A Novel Grading System for Salpingopharyngeal Fold Hypertrophy in Obstructive Sleep Apnoea

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Abstract The present study aimed at reporting the incidence of Salpingopharyngeal Fold (SPF) hypertrophy on Drug Induced Sleep Endoscopy (DISE) in patients with Obstructive Sleep Apnoea (OSA), validate a grading system and analyse the impact of various grades on the clinical presentation while ascertaining its relation with Apnoea-Hypopnoea Index (AHI). A retrospective analysis of 169 patients with polysomnographic confirmation of obstructive sleep apnoea has been done in the study. The DISE video data of 169 patients was evaluated by two ENT surgeons individually and they graded the hypertrophy of the fold as Grade 0 being normal anatomy, Grade 1 being hypertrophy causing partial obstruction and Grade 2 being hypertrophy causing complete obstruction of lateral pharyngeal wall. It was found that the presence of SPF hypertrophy independently adds considerably to the severity of the obstruction, attributing to lateral collapse at the upper retropalatal level and also significantly increases AHI. It is thus advised to consider the grade of SPF hypertrophy while surgically planning the management of patients with OSA.

Keywords Obstructive sleep apnoea · SPF hypertrophy · Agrawal's grading

Introduction

Obstructive Sleep Apnoea (OSA) is by far the most common cause of sleep disordered breathing [1], leading to a spectrum of potentially serious physiological, social and neurocognitive consequences. Though widely prevalent, it is often unrecognized and underdiagnosed [1]. Epidemiological studies report a prevalence of 2–9% for women and 4–24% for men; with an increased prevalence of 40% for obese [2, 3].

OSA significantly impairs health-related quality of life [4], reduces efficiency of those affected and also increases home and motor vehicle accidents by 2–3 folds [5]. A number of studies and meta analyses have indicated the association of OSA with increased risk of hypertension, diabetes mellitus, coronary artery disease, stroke and all-cause mortality [6–10]. Non-surgical or surgical, management of OSA is thus, rendered vital to alleviate the physiological complications and improve the patient's quality of life.

Patients who exhibit symptoms of snoring and sleep apnoea are evaluated with overnight polysomnography followed by Drug Induced Sleep Endoscopy (DISE) which has the advantage of simulating the upper airway collapse that occurs during physiological sleep [11] and also provides an opportunity to observe directly and define the pathophysiology. Currently, DISE is the most reliable standard method to determine the level, number and severity of site of obstruction in sleep apnoea patients [12] and is shown to be safe, diagnostic and influential in surgical decision making [13].

Non-surgical treatment mainly includes the use of Continuous Positive Airway Pressure (CPAP). CPAP therapy, though is impactful in improving clinical symptoms, quality of life and potential consequences associated with OSA, the effectiveness of same is strongly related to

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Fig. 1 A representative picture of SPF hypertrophy as different grades. Grade 0 of the grading system—normal anatomy causing < 25% obstruction of lateral pharyngeal wall. Grade 1 of the grading system—hypertrophy causing partial (25–75%) obstruction of lateral

pharyngeal wall. Grade 2 of the grading system—hypertrophy causing complete (> 75%) obstruction of lateral pharyngeal wall

patient compliance [14, 15]. Recent studies have reported CPAP compliance of only 35.3% over a period 12 months of usage [16]. Since the first description of uvulopalatopharyngoplasty (UPPP) by Fujita et al. [17], surgical options and techniques for obstructive sleep apnoea are constantly upgrading. Available surgical treatment options include, surgery of nose, palate, base of tongue, epiglottis, maxilla and mandible. In spite of the range of armamentarium available, dissatisfactory results have been reported [18, 19].

Special mention regarding our observation about the presence and need for management of SPF hypertrophy is proposed thus to aid as an adjunctive procedure to reduce failure rates. A previous study by Agrawal, 2015 [20] has reported better surgical outcome. Thus, the present study aims at reporting the incidence of SPF hypertrophy on DISE in patients with OSA, validate a grading system and analyse the impact of various grades on the clinical presentation while ascertaining its relation with AHI.

