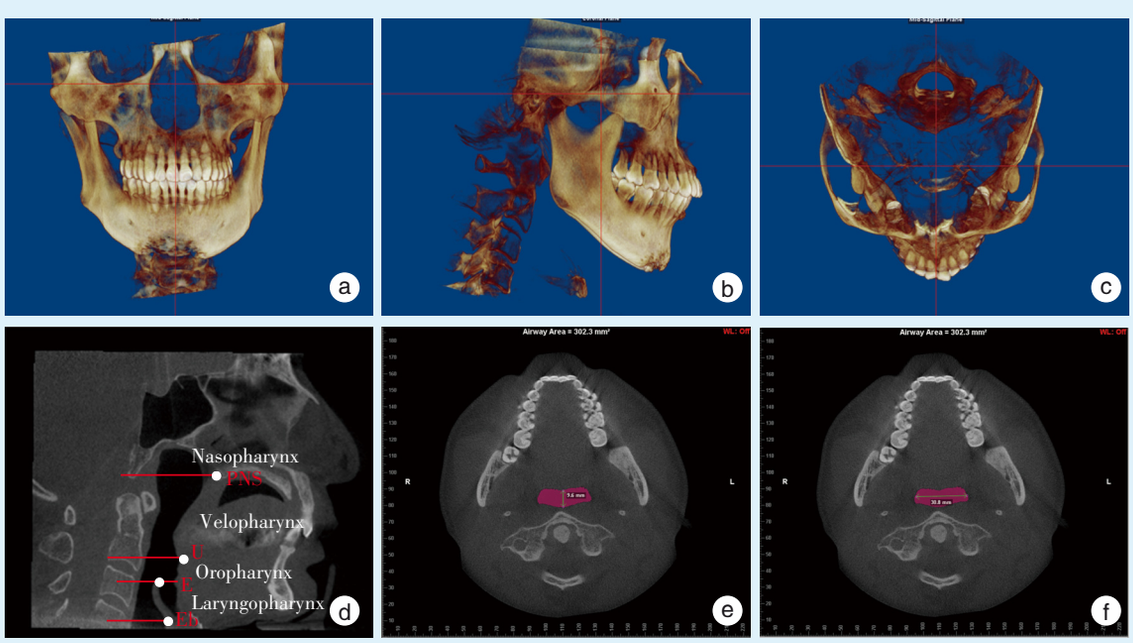
对照组纳入标准：①与抢救组同年龄段；②身体健康；③已拍摄完整清晰的CBCT影像。对照组排除标准：①有系统性疾病史；②有放射治疗史；③上气道因疾病而改变；④无CBCT影像。

1.2　测量指标

为进一步研究上气道结构的变化，选择收集抢救组、放疗后非抢救组及对照组的CBCT数据。将CBCT dicom数据导入Dolphin Imaging软件进行三维重建。首先对图像进行三维空间校准（水平向、矢状向、垂直向）。上气道测量分为鼻咽段、腭咽段、舌咽段及喉咽段，其分界为后鼻棘点（posterior nasal spine，PNS）、悬雍垂尖点（uvula tip，U）、会厌顶点（tip of epiglottis，E）及会厌最低点（base of epiglottis，Eb）至咽后壁的垂直平面，最终测量各气道分段的矢状径和冠状径（图2）。

1.3　统计学方法

所有统计学分析均使用SPSS 25.0软件，以$P<0.05$为差异有统计学意义。计量资料首先进行正态性检验和方差齐性检验。符合正态分布的资料以均数±标准差描述，组间比较采用独立样本t检验（方差齐）或Welch's t检验（方差不齐）；非正态分布资料以中位数（四分位数间距）[M（*IQR*）]描述，组间比较采用Mann-Whitney U检验。多组比较时，正态分布资料采用单因素方差分析，事后两两比较，若方差齐性，采用最小显著性差异法检验（least significant difference，LSD）；若方差不齐，则采用或Tamhane's $T2$检验。计数资料以频数（率）表示，组间比较采用卡方检验。



a: horizontal calibration. b: sagittal calibration. c: vertical calibration. d: the upper airway is classified into four segments, namely, nasopharynx, velopharynx, oropharynx, and laryngopharynx--using the vertical planes from the posterior nasal spine (PNS), uvula tip (U), tip of the epiglottis (E), and base of the epiglottis (Eb) to the posterior pharyngeal wall as boundaries. e: sagittal diameter measurement. f: coronal diameter measurement

