Multi-Level Surgery in Obstructive Sleep Apnea (OSA)

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Abstract

Obstructive sleep apnea (OSA) is characterized by nocturnal collapsing of the upper airways. Consequently complete cessation of breathing or reduced breathing phases appears. OSA is a widespread disorder affecting up to 11% of the male and up to 6% of the female population. It is associated with serious consequences such as myocardial infarction, stroke, hypertension and traffic accidents. Nasal continuous positive airway pressure (nCPAP) ventilation is the gold standard in the treatment of obstructive sleep apnea syndrome (OSAS). Long-term compliance rates do not exceed more than 60 to 70%. Other options like surgical procedure exist. But only one surgical procedure won't be successful in cases of moderate and severe OSA because one surgery will enlarge the airway only at one location. Alternative multi-level surgeries are of interest, combining procedures at the level of the base of tongue and the soft palate in order to stabilize the whole upper airway like the CPAP-ventilation. Several multi-level surgery concepts exist. Our multi-level surgery based on the hyoid suspension with the combination of a radiofrequency therapy of the tongue base brings out the effectiveness of this concept. With this concept we achieve a success rate of 57.6%; this result situates us at the average level of the cited multi-level surgery studies. With this success rate this protocol can replace the CPAP mask especially in cases with CPAP intolerance or decline

Keywords: Obstructive sleep apnea syndrome (OSAS), multi-level surgery, hyoid suspension, CPAP

Introduction

In our modern competitive society, non-restorative sleep is acquiring an enhanced significance. The international classification of sleep disorders includes 80 different diagnoses of possible causes for non-restful sleep [1]. A subgroup with a comparatively high incidence rate is formed by the so-called sleep disordered breathing disorders (SDB). These are further divided into disorders with and without obstruction in the upper airway.

SDB with obstruction include primary snoring, upper airway resistance syndrome (UARS) and obstructive sleep apnea (OSA). Currently, these syndromes are regarded as different grades of severity of the same pathophysiological disorder [22]. Snoring is caused by vibrations of soft tissue in constricted segments of the upper airway. By definition, primary snoring is not accompanied by breathing impairment, and entails neither a disruption of sleep nor an increased daytime sleepiness. Primary snoring may lead to a social problem as a result of the nocturnal breathing sounds, but it is not essentially a disorder of the patient's physical health.

Yet in the case of OSA, an imbalance exists between forces dilating and occluding the pharynx during sleep. The muscle tone supporting the pharyngeal lumen is too low, and the inspiratory suction force as well as the pressure of the surrounding tissue, both narrow the pharynx, are too high [29, 27]. This disorder occurs only during sleep due to a physiological loss of muscle tone of the pharyngeal muscles in this state. The effects are complete cessation of breathing (apneas) or reduced breathing phases (hypopneas). Both events trigger, if sustained long enough, an emergency situation for the body. The body reacts with a central arousal which disturbs the physiological sleep

by a release of catecholamines. The latter lead via an increase of the tone of the sympathetic system to a strain upon the cardiovascular system.

In contrast to primary snoring, OSA has an adverse effect on the daytime life quality. Cardinal symptoms of OSA are intermittent snoring (94%), daytime sleepiness (78%) and diminished intellectual performance (58%). Further symptoms are personality changes (48%), impotence in men (48%), morning headaches (36%) and enuresis nocturna (30%) [10].

Obstructive sleep apnea is a widespread disorder affecting up to 10.9% of the male and up to 6.3% of the female population [16, 40]. It is associated with serious adverse consequences for afflicted individuals, such as myocardial infarction [15], stroke [5], hypertension [26] and traffic accidents [34].