Materials and Method

A retrospective analysis of patients with polysomnographic confirmation of obstructive sleep apnoea has been done in the study. ApneaLink™ Air was used, which is a tool validated for the purpose [21]. These patients underwent Drug Induced Sleep Endoscopy (DISE) using KARL STORZ flexible video rhino-laryngoscope under BIS™ monitoring which is a valid bispectral index monitor for measuring the depth of sedation [22]. Dexmedetomidine and midazolam was used in titrating doses to maintain BIS™ score in the range of 60–80. The DISE video data of 169 patients was evaluated by two ENT surgeons

individually. Each of them were instructed to grade the hypertrophy of the fold as Grade 0 being normal anatomy, Grade 1 being hypertrophy causing partial obstruction and Grade 2 being hypertrophy causing complete obstruction of lateral pharyngeal wall. Data of 154 patients of the 169 had 100% agreement between the two experts while grading the hypertrophy. Thus 154 patients' data was included in the study for further analyses. Figure 1 shows the representative image of SPF hypertrophy as different grades.

The patient's data was further classified into two groups. Group 1 included 107 patients who had isolated palatal level obstruction whereas group 2 constituted 47 patients suffering with sleep apnoea due to obstruction at multiple levels BMI of the patient was calculated. There was no significant difference between the two groups for age ($p > 0.05$), AHI ($p > 0.05$) and BMI ($p > 0.05$) Shapiro Wilks test of Normality was administered to check for the distribution of the data, however as most of the parameters showed non-normal distribution the data was subjected to non-parametric analyses.

Results

Overall

Incidence

It was observed that 76/154 patients had hypertrophy of the SPF, as reported by the experts, amounting to 49%. Out of the 76 patients, 35% of the patients had grade 1 hypertrophy of the salpingopharyngeal fold while 14% had grade 2. Figure 2 shows the representation of patients whose SPF hypertrophy was graded as 0, 1 and 2 respectively.

Fig. 2 The relation between SPF hypertrophy and AHI

SPF Hypertrophy and AHI

Mann Whitney U test showed that there was no significant difference between the two groups for AHI for grade 0 hypertrophy ($Z = 1.6$, $p = 0.11$), for grade 1 hypertrophy ($Z = 1.38$, $p = 0.17$) and grade 2 hypertrophy ($Z = 0.81$, $p = 0.47$), thus the data of the two groups were combined to find the effect of hypertrophy on AHI. Table 1 shows the AHI values of the patients with SPF hypertrophy across groups.

Kruskals Wallis H test showed that there occurred significant increase in the AHI scores as the hypertrophy increased ($\chi^2 = 12.22$, $p = 0.002$). Mann whitney U test showed that patient with no hypertrophy (grade 0) had significantly lesser AHI values as compared to patients with grade 1 ($Z = 3.001$, $p = 0.003$) and grade 2 hypertrophy ($Z = 2.653$, $p = 0.008$). Figure 2 shows the relation between SPF hypertrophy and AHI.

BMI and AHI

Out of 154 patients, 64 patients had BMI > 30 and 90 of them had BMI < 30. Mann whitney U test showed that patients with high BMI values had higher AHI as compared

Fig. 3 Shows that there occurs significant positive correlation between BMI and AHI

to those having low BMI ($Z = 3.50$, $p = 0.00$). Spearman's correlation showed that there was significant increase in the AHI with increase in BMI ($r_s = 0.297$, $p = 0.000$). Figure 3 shows the scatter plot of AHI versus BMI.

SPF and BMI

Kruskal Wallis H test showed that there was no significant difference for the BMI across patients having different grade of SPF hypertrophy [$\chi^2(2) = 2.75$, $p = 0.45$]. There was no significant relation between BMI and SPF ($r_s = 0.019$, $p > 0.05$).

Group 1 (Isolated Palatal Obstruction)

This group included 107 patients with palate as the sole cause for obstruction. On comparison of two groups it was observed that among the patients included in this group, 30% of them had grade 1, while 15% had grade 2 hypertrophy.