Figure 2　The upper airway dimensional measurements

图2　上气道径线测量

2　结　果

2.1　患者基线特征比较

共纳入头颈癌放疗后再次入院治疗患者86例，其中抢救组20例，非抢救组66例，住院期间均接受手术治疗。抢救组和非抢救组患者的基线特征如表1所示。独立样本t检验及卡方检验结果显

示，两组患者的年龄、性别及身体质量指数（body mass index，BMI）上的差异无统计学意义。然而，抢救组患者合并肺部疾病的发生率高于非抢救组。抢救组入院的主要原因包括下颌骨放射性骨髓炎（55%）以及口腔肿瘤复发或口腔新发肿瘤（40%）。抢救组与非抢救组入院诊断见表2。

表1　头颈癌放疗后住院患者抢救组和非抢救组的基线特征

Table 1　Baseline characteristics of inpatients following radiotherapy for head and neck cancer in the rescue and non-rescue groups

Group	Age/years	Gender [*n* (%)]		BMI/(kg/m^2)	Pulmonary disease [*n*(%)]		Hypertension [*n*(%)]		Diabetes mellitus [*n*(%)]	
		Male	Female		Yes	No	Yes	No	Yes	No
Rescue (*n*=20)	54.75±11.59	15(75.0)	5(25.0)	20.65±3.37	5(25.0)	15(75)	4(20.0)	16(80.0)	1(5.0)	19(95.0)
Non-rescue (*n*=66)	52.5±8.18	46(69.7)	20(30.3)	21.12±3.19	4(6.1)	62(93.9)	7(10.6)	59(89.4)	5(7.6)	61(92.4)
t/χ^2	0.97	0.21		0.58	5.88		1.21		0.16	
P	0.34	0.64		0.56	0.02		0.27		0.69	

BMI：body mass index

表2　头颈癌放疗后住院患者抢救组与非抢救组本次入院原因

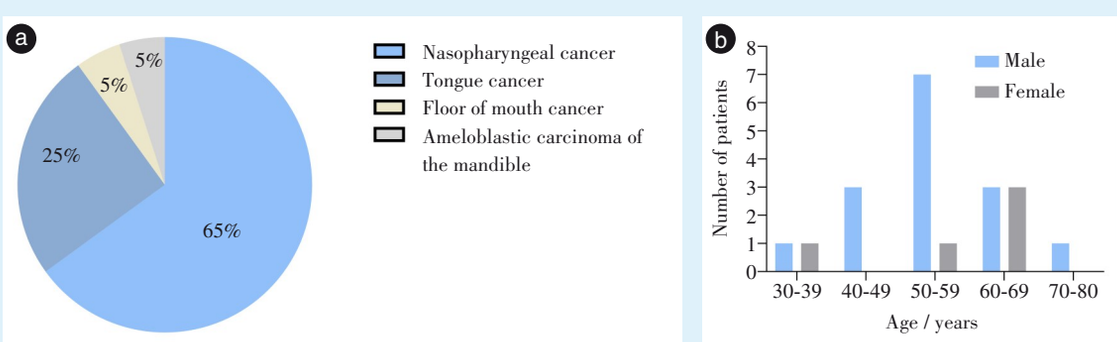
Table 2　Reasons for the current admission of inpatients following radiotherapy for head and neck cancer in the rescue and non-rescue groups

n (%)

Group	radio-osteomyelitis in the mandible	Oral and maxillofacial tumors recurrence or new tumor	Other
Rescue (*n*=20)	11(55.0)	8(40.0)	1(5.0)
Non-rescue (*n*=66)	64(97.0)	2(3.0)	0(0.0)

