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Swallowing disorders after radiotherapy-based treatment of head and neck cancer

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Abstract
Introduction: This study aimed to assess the swallowing function of head-and-neck cancer patients before and after radiotherapy.
Materials and Methods: A repeated descriptive cross-sectional study was carried out on 33 head and neck cancers patients treated at Aristide LeDantec Hospital Radiation Therapy Department, Dakar, Senegal. The swallowing function was assessed through a self-assessment questionnaire (DHI) and a functional swallowing test: : Constraints, Oral phase, Laryngeal phase, Pharyngeal phase- Grade of dysphagia- Aspirations (COLP-G-A). Each patient was seen twice: before treatment (T0) and three months after radiotherapy (T).
Results: Patients maximum ages were 18 and 69 years. Persons aged over 60 (39.4%) were predominant. Men have accounted for the majority of the 58% series with a sex ratio of 1.35. Swallowing disorders existed in some patients before radiotherapy (T0). In fact, at this stage, nine people had physical disorders, fourteen functional disorders and twelve emotional disorders all related to swallowing. At time of T, DHI scores in (P) (F) and (E) areas had significantly increased ($p = 0.0001$ for (P); $p = 0.001$ for (F); $p = 0.004$ for (E). Likewise, the COLP-G-A on mineral water, sparkling water, actimel, compote and cake had shown that dysphagia was highly associated with radiotherapy ($p \leq 0.05$). These results show that radiotherapy aggravates swallowing disorders.
Conclusion: Oropharyngeal dysphagia is a common symptom in irradiated head and neck cancer patients and compromising their quality of life. Exploring, preventing and relieving swallowing disorders remains a key priority in head and neck cancer care.

Keywords: dysphagia, head and neck cancer, radiotherapy, senegal, swallowing

1. Introduction

Dysphagia or swallowing disorders is the difficulty or inability swallowing fluids, food or drugs. Dysphagia can occur during oropharyngeal or esophageal phase of swallowing. Various swallowing process alterations that may interfere with physiological functions cause dysphagia. Dysphagia is a frequent, multifactor and debilitating after effects in head and neck cancer patients undergoing a definitive radiotherapy (RT). Acute after effects related to RT, such as the edema, the mucositis, pain and the xerostomia distort the short-term swallowing mechanism [1-3]. Radiation-induced fibrosis of tissue and chronic oxidative stress continue this impaired swallowing long after RT [4, 5]. Depending on the type of tumor treatment (radiotherapy alone or combined with chemotherapy), irradiated tissue volume, radiation dose, splitting, and overall duration of treatment, late swallowing disorders incidence may vary up to 50% of irradiated patients [6-8]. Tumor site, stage, age of patient, pre-treatment weight loss, pre-treatment swallowing disorders and smoking are other contributing factors of RT induced swallowing disorders' rates [9-11]. The swallowing can be objectively assessed using videofluoroscopy of modified barium [12] and fibroscopic endoscopic assessment or even functional tests [13]. Silbergleit *et al.* [14] developed the DHI (Dysphagia Handicap Index), which measures the disabling effect of dysphagia on the physical, functional and emotional aspects of the patient's life.
Post-radiotherapy swallowing disorders frequency and mechanism have yet to be defined in Senegal. Radiotherapy late-effects tend to develop, with the increase in survival, directly impacting the patient's life, including their breathing, phonation, communication, salivation [15] and swallowing. These long-term swallowing complications can be a heavy burden for head and neck cancer patients survival [15], negatively impacting their daily life psychosocial aspects [16, 17] and ultimately the quality of life [16, 17, 18].
This study's purpose was to assess the before and after definitive curative radiotherapy (RT) swallowing function of patients with head and neck cancers.

2. Materials and Methods

2.1. Study design and eligibility criteria

This was a repeated descriptive cross-sectional study pre-RT/post-RT. Patients were treated with RT for head and neck cancer at the Institute of External Oncology at LeDantec

University Hospital in Dakar, Senegal.
The inclusion criteria were:
1. Head-and-neck cancer history,
2. Referred patients for RT or definitive chemo-radiotherapy or radiotherapy surgery,
3. And informed consent obtained.