The goal of any treatment consists in a complete elimination of all apneas, hypopneas, desaturations, arousals, snoring and other related symptoms in all body positions and all sleep stages. The standard therapy for obstructive sleep apnea is a night-time ventilation therapy with continuous positive airway pressure (CPAP) [33]. In almost all cases, CPAP ventilation enables the reduction of pathological respiratory events to a physiological level. This positive airway ventilation stabilizes the whole upper airway, which therefore is regarded as one unit (Figure 1). Unfortunately, the

Figure 1: Method of pneumatic stenting of the upper airway with CPAP. Left) airway collapse. Right) stabilization with continuous positive airway pressure.

CPAP long-term compliance rate is assessed as below 70% [20]. Therefore surgical alternatives exist which stabilize the upper airway. Surgical interventions at one level of the upper airway (e.g. the soft palate) can not avoid obstructions located anywhere else in the airway. In order to be as successful as CPAP ventilation or to replace the CPAP mask various so-called multi-level surgery procedures exist.

A multi-level procedure for the surgical therapy of OSA was presented first in 1989 by Waite and colleagues [38]. The authors combined nasal surgery with a UPPP, tongue surgery, a genioglossus advancement, and a maxillomandibular advancement osteotomy (MMO). Basically, the classification of the upper airway into different levels of obstruction stems from Fujita [9], who distinguished between retropalatal, retrolingual, and combined retropalatal and retrolingual obstruction. On the basis of this distinction Riley et al. [30] defined the term and concept of multi-level surgery.

In the meantime, first studies have been published concerning virtually every possible combination of soft palate and tongue base procedures.

Surgical Concepts

For the sake of giving some structure to these data, we will distinguish in the following between minimally invasive concepts for mild OSA and more invasive concepts for moderate and severe OSA.

Effectiveness of Minimally-invasive multi-level surgery for mild to moderate OSA

Of the procedures employed, only the isolated RFQ therapy can be regarded as a minimally invasive technique. With an apnea-hypopnea-index (AHI) of 10/h to 20/h the patient suffer from a mild OSA; with an AHI of 20/h to 40/h the patient suffer from a moderate OSA. Table 1 presents two studies with only a radio-frequency (RFQ) -based multi-level surgery.

Table 1: Combined RFQ surgery for OSA. SP, soft palate; TB, tongue base; Tons, tonsils.

Author	N	Application sites	Device	Follow-up [months]	Sessions / total energy / lesions	AHI pre	AHI post	Success Rate [%]
Stuck et al. 2002 [32]	18	SP, TB	Somnus	2	3 / 4300 J/ 7	25.3	16.7	38
Fischer et al. 2003 [7]	15	SP, TB, Tons	Somnus	4.8	1 / 7750 J/ 12	32.6	22	20
all	33		Somnus	3.3		28.6	19.1	30.3

The table demonstrates the limitation of RFQ surgery to cases of mild OSA with an AHI of maximally 20/h. This trend is corroborated by the results of the currently single existing placebo-controlled study on this topic. Woodson et al. [39] treated 30 patients respectively either with CPAP, with combined RFQ at soft

palate and tongue base, and with a sham operation. Unfortunately, the authors did not provide any raw data; therefore this study could not be included in table 1. As expected, CPAP respiration was found to be superior to RFQ surgery, and RFQ in turn superior to the sham operation. Yet in regards to the subjective

results, which were measured with various validated test instruments for the assessment of life quality, no differences were found in the comparison of CPAP with RFQ surgery.

The combined treatment of tongue base plus soft palate does not appear to significantly improve the results of an isolated tongue base treatment in respect to the AHI. In our clinical experience, the advantages of a combined treatment lie more in an additional effect upon the respiratory noises during sleep. We have recently been able to demonstrate [32] that the postoperative morbidity and complication rate after combined treatment and after isolated tongue base treatment are identical.