2.2　抢救组患者临床特征与抢救事件分析

2.2.1　抢救组患者基线特征与治疗情况　抢救组20例患者均有外院头颈癌放疗史，其放疗的主要原因为鼻咽癌（65%）及舌癌（25%）。从放疗结束到至本次再入院的中位时间间隔为5（1.24，13.75）年。患者的中位年龄为54岁，男女比例为3∶1（图3）。



a：reasons for pre-admission radiotherapy. b：age and gender distribution

Figure 3　Reasons for pre-admission radiotherapy, and age and gender distribution of inpatients following radiotherapy for head and neck cancer in the rescue group

图3　头颈癌放疗后住院患者抢救组入院前放疗原因、年龄及性别分布

在治疗方面，抢救组有16例（80%）患者在本次住院期间接受了手术治疗。其中，13例患者接受了下颌骨部分或扩大切除术。为修复组织缺损，共9例患者接受了皮瓣移植，其中游离组织瓣移植（股前外侧肌皮瓣或腓骨肌皮瓣）应用最广泛（8例），另外1例使用了带蒂邻位瓣。在本次入院原因为肿瘤复或新发肿瘤的8例患者中，有5例在本次手术中同期接受了颈淋巴结清扫术（表3）。

2.2.2　抢救事件分析　分析显示，呼吸困难（55%）是首要原因、其次为急性大出血（15%）及心脏骤停

表3　头颈癌放疗后住院患者抢救组手术情况汇总表

Table 3　Summary of surgical procedures of inpatients following radiotherapy for head and neck cancer in the rescue group

Patient No.	Primary disease	Diagnosis	Surgery
1	Left tongue cancer	Recurrent left tongue cancer with orocutaneous fistula and infection	Mass excision + Soft tissue debridement + Tracheostomy
2	Left tongue cancer	Left radio-osteomyelitis in the mandible	None
3	Nasopharyngeal carcinoma	Right radio-osteomyelitis in the mandible	Osteomyelitic lesion clearance + Partial mandibulectomy + Free fibula osteocutaneous flap reconstruction
4	Nasopharyngeal carcinoma	Right radio-osteomyelitis in the mandible	None
5	Right tongue cancer	Submental metastasis after right tongue cancer surgery	Extended resection of metastatic lesion + Extended mandibulectomy + Neck dissection + Free fibula osteocutaneous flap reconstruction
6	Nasopharyngeal carcinoma	Left radio-osteomyelitis in the mandible	None
7	Floor of mouth cancer	Mandibular alveolar defect after floor of mouth cancer surgery	Mandibular reconstruction + Free fibula bone graft
8	Ameloblastoma of the right mandible	Right radio-osteomyelitis in the mandible, right mandibular ameloblastic carcinoma	Mandibulectomy + Extended mass resection + Osteomyelitic lesion clearance + Free anterolateral thigh flap transplantation
9	Nasopharyngeal carcinoma	Right buccal carcinoma	Extended mass resection + Partial mandibulectomy + Suprahyoid neck dissection
10	Nasopharyngeal carcinoma	Left lower gingival carcinoma	Extended resection of gingival carcinoma + Partial mandibulectomy + Neck dissection
11	Left tongue cancer	Recurrent left tongue cancer	Extended tongue cancer resection + Bilateral neck dissection + Partial mandibulectomy + Free anterolateral thigh flap transplantation + Tracheostomy
12	Nasopharyngeal carcinoma	Left tongue cancer	Extended resection of tongue, floor of mouth, and oropharyngeal masses + Bilateral neck dissection + Mandibulectomy+Free anterolateral thigh flap transplantation+Tracheostomy
13	Nasopharyngeal carcinoma	Bilateral radio-osteomyelitis in the mandible	Sequestrectomy for osteomyelitis + Local flap repair
14	Nasopharyngeal carcinoma	Osteosarcoma of the left mandible	Sequestrectomy for osteomyelitis + Extended mandibulectomy + Free fibula osteocutaneous flap reconstruction
15	Nasopharyngeal carcinoma	Tongue base carcinoma	Incisional biopsy of tongue base mass
16	Right tongue cancer	Right radio-osteomyelitis in the mandible	Debridement of osteomyelitic lesion + Partial mandibulectomy
17	Nasopharyngeal carcinoma	Left radio-osteomyelitis in the mandible	Sequestrectomy for osteomyelitis + Free fibula osteocutaneous flap reconstruction
18	Nasopharyngeal carcinoma	Right radio-osteomyelitis in the mandible	None
19	Nasopharyngeal carcinoma	Right radio-osteomyelitis in the mandible	Debridement of osteomyelitic lesion + Partial mandibulectomy + Free fibula osteocutaneous flap reconstruction
20	Nasopharyngeal carcinoma	Right radio-osteomyelitis in the mandible	Debridement of osteomyelitic lesion + Partial mandibulectomy