The exclusion criteria were: patients who
1. Did not carry on with all the RT protocol, and
2. Who died before the end of the RT protocol.

Participants were informed and included by a treating team doctor during the diagnosis and inclusion questionnaire were signed at the Oncology RT Service, where eligibility criteria were verified. The ethics committee of the Health and Social Action Ministry of Senegal approved the study.

2.2. Measurement/appreciation of swallowing parameters

Dysphagia Handicap Index (DHI)

The subjective assessment of the swallowing was also conducted using a validated self-assessment questionnaire [14]: Dysphagia Handicap Index (DHI). The DHI measures the dysphagia disabling effect on the physical (P), functional (F) and emotional (E) aspects of an individual's life. Patients were asked to complete questionnaires precisely according to their current status. They noted their swallowing problems according to the suggested rating "never, sometimes or always". Ratings were scored considering 0 for never, 2 for sometimes and 4 for always. A high score indicates a significant impact of the impairment. The maximum score is 120. Several grades are established, a score between 0 and 30 corresponds to a slight impairment, a score between 31 and 60 to an average impairment and a score between 61 and 120 to a severe impairment.

The swallowing functional test (COLP-G-A)

The swallowing objective assessment was also performed using a functional and qualitative test, the COLP-G-A, which assesses: swallowing related Constraints, the Oral phase, the Laryngeal phase, the Pharyngeal phase, Grade degree of dysphagia and Aspirations [13]. The perceptual qualitative rating scale of voice disturbances inspired the COLP-G-A. The administration speed and the possibility of assessing on many different textures make it possible to quickly detect the affected swallowing phase. According to patients'abilities at time t, the following textures were suggested during the COLP-G-A test: mineral water, sparkling water, thickened liquids (actimel), applesauce and small portions of cakes.
Four perspectives make up the COLP
C = Constraints: these are compensation strategies the therapist could suggest or be used spontaneously by the patient (posture, texture and quantity).
O = Oral phase: this step assesses the mobility and tonus possibilities of the oro-facial sphere (lips, tongue, cheeks).
L = Laryngeal phase: at this stage the larynx protection mechanisms (voice, cough, elevation of the larynx) are controlled.
P = Pharyngeal phase: this dimension takes into account swallowing mechanisms involved in the pharyngeal phase (swallowing reflex, stasis, velar sphincter and pharyngeal).
Each dimension is scored from 0 to 3 (0 no problem and 3 maximum difficulty).
G = Grade: this is the general assessment of the dysphagia severity (0 = normal swallowing, 1 = slight impaired swallowing but require to adapt to, 2 = moderately impaired swallowing with extended monitoring and to adapt to, 3 = swallowing severely altered, impossible bone per-os.
A = Aspirations: This dimension highlights the presence or absence of aspirations and their location at the time of swallowing. It is necessary to differentiate: Av = Aspirations before, it is a cough that triggers the swallowing reflex, P = Aspirations during, which most evocative signs is the reflex cough during the course of the swallowing, Ap = Aspirations after with stasis in the pharynx and the coughing happens away from the swallowing reflex (a few seconds or even a few minutes later), N = no aspirations.

2.3. Experimental Protocol

Patient and tumor characteristics were collected before RT (T0): age, gender, primary tumor location, TNM classification for clinical tumor status, co-treatment, dose and RT methods. The questionnaire content and patients medical records made it easy to collect the information. In some cases, though, it was difficult to collect all medical information, given the long delay between the treatment and the disorder onset. Then patients were asked to complete the self-assessment questionnaire DHI. Finally, one (or two) functional test COLP-G-A was done for each patient (solid texture and liquid texture according to patients' possibilities and their diet).
During this visit at time T0, these steps made it possible to identify any dysphagia linked to the localization of the tumor. If the subject has dysphagia at T0, it is important to check if this dysfunction worsens, decreases or disappears after RT.
Radiation therapy and possibly concomitant chemotherapy were performed at the Institute of External Oncology at LeDantec University Hospital Center in Dakar. This treatment lasts 7 weeks on average. After RT, the swallowing function is again assessed. The approach remains the same as at time T0.