Table 2: Multi-level surgery for OSA. HS: hyoid suspension, GA: mandibular osteotomy with genioglossus advancement; MLP: midline partial glossectomy; RFQ: radiofrequency of tongue base

Author	N	Technique level 1	Technique level 2	Follow-up [months]	AHI pre	AHI post	Success Rate [%]
Djupestrand et al. 1992 [4]	19	UPPP	MLP	8.7	54	31	31.6
Riley et al. 1993 [30]	223	UPPP	GA HS	9	48.3	9.5	60.1
Johnson et Chinn 1994 [17]	9	UPPP	GA	39	58.7	14.5	77.8
Ramirez et Loube 1996 [28]	12	UPPP	GA HS	6	49	23	41.7
Elasfour et al. 1998 [6]	18	UPPP	MLP	3-21	65.0	29.2	44.4
Lee et al. 1999 [12]	33	UPPP	GA	4-6	55.2	21.7	66.7
Bettega et al. 2000 [2]	44	UPPP	GA HS	6	45.2	42.8	22.7
Hsu et al. 2001 [14]	13	UPPP	GA HS	12.6	52.8	15.6	76.9
Hendler et al. 2001 [11]	33	UPPP	GA	6	60.2	28.8	45.5
Nelson 2001 [23]	10	UPPP	RFQ	2	29.5	18.8	50.0
Vilaseca et al. 2002 [37]	20	UPPP	GA HS	6	60.5	44.6	35.0
Neruntarat 2003 [25]	32	Flap	HS	8.1	44.5	15.2	78.0
Neruntarat 2003 [24]	49	Flap	GA HS	39.4	47.9	18.6	65.2
Friedman et al. 2003 [8]	143	UPPP	RFQ	no data	43.9	28.1	41.0
Miller et al. 2004 [21]	24	UPPP	GA	4.7	52.9	15.9	66.7
Dattilo et al. 2004 [3]	37	UPPP	GA HS	1.5	38.7	16.2	70.3
Verse et al. 2004 [25]	45	Flap	RFQ, HS	4.7	38.3	20.6	51.1
Hörmann et al. 2004 [13]	66	Flap	RFQ, HS	3.4	38.9	19.3	57.6
all	830			1-39	47.1	20.6	53.9

Altogether, data of 830 patients from retrospective studies and from prospective case control studies exist. The success rate according to Sher et al. [31] lies at almost 54%. With the exception of the study by Nelson [23], the studies dealt with on average severe forms of OSA. We are of the opinion that a sufficient amount of data exist to validate the efficacy of multi-level surgery in the case of severe OSA.

Difficulties arise in attempting to evaluate the divergent concepts against each other. For the area of the soft palate, all study groups either perform the conventional UPPP or more rarely the uvulopalatal flap, always including a tonsillectomy. We consider these techniques to be comparable. Therefore the concepts differ from one another in respect to the therapy of the hypopharyngeal constriction of the upper airway. Two

Effectiveness of multi-level surgery for moderate to severe (AHI > 40/h) OSA

On the level of the soft palate, invasive therapy concepts include either a UPPP or a uvulopalatal flap.

For the treatment of the hypopharyngeal obstruction different procedures have been recommended. Table 2 summarizes the existent data. In the case of a relevant clinical diagnosis several authors additionally perform nasal surgery. Recently, we were able to demonstrate that additional nasal surgery does not have a positive effect on the severity of the OSA [35, 36].

study groups [4, 6] recommend in somewhat dated publications a partial resection of the tongue base. With 32% and 44% respectively the success rates lie below average.

Two further concepts [8, 23] solely employ the minimally invasive RFQ surgery at the tongue base. The retrospective analysis of Friedman et al. [8] achieves with 41% a relatively low success rate. Yet of interest in this study is the fact that a control group of patients, who only had received a UPPP, performed significantly worse. Nelson [23] presents with 50% an average success rate, but treated patients with less severe OSA. The mean AHI in his series was 29.5/h, compared to the mean value of all studies, which was 47.1/h. Undoubtedly, of all the tongue base procedures presented here the RFQ has the lowest postop-

erative morbidity and complication rate. But we infer from the data a tendency indicating that solely a RFQ at the tongue base, combined with the UPPP, is not in itself sufficient for properly treating a severe OSA with surgical means.