(15%)等(表4)。抢救事件多发生于手术后(65%),中位发生时间为术后5(2,12)d;另有30%发生于手术前,5%为手术中(图4)。

2.3　实验室指标及气管切开情况比较

2.3.1　实验室炎症及营养指标比较　抢救组患者术前及术后的中性粒细胞计数均高于非抢救组,而术后白蛋白水平则低于非抢救组,差异均具有统计学意义(P<0.05)。其余观察指标在两组间无统计学差异(表5)。

2.3.2　抢救组与非抢救组气道切开情况比较　抢救组气管切开占比高于非抢救组(P<0.001),非抢救组发生的14例气管切开均为手术治疗中同期进行的预防性气管切开。

进一步分析抢救组中13例气管切开病例发现,10例(77%)为抢救中实施气管切开,其余3例(23%)为手术治疗中同期进行的预防性气管切开。

表4　头颈癌放疗后住院患者抢救组的抢救原因

Table 4　Rescue event causes of inpatients following radiotherapy for head and neck cancer in the rescue group

Causes of resuscitation	Cases [*n*(%)]
Respiratory distress	11(55)
Acute massive hemorrhage	3(15)
Cardiac arrest	3(15)
Anaphylactic shock	2(10)
Acute cerebral infarction	1(5)
Total	20(100)

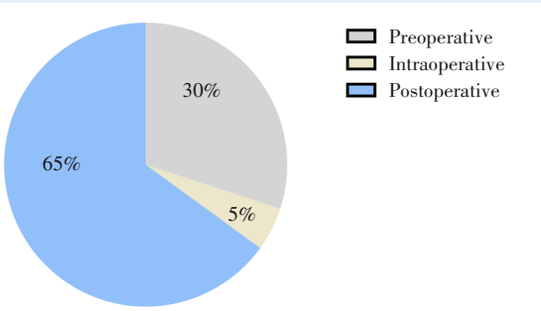


Figure 4　Distribution of the timing of rescue events in relation to the current surgery within inpatients following radiotherapy for head and neck cancer in the rescue group

图4　头颈癌放疗后住院患者抢救组发生抢救时点与本次手术的关系分布

本研究中无患者在放疗前接受预防性气管切开术(表6)。

2.4　抢救组、非抢救组、对照组上气道指标

抢救原因多为呼吸困难。为此,本研究进一步分析了上气道的变化。

通过dolphin imaging软件对抢救组、非抢救组及对照组的CBCT进行上气道测量,结果显示,抢救组和非抢救组的鼻咽段矢状径、冠状径及舌咽段冠状径均小于对照组(P<0.05),而抢救组与非抢救组之间的差异均无统计学意义(P > 0.05)(表7)。

表5　头颈癌放疗后住院患者抢救组和非抢救组实验室炎症及营养指标比较

Table 5　Comparison of laboratory inflammatory and nutritional parameters between rescue and non-rescue groups of inpatients following radiotherapy for head and neck cancer　M(*IQR*)