2.4. Statistical Analysis

The statistical analysis was performed with the software "SPSS" Version 16.0. Numbers and percentages, averages and scores were calculated. The Pearson chi-square test was used for the ratio comparison and the Student's t-test for averages comparison. The level of significance was set at $p \leq 0.05$.

3. Results

In all, 42 patients were selected, nine were excluded from the study (6 had not followed the entire RT protocol and 3 had died before the end of the RT protocol). The final sample of 33 patients (19 men and 14 women) including 60.6% of patients aged 50 and over, only 2 patients (6.1%) were aged between 18 and 29 years. The majority of tumors were in the oral cavity (45.4%) against 18.2% in the larynx and 18.2% in the pharynx (Table 1). Table 1 summarizes the tumor classification and clinical stage. RT was performed alone or concomitant with other treatments, such as chemotherapy or surgery (Table 1). The maximum dose of RT was 49.5 Gy and the minimum dose 15 Gy, spread over 15 to 33 sessions. The minimum daily dosage was 1Gy for the right and left lateral field and the maximum 2Gy for the subclavicular field.

RT significantly increases DHI physical (P), functional (F) and emotional (E) aspects' score with respectively: for P : T0/T score = *9/32*, $p = 0.0001$; for F: Score T0/T = 14/22, $p = 0.01$and for E : T0/T score = 12/16, p = *0.0 4*.

After RT, 63.6% of patients had a severe difficulty swallowing compared to 9 % before RT. This difference was statistically significant $(p = 0.001)$ (Table 2)

Before RT (Figure 1), the functional test on mineral and sparkling water showed little difficulties in different swallowing times (score 1 for COLP). The swallowing was slightly impaired (Grade 1). After RT, there were no more constraints for these foods (C = score 2, $p \leq 0.05$) (Figure 1 and 2). On compote, there were more constraints related to the texture and a delay to trigger the swallowing reflex after RT during the pharyngeal time (P = score 2, $p \leq 0.05$). However, the swallowing was slightly impaired (G = grade 1). The functional test on cake showed significant constraints related to the texture and the amount of food to be ingested (C = score 2, $p \leq 0.05$) before RT (Figure 3). After RT, due to the texture (Figure 4) and quantity constraints (C = score 3, $p \leq 0.001$) (Figure 3), most patients adopt a particular posture to swallow the cake. Depending on the tumor site, some patients encountered difficulties in score 3 during the oral phase of swallowing after RT (Figure 5). During laryngeal phase also, there were a change of voice and coughing difficulties (L = score 2, $p \leq 0.05$) (Figures 3 and 6). After RT, the swallowing average general grade increases from 1 to 2, meaning a moderately altered swallowing, but possible with sustained monitoring and an adaptation (Figure 3). However, after RT still, 12 patients (36.4%) had a significantly impaired swallowing that was utmost per-os $(p = 0.04)$ (Table 3). DHI's high scores (between 61 and 120) were positively correlated with grade 3 (highly impaired swallowing) of the functional swallowing test COLP–G-A ($p < 0.001$).

Before and after RT, only two patients had aspirations, one during swallowing and the other after swallowing of liquid (mineral water, sparkling water and actimel). On cake, only one patient had aspirations after the swallowing triggered, before and after RT.