SPF and AHI

We can see from Table 1 that as the hypertrophy of SPF increased, there was an increase in the AHI scores. Kruskal

Table 1 AHI score of patients with SPF hypertrophy (Agrawals grading) across groups

Grade 0			Grade 1			Grade 2		
X	M	SD	X	M	SD	X	M	SD
<i>Group 1 (107)</i>								
37.61	38 (N = 58)	25.15	49.32	50 (N = 32)	26.7	55.4	60.2 (N = 16)	25.08
<i>Group 2 (47)</i>								
34.52	37.5 (N = 19)	24.21	46.4	49 (N = 23)	25.8	55.1	56.58 (N = 5)	28.1

0, normal anatomy; 1, moderate hypertrophy; 2, severe hypertrophy; X, mean; M, median; SD, standard deviation

Wallis H test also showed that patients having higher grade of SPF hypertrophy had higher AHI scores [$\chi^2(2) = 27.93$, $p = 0.00$]. Mann Whitney U test showed that patients with grade 2 hypertrophy had significantly higher AHI score compared to grade 1 ($Z = 2.1$, $p = 0.04$), grade 1 had significantly higher AHI compared to grade 0 ($Z = 3.63$, $p = 0.000$) and grade 2 had significantly higher AHI compared to grade 0 ($Z = 4.16$, $p = 0.00$).

BMI and AHI

Out of 107 patients, 47 had BMI > 30 and 60 had BMI < 30. It was observed that patients with high BMI had significantly higher AHI compared to patients having low BMI ($Z = 2.44$, $p = 0.01$) on administration of Mann Whitney U test. Spearmans test of correlation showed that the BMI scores had significantly positive correlation with AHI ($r_s = 0.401$, $p = 0.000$) i.e as BMI increased AHI also increased.

SPF and BMI

Kruskal Wallis H test showed that there was no significant difference for the BMI across patients having different grade of SPF hypertrophy [$\chi^2(2) = 1.99$, $p = 0.78$]. There was no significant relation between BMI and SPF ($r_s = 0.026$, $p > 0.05$).

Group 2 (Multiple Level Obstruction)

This group included 47 patients with multiple level obstruction. Of these, 49% had grade 1 hypertrophy while 11% had grade 2.

SPF and AHI

We can see from Table 1 that as the hypertrophy of SPF increased, there was an increase in the AHI scores. Kruskal Wallis H test also showed that patients having higher grade of SPF hypertrophy had higher AHI scores [$\chi^2(2) = 16.61$, $p = 0.01$]. Mann Whitney U test showed that patients with grade 1 hypertrophy had significantly higher AHI compared to grade 0 ($Z = 2.5$, $p = 0.01$) and grade 2 had significantly higher AHI compared to grade 0 ($Z = 3.91$, $p = 0.00$). Though the difference was seen for AHI score between grade 1 and grade 2 hypertrophy it was not statistically significant ($Z = 1.76$, $p = 0.08$).

BMI and AHI

Out of 47 participants, 17 had BMI > 30 and 30 had BMI < 30. It was seen that patients with high BMI had significantly higher AHI compared to patients having low

BMI ($Z = 2.27$, $p = 0.02$) on administration of Mann Whitney U test. Spearmans test of correlation showed that there was no significant correlation between BMI and AHI ($r_s = 0.24$, $p = 0.087$).

SPF and BMI

Kruskal Wallis H test showed that there was no significant difference for the BMI across patients having different grade of SPF hypertrophy [$\chi^2(2) = 2.12$, $p = 0.88$]. There was no significant relation between BMI and SPF ($r_s = 0.038$, $p > 0.05$).

To summarize,

Incidence of SPF hypertrophy amounts to approximately half (49%) of the patients evaluated with DISE for OSA. It was observed that 35% of the positive cases had grade 1, while 14% had grade 2.