Group	Timing	Neutrophils /(×10^9/L)	NLR	Albumin /(g/L)	Total protein /(g/L)
Rescue	Preoperative	5.19 (3.23, 7.18)	3.37 (1.76, 5.32)	39.7 (35, 41.6)	64.8 (60.5, 67.2)
	Postoperative	10.65 (8.12, 14.36)		33.5±4.64	56.3±6.61
Non-rescue	Preoperative	3.49 (2.98, 4.96)	2.59 (1.89, 3.92)	40.1 (37.7, 42.4)	65 (61.6, 69.9)
	Postoperative	6.22 (4.16, 9)		36.07±4.09	59.21±7.48
Z/*t*	Preoperative	1.976	1.209	1.044	0.912
	Postoperative	2.571		2.014	1.312
P	Preoperative	0.048	0.227	0.296	0.362
	Postoperative	0.010		0.048	0.19

NLR: neutrophil-to-lymphocyte ratio. Postoperative NLR data were unavailable for the rescue group due to missing original data

表6　头颈癌放疗后住院患者抢救组与非抢救组气管切开对比

Table 6　Comparison of tracheotomy between rescue and non-rescue groups of inpatients following radiotherapy for head and neck cancer

Group	Tracheotomy [*n*(%)]		χ^2	*P*
	Yes	No		
Rescue	13(65.00)	7(35.00)	13.66	<0.001
Non-rescue	14(21.21)	52(78.79)		

3　讨　论

3.1　抢救事件的人群特征

放疗作为头颈癌综合治疗的重要一环,虽然显著改善了生存率,但放疗后可能出现出血等各种危急情况。其中最为突出的是放疗后导致颈动脉狭窄、颈动脉破裂[14-15]及喉咽部水肿[16-17]等,其它还有放疗后鼻咽出血,这可能导致血液吸入、窒息和死亡,这些危急情况死亡率较高。因此,有必要深入探讨头颈癌放疗后住院患者发生危急事件的临床特征与救治策略,为临床早期识别和干预提供依据。

本研究报道了头颈癌放疗后住院患者发生抢救事件的情况。数据显示,抢救患者多为中老年人,抢救事件多发生于手术后。抢救患者主要因放疗后发生下颌骨放射性骨髓炎再次入院,这与

表7　头颈癌放疗后住院患者抢救组、非抢救组、对照组之间上气道比较

Table 7　Comparison of upper airways of inpatients following radiotherapy for head and neck cancer in the rescue, non-rescue, and control groups

Upper airway analysis index/mm	Rescue group（n=20）	Non-rescue group（n=66）	Control group（n=20）	F	P
Sagittal diameter of nasopharyngeal segment	18.21±3.82^{b}	18.13±3.05^{b}	20.73±2.8^{a}	5.421	0.006
Coronal diameter of nasopharyngeal segment	23.65±3.06^{b}	24.79±2.64^{b}	30.54±5.06^{a}	27.902	<0.001
Sagittal diameter of velopharynx segment	10.01±3.7	9.96±2.32	10.21±2.72	0.064	0.938
Coronal diameter of velopharynx segment	21.98±5.04	22.75±3.7	22.76±6.22	0.239	0.788
Sagittal diameter of the oropharyngeal segment	7.97±3.19	8.03±2.48	8.07±2.8	0.007	0.993
Coronal diameter of the oropharyngeal segment	19.24±4.09^{b}	17.51±3.6^{b}	23.87±4.82^{a}	20.002	<0.001
Sagittal diameter of laryngopharyngeal segment	11.99±3.57	11.48±2.65	12.66±3.94	1.154	0.319
Coronal diameter of laryngopharyngeal segment	19.77±5.05	18.5±3.79	20.59±3.5	2.394	0.096

Different superscript letters within a row indicate significant differences based on one-way ANOVA followed by post-hoc tests (LSD for equal variances or Tamhane's T2 for unequal variances). Values sharing a common letter are not significantly different (P>0.05), while those with different letters are significantly different (P<0.05)

放疗导致颌骨和周围组织的结构和功能改变有关[18-19]，增加了患者出现严重口腔并发症的风险。因此，中老年头颈癌放疗患者在初次治疗后，应格外注意放射性颌骨骨髓炎的发生，定期复查。