4. Discussion

Dysphagia is an abnormality in one of the swallowing structures: the mouth, larynx, pharynx or esophagus. Its severity ranges from simple discomfort to an inability to swallow. The gold standard for assessing swallowing disorders is the modified barium videofluoroscopy [12]. This objective method was not available to us. In this study, it was desirable to define the severity of dysphagia for each patient based on practical, reliable and approved scale and functional test. There are several scales in study, in particular the Dysphagia Outcome and Severity Scale [19] and SWAL-QOL [20]**.** But these scales were too analytical compared with the data to be collected. Therefore, the Dysphagia Handicap Index (DHI) [14] was suitable for this study. The dysphagia severity was defined according to the score: slight handicap (score between 0 and 30), moderate handicap (score between 31 and 60) and severe handicap (score between 61 and 120). Some patients had swallowing disorders before RT (T0). Indeed, at this stage, nine people had physical disorders linked to swallowing, fourteen functional disturbances and twelve emotional disturbances all linked to swallowing. In this set still, 45.5% had a slight disability, 45.5% others a moderate disability and the remaining 9% a severe disability. These disorders were due to an invasive tumor, a previous surgery or chemotherapy (5 Fluoro-uracil) [21]. Lazarus *et al.* [22], had found that after chemotherapy, swallowing treatment effects are the same as for radiotherapy, namely: reduced range of movement of the tongue base, reduction of lingual strength, reduction of the laryngeal elevation and a reduced efficiency of the oropharyngeal phase [22]. The author adds that the reduction of lingual activity in the propulsive phase of the bolus altered the swallowing biomechanics [22]. This study's results corroborate these facts where the majority of the population suffered from oral cavity cancer (45.4%) which is mainly located on the tongue. The severity of these swallowing disorders tends to decrease over time. However, the dysphagia incidence seems the more so severe as radiotherapy and chemotherapy are combined. After RT, DHI scores in the (P) (F) and (E) aspects have significantly increased $(p = 0.0001$ for (P)*;* $p = 0, 001$ for (F)*;* $p = 0.004$ for (E)). These results show that radiotherapy worsens the dysphagia. Likewise, after RT, the number of patients with severe disability has distinctly increased, that is 21 (63.6% after RT) against 3 (9% before RT), and significantly (p = 0.001).

Along the DHI questionnaire, we used the COLP-G-A, a functional test that objectively assesses the phase swallowing disorders occurred [13]. At each appointment, patients were offered five foods successively, in the following order: (1) mineral water, (2) sparkling water, (3) actimel (curd), (4) applesauce, (5) cakes. As a rule, in both before and after RT, patients tolerate liquid and semi-liquid foods better than solid foods. They experienced, however, huge difficulties swallowing cakes. Sure enough, after RT, disorders had considerably increased to the point to end up with 12 (36.4 %) patients who were unable to swallow solid foods. It can be, therefore, concluded that 3 months after RT, patients' diet had virtually deteriorated. Radiation therapy, which is currently part of head and neck cancer standard of care, will generate reversible side effects at the acute stage of treatment and often irreversible at its chronic stage [7, 8, 23]**.** More and more patients suffered from swallowing disorders despite strict protocols aimed to preserve structures deemed at risk. New external radiotherapy techniques (Conventional three-dimensional conformal fields or intensity modulated radiotherapy [IMRT], tomotherapy, dynamic therapy arc, Cyberknife®, etc.) were based on most modern medical imaging techniques, reliable dosimetry software and sophisticated applications accessories. These new techniques reduce the dysphagia severity prevalence while maintaining the same efficiency, even improved [24]. However, in the area of cervico-maxillofacial tumors in particular, and in other area in general, whatever the improvement made in radiotherapy, only an integrated and multidisciplinary care of patients in dedicated centers will result in "more survival and a better quality of life". In this study's sample, only two patients had aspirations, one during swallowing and the other just after liquid swallowing, and only one had aspirations after the cake swallowing triggered. Dysphagia side-effects can be disastrous, especially on the lower respiratory system. In spite of natural defense

mechanisms in the human body, uncontrolled and infiltrating aspirations can appear over time and cause serious infections and, in the worst case scenario, death of the patient. In this study, although there were only two aspiration cases, they may occur over time if these patients are not properly cared for for their dysphagia. This study showed that external radiotherapy results in a set of complications that can lead to local immobility of certain structures essential for the proper functioning of swallowing: lack of elevation of the tongue base, insufficient elevation of the larynx, imperfect closure of vocal folds, imperfect opening of the cricopharyngeal, as has been seen in other studies [7, 8, 25]. Likewise, as shown in this study, as well as in others, dysphagia caused by cancer and radiotherapy side- effects, became, for a while now, a concern of the medical world. This study showed that there is a real and alarming dysphagia after RT, hence the importance of their management by manual methods of local rehabilitation such as lingual handling, laryngeal and that of systems: hyoid, manducator and pharyngeal. So, the patients swallowing is then facilitated to the extent that a benefit is provided in lingual, laryngeal, glottic closure, chewing, intraoral and proprioception [26]. However, progresses achieved through rehabilitation are temporary and must be maintained by regular and definitive home-based practice. The care should be broken down into several basic steps [26, 27, 28]. Firstly, ensure adequate feeding to protect respiratory tracts. To adapt to textures, the quantity and postures particularly deemed necessary during the swallowing qualitative assessment (COLP). Secondly, adapt to each patient to types of exercises, whether strengthening or toning, to practice according to affected structures. Finally, set up a therapeutic guidance so that each patient and his/her entourage can benefit from the most relevant advice, and in response to their expectations or worries.