The majority of studies employs for the therapy of the hypopharyngeal constriction either the mandibular osteotomy with genioglossus advancement or the hyoid suspension or both. Currently, the data does not provide information as to which combination is superior. It presumably depends more on the surgeon with which technique he or she achieves the best results. Initially, we followed the Stanford [30] concept. Yet after the mandibular osteotomy with genioglossus advancement several complications occurred in our patient pool, such as infections of the oral floor with abscess formation and loosening of the osteosynthesis; therefore, we have searched for alternatives with less complications. We believe to have found the solution for obstructions located hypopharyngeal. We perform the combination of RFQ of the tongue base and the hyoid suspension by Hörmann [36, 13]. The hyoid suspension enlarges the upper airway in moving the hyoid bone anteriorly. The hyoid bone will be fixed to the thyroid cartilage in its new position [12] (Figure 2).

Figure 2: Hörmann's technique of hyoid suspension. Left) Preoperative situation. Center) Movement of the hyoid bone anteriorly and fixation to the thyroid cartilage with only one wire. Right) Situation after surgery.

In the context of this concept, tonsillectomy and hyoid suspension have shown themselves to be the most effective elements of our multi-level concept.

Obviously, the best success rates are found for staged concepts, which provide as a second, additional surgical stage a bimaxillary advancement in the case of the non-responders. This dividing up into 2 phases also goes back to the Stanford study group [30] and has gained acceptance in many places. The available data are presented in table 3.

Table 3: Staged concepts of multi-level surgery for OSA. MMO: bimaxillary advancement; Non-Resp.: Non-Responder

Author	N stage 1	Non-Resp. stage 1	N stage 2 (MMO)	Resp. stage 2 (MMO)	AHI pre stage 1	AHI post stage 2
Riley et al. 1993 [30]	223	89 (40%)	24	23 (97%)	75.1	8.4
Lee et al. 1999 [19]	33	11 (33.3%)	3	3 (100%)	74	5
Bettega et al. 2000 [2]	44	34 (77.3%)	20	15 (75%)	59.3	11.1
Li et al. 2000 [18]			19	18 (94.7)	63.6	8.1
Hendler et al. 2001 [11]	33	18 (54.5%)	7	4 (57.1%)	90.1	16.5
all	333	152 (45.6%)	73	63 (86.3%)	69.2	9.7

The MMO is also in the context of multi-level surgery an eminently successful treatment in regards to the severity level of the OSA. This is apparently also the case for morbidly obese patients. In a series of 23 obese sleep apneics with a mean BMI of 45 kg m⁻² the Stanford two phase concept achieved a success rate of 82.6%. In this series, the mean AHI fell from preoperatively 83/h to 10.6/h six months postoperatively. But it needs to be mentioned that the patients had also reduced their weight. The average BMI was postoperatively 43 kg m⁻². The authors conclude from their data that counseling in regards to weight reduction and avoidance of weight gain will improve treatment outcomes.

It is striking that only a relatively small number of patients have actually chosen an MMO, as can be seen in two series [19, 30]: in both of the studies only 27%

of the candidates chose the option MMO. The reason for this remained unanswered in the studies. Apparently, due to the potential risks involved, MMO is not a surgical option for the majority of sleep apneics.

Conclusion

Minimally invasive multi-level surgery in the form of an isolated radiofrequency therapy is not effective in apneics with an AHI above 20/h. For these cases and cases with moderate and severe OSA we perform the combination of the uvula flap, the radiofrequency of the tongue base and the hyoid suspension by Hörmann. With this concept we achieve a success rate of 57.6% after Sher [31]; this result situates us at the average level of the cited multi-level surgery studies. With this success rate this protocol can replace the CPAP mask especially in cases with CPAP intolerance or decline.

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