3.2　气道狭窄的机制剖析

数据分析表明，头颈癌放疗后患者抢救事件主要原因为呼吸困难。且这一现象与上气道（尤其是鼻咽段和舌咽段）的狭窄密切相关。对比分析结果显示，放疗后患者（无论是否发生抢救）的鼻咽段冠状径、矢状径及舌咽段冠状径均较对照组缩小，这凸显了放疗对气道结构的普遍影响。然而，抢救组与非抢救组在狭窄程度上无显著差异，表明结构性狭窄本身并非抢救事件的唯一决定因素。

放疗导致鼻咽段与舌咽段这一特定区域成为狭窄“重灾区”，是其解剖位置与放射物理学共同作用的结果。咽部是鼻咽癌原发灶，是放疗计划的中心靶区，需要接受最高剂量的照射[20-21]。其他头颈部癌，如舌癌、口底癌，其放疗靶区包括肿瘤原发灶及颈部淋巴引流区，舌咽正好对应照射的中心通道[22]。气道狭窄的具体机制是一个多因素叠加、渐进发展的过程：首先，辐射直接损伤血管内皮细胞，导致细胞肿胀、坏死[23-24]，而持续损伤引起血管网络闭塞，局部组织血液灌注减少，处于长期慢性缺氧状态[25]；继而，缺氧和组织损伤持续释放转化生长因子-β（transforming growth factor beta，TGF-β），白细胞介素-6（interleukin-6，IL-6）等各种炎性因子和细胞因子[26-27]，这些因子持续刺激下，成纤维细胞被异常激活并大量增殖[28]；成纤维细胞分泌过量的胶原蛋白和细胞外基质，发生交联后最终取代软组织，导致组织纤维化和瘢痕挛缩[29-30]。与此同时，辐射存在引发受照区域肌肉萎缩及神经损伤的风险[31-32]。由此推测，辐射同样可能损害由骨骼肌构成的气道支撑结构，导致肌肉无力与神经支配异常，从而潜在削弱气道扩张能力。此外，淋巴管网络的破坏所致的淋巴水肿进一步加剧了管腔的狭窄[33-34]。正是由于最高剂量照射与微血管损伤、纤维化、肌肉萎缩、淋巴回流障碍等多重机制叠加，使得鼻咽段和舌咽段狭窄最显著。

值得注意的是，抢救组患者往往合并肺部疾病或肿瘤复发/新发，这些基础病情可能加剧了呼吸功能不全的风险。此外，实验室指标显示抢救组术前及术后中性粒细胞计数升高，术后白蛋白水平降低，提示全身炎症反应活跃及营养代谢失衡状态加剧，可能通过加重气道水肿和分泌物潴留而触发急性梗阻。因此，呼吸困难的发生是结构性狭窄、基础疾病和急性炎症共同作用的结果。

3.3　临床启示与研究展望

一旦发生呼吸困难，气管切开术成为主要的抢救措施[35]。气管切开能快速建立人工气道，绕过因水肿、分泌物潴留或软组织塌陷造成的上呼吸梗阻[36-37]，是挽救生命的决定性干预。本研究结果提示，对于放疗后患者，除监测气道结构变化外，应重点关注炎症控制、肺部并发症管理[38]和个体化风险评估，以预防抢救事件的发生。

本研究为回顾性小样本研究，未能评估放疗剂量对气道的影响。因此，未来需开展大样本、多

中心前瞻性研究，验证本结论并精确量化放疗剂量-体积参数与特定气道狭窄、抢救风险之间的关系；同时对高危患者实施定期的前瞻性气道评估（如内镜或动态影像学监测），以期在梗阻发生前进行干预，最终降低抢救事件的发生率和死亡率。

本研究结果提示，头颈癌放疗后再次入院患者中，合并肺部疾病或肿瘤复发/新发的患者，是发生抢救事件的高危人群，呼吸困难为其主要抢救原因。发生抢救事件的患者普遍存在上气道狭窄，并伴有更显著的全身炎症反应与营养不良，共同构成了其高危病理生理基础。对此，临床应加强围术期预警，并将及时的气管切开术作为逆转呼吸衰竭的关键干预措施。

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