5. Tables and Figures

Table 1: Patients and tumor characteristics.

Characteristics	Number of patients (n)	Percentage (%)
Age		
≤ 60 years	20	60.6
> 60 years	13	39.4
Gender		
Male	19	58
Female	14	42
Primary site		
Oral cavity	15	45.4
Larynx	6	18.2
Oropharynx	4	12.1
Hypopharynx	2	6.1
Other	6	18.2
Therapeutic combination		
Chemotherapy alone		60.6
Surgery only		12.1
Surgery and chemotherapy		27.3
T classification		
T1	1	3
T2	7	21.2
T3	5	15.2
T4	18	54.5
Tx	2	6.1
N classification		
N0	18	54.54
N1	3	9.10
N2	7	21.21
N3	4	12.12
Nx	1	3.03
Clinical stage		
Stage I	8	24.24
Stage II	1	3.03
Stage III	10	30.30
Stage IV	14	42.43

T = primary tumor, N = lymphadenopathy, T0 no tumor (t), T1 = t ≤ 2 cm, T2 = t> 2 cm and ≤ 4 cm, T3 = t> 4 cm, T4 = t extended to bone, muscles, etc., Tx = t unclassifiable, N0 = no lymphadenopathy, N1 = single homolateral lymphadenopathy, N2 = bilateral or contralateral lymphadenopathy N3 = fixed lymphadenopathy, Nx = lymphadenopathy unclassifiable, stage I = t ≤ at 2 cm no lymphadenopathy no metastases, stage II = t> at 2 cm and ≤ at 4 cm no lymphadenopathy no metastases, stage III = t> at 4 cm with and or homolateral lymphadenopathy, stage IV = extended tumor with bilateral or

fixed adenopathies and or distant metastases.

Table 2: Distribution according to dysphagia disability before and after RT

DHI	Radiotherapy		p-value
	T0	T	
	n %	n %	
Light disability = [0-30]	15 45.5	0 0	*0,001*
Moderate disability = [31-60]	15 45.5	12 36.4	*0.301*
Severe disability = [61-120]	3 9	21 63.6	*0,001*
Total	33 100	33 100.0	-

Table 3: Distribution according swallowing grade on the cake before and after RT

	Radiotherapy				*p-value*
	T0		T		
Swallowing	Number	Percentage	Number	Percentage	
Average	7	21.2	3	9.1	*0.16*
Little altered	13	39.4	7	21.2	*0.11*
Moderately altered	8	24.2	11	33.3	*0.29*
Very altered	5	15.2	12	36.4	*0.04*
Total	33	100.0	33	100.0	-