Group 1 (patients with isolated palatal level obstruction)—of the patients included in this group, 30% of had grade 1, while 15% had grade 2 hypertrophy with AHI increasing with increasing grades and no significant correlation with variations in BMI and SPF hypertrophy. Group 2 (patients with multiple level obstruction)—of these patients, 49% had grade 1 while 11% had grade 2 hypertrophy with AHI increasing with increasing grades and no significant correlation with variations in BMI and SPF hypertrophy.

Between the two grades, grade 2 hypertrophy is observed to have higher contribution in increasing AHI as compared to grade 1 in patients with isolated palatal level block.

In patients with multilevel obstruction, presence of SPF hypertrophy either grade 1 or grade 2 is observed to cause an increase in AHI, warranting management of even grade 1 hypertrophy.

BMI has no particular correlation with SPF hypertrophy.

Discussion

The salpingopharyngeal muscle is a slender muscle which arises from the medial and inferior borders of the tubal cartilage through slips of muscular and tendinous fibres. The muscle then courses posteroinferiorly to blend as a fan-shaped insertion into the palatopharyngeus muscle at the junction of the velum and lateral pharyngeal wall [23]. A raised ridge of mucous membrane extending from the lower end of the tubal elevation along the wall of the pharynx overlying the salpingopharyngeus muscle forms the salpingopharyngeal fold [23]. Through the available literature, function assigned to the muscle, is limited to closing the Eustachian tube

[24], opening of the Eustachian tube [25], elevating the lateral wall of the oropharynx [26] and elevating the velum [27] rendering it vestigial, poorly developed and probably nonfunctional [28, 29].

Since decades studies have reported SPF with limited function. However, the present study has contention of further functionality. Plethora of professionals are often perplexed when it comes to treating OSA, owing to its complexity in presentation and various surgical options available [19].

Retropalatal obstruction is reported as the most common site of obstruction in patients with OSA [19, 30]. It can present as an anteroposterior collapse owing to the soft palate, lateral collapse by the lateral pharyngeal wall and circular as a combined entity. A missing entity here could be the SPF which is prevalent but unrecognised. SPF plays a significant role in being additive to the obstruction due to the lateral wall collapse in patients with OSA.

A number of procedures designed for the treatment, aim at the managing the palate and not the retropalatal region [19]. As can be appreciated, dealing with isolated palatal obstruction with omission of retropalatal SPF hypertrophy is partial treatment and leads to failure or incomplete surgery with patient still having apnoea and hypopneas as reported by a number of studies [31].

We therefore propose, Agrawal's grading system for SPF hypertrophy.

By definition,

Grade	Description
0	Normal anatomy causing < 25% obstruction of lateral pharyngeal wall
1	Hypertrophy causing partial (25–75%) obstruction of lateral pharyngeal wall
2	Hypertrophy causing complete (> 75%) obstruction of lateral pharyngeal wall

The AHI showed significant increase with increase in hypertrophy as well. This provides a testimony to the possible role of SPF hypertrophy in patients with OSA. The increased AHI and hypertrophy was seen in patients with having multiple level obstruction as well. It has been found that BMI has no correlation with the presence of hypertrophy, indicating its value as an independent contributor to increase in AHI and the severity. Thus, the role of SPF hypertrophy needs more attention than it is usually given. To the best of knowledge there has been no study which have reported structural changes of SPF in OSA however in a study presented by the author [20], it was propagated that channeling of the SPF in grade 1 and 2 with coblation

plasma wand provided significantly better post-operative outcome. Thus the management of these patients must consider role of SPF in causing OSA and its subsequent channeling if required must be done.

Limitation

The study is novel and to the best of our knowledge nothing in this aspect has been reported previously, thus more research and better acknowledgement in this aspects is warranted.

Conclusion

Thus with the study, we conclude that though vestigial / non functional, hypertrophy of SPF significantly increases AHI in patients with OSA. The presence of SPF hypertrophy adds considerably to the severity of the obstruction, attributing to lateral collapse at the upper retropalatal level and also significantly increases AHI. It is thus wise to consider management of the SPF hypertrophy while surgically dealing with OSA.

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Compliance with Ethical Standards

Ethical Standards The study followed the ethical guidelines given by Helsinki declaration of Medical research involving human subjects.

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