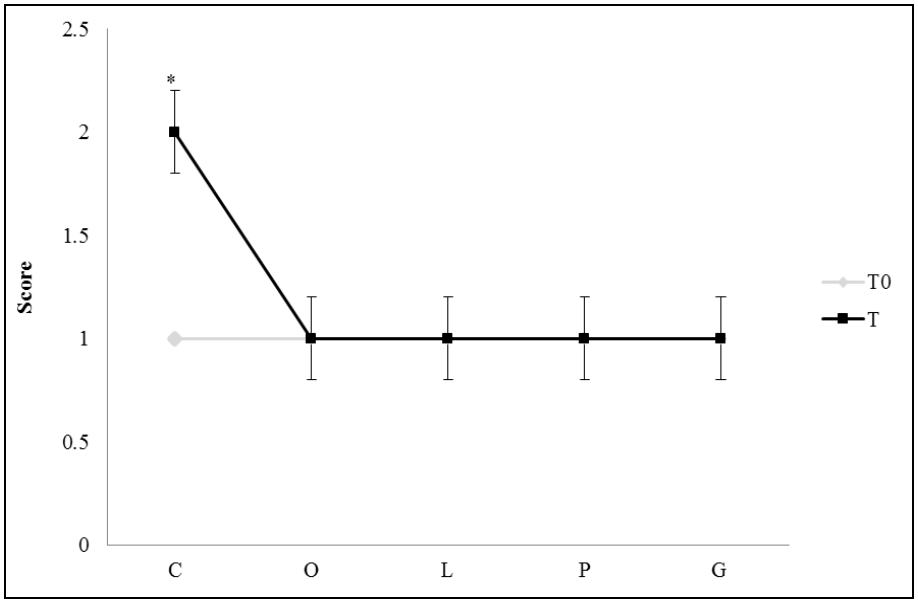


Fig 1: COLP-G test on mineral and sparkling water average scores after RT ($^{*}p \leq 0.05$).

(a) **(b)**

Fig 2: (**a)** Tongue cancer treated with surgery before radiotherapy (**b)** Posture at stake due to pain during the swallowing of mineral and sparkling water (Radiotherapy Department CHU LeDantec)

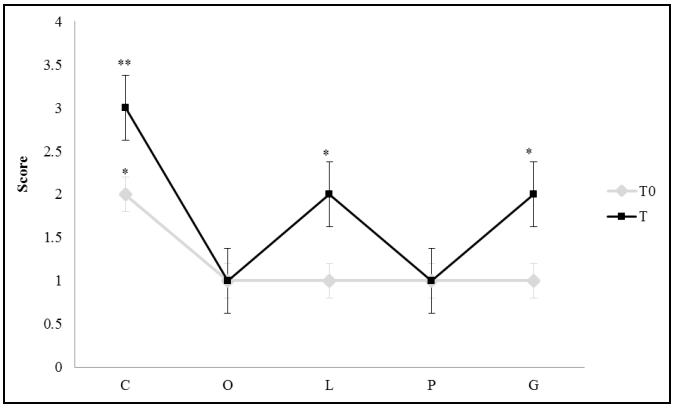
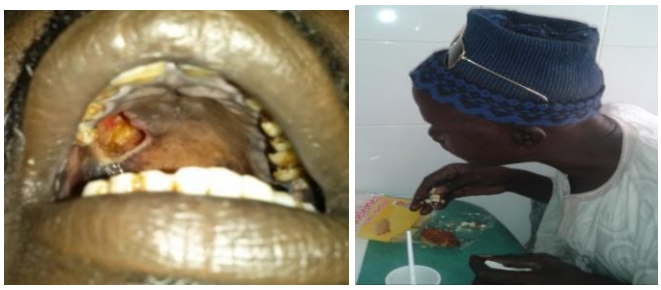


Fig 3: Average scores of the test COLP-G on cake before and after RT ($^{*}p \leq 0.05$, $^{**}p \leq 0.001$)



(a) **(b)**

Fig 4: a) Sinus cancer **b)** Difficulty related to the texture: crumbling of the cake by the patient to facilitate the swallowing (Radiotherapy Department, CHU LeDantec, Dakar).

(a) **(b)**

Fig 5: a) Tongue Cancer; b) Mandible cancer (Radiotherapy Department, CHU LeDantec, Dakar). The COLP G shows difficulties in score 3 during the oral phase of swallowing cake in these two patients after RT.

Fig 6: Laryngeal cancer + tracheostomy (Radiotherapy Department CHU Le Dantec). The COLP-G shows difficulties in laryngeal protection mechanisms (voice) for all foods and a delay in reflex triggering of the pharyngeal phase for compote and cake during radiotherapy.

6. Conclusion

Oropharyngeal dysphagia is a common symptom in irradiated head-and-neck cancer patients and impacts their quality of life. To explore, prevent and relieve swallowing disorders remains a key priority in head-and-neck cancer care.

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8. Conflict of interest

The authors declare no potential conflict of interests

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