Usefulness of Video-Fluoroscopy in Assessment of Obstructive Sleep Apnea Syndrome

Ki-Jeong Kim¹, Hong-Ryang Jung²*, Cheong-Hwan Lim³, Woo-Taek Im³, Jae-Goo Shim⁴ and Mi-Hwa Lee⁵

¹Department of Radiology, Konkuk University Medical Center, Seoul, South Korea; raidline@kuh.ac.kr
²Department of Radiology Science, Hanseo University, ChungcheongNam-do, South Korea; hrjung@hanseo.ac.kr
³Department of Health Care, Hanseo University, ChungcheongNam-do, South Korea; lch116@hanseo.ac.kr, 040114@kuh.ac.kr
⁴Department of Oncology, Samsung Medical Center, Seoul, South Korea; jg.shim@samsung.com
⁵Department of Radiology, Gangdong Kyung-Hee University Hospital, Seoul, South Korea; rjqnrdl113@hanmail.net

Abstract
The study tried to comparatively analyze surgical findings based on the examination results of polysomnography and video-fluoroscopy which are examinations useful in diagnosis of obstructive sleep apnea syndrome. The subjects were patients over the age of 18 who were admitted for snoring, observed apnea, or sleepiness. Received under polysomnography and video-fluoroscopy inspection of obstructive sleep apnea of doubt from March 2013 to February 2014, it was intended for patients who have undergone surgical treatment. In the analysis was obstructive sleep apnea severity, there were difference in all clauses excluding age and height (P<0.05). Crosstab due to the presence or absence of video-fluoroscopy and polysomnography and surgical treatment, there was a significant difference (p<0.05). There are many examinations for diagnosing obstructive sleep apnea but as an essential examination there are polysomnography and video-fluoroscopy examination that can observe the dynamic change of the obstruction which are clinically useful.

Keywords: Apnea-Hypopnea Index, Obstructive Sleep Apnea, Polysomnography, Video-Fluoroscopy

1. Introduction
This Sleep apnea refers to the symptom that is characterized by periodic cease of respiration during sleep. Obstructive sleep apnea syndrome is a disease that can show various symptoms such as sleep symptoms including excessive sleepiness, headaches, and snoring as well as severe cardiovascular complications. It is a syndrome that can have limitations on the patient’s psychological, physical and social activities⁴. The most common form is where there is repetition of closing of the upper respiratory tract caused by sleep accompanied by the effort to breathe, and this is called obstructive sleep apnea⁵. Obstructive sleep apnea syndrome is a complex disease of the neuromuscular, respiratory and cardiovascular systems and it is a disease that can cause severe problems physiologically and socially. Before deciding on surgical treatment, first there needs to be detailed examination for diagnosis such as signs, symptoms, physical conditions, and habits as well as detailed investigation of things such as the social environment of the patient. Whether the surgery should be done or not must be decided upon considering influence of the airway obstruction in the daily life of the patient, physical and mental health as well as the accompanied discomfort and complications with surgery. The methods to treat snoring and Obstructive

* Author for correspondence
Usefulness of Video-Fluoroscopy in Assessment of Obstructive Sleep Apnea Syndrome

sleep apnea syndrome are largely divided into internal medicinal methods and surgical methods. For internal medicinal methods there are continued positive pressure therapy, intraoral devices, and drug therapy. For surgical treatment methods there are bronchotomy, uvulopalatopharyngoplasty, laser palatopharyngeal surgery, genioglossus advancement, maxillomandibular advancement and high-frequency thermal treatment. The purpose of surgical treatment is to acquire the airway space without obstruction by soft-tissue and to maintain adequate airflow in normal air intake process by decreasing airway resistance. Closure can occur in all parts of upper airway and there are a lot of them such as the nasal cavity, the soft palate, the root of the tongue, and the epiglottis. There are variety of ways to check closure site such as Muller which uses the nasopharynx fiber, cephalometry that simply shoots side of the upper airway, manometry that decides the closure part by measuring the pressure of upper airway, computed tomography that observes the closure site solidly and magnetic resonance. There are a lot of controversy in undergoing clinical trial utility, patient compliance and economical burden. Compared to this, video-fluoroscopy can check the dynamic change in upper airway when sleeping; It is non-invasive and can grasp the closure that happens in several parts. Also in the polysomnography, it is a standardized test of sleep apnea so it can be over or under evaluated according to the sleep environment and measuring equipment, but until now it has been thought as reference standard, so it has been gone over without any doubt of reliability and technological accuracy.

Fortis the study tried to figure out the relevance in patients who are admitted for obstructive sleep apnea is the main symptom that received polysomnography and video-fluoroscopy examinations.

2. Materials and Methods

2.1 Materials
The subjects were patients over the age of 18 who were admitted for snoring, observed apnea or sleepiness. Received under polysomnography and video-fluoroscopy inspection of obstructive sleep apnea of doubt from March 2013 to February 2014, it was intended for patients who have undergone surgical treatment. From the people studied, 24(80%) of them were men, 6(20%) of them were women. The age distribution was from 18 to 62, average age was 43.5±13.4, average height was 170.1±9.6cm, weight of 76.1±12.7kg, and the average Body Mass Index (BMI) was 26.3±3.5kg/m².

2.2 Polysomnography
Five busy for the examination the administration of medicaments that influence sleep was ceased and help them arrive at the examination room two hours earlier than the average sleeping times and before polysomnography, explained to patients about physical measurement and polysomnography. In the record of polysomnography, we used medcare Embla N 7000 and A 10 recording system, and for the analysis program, we used Somnologica version 3.0. The review of the polysomnography record followed international review standards and apnea was defined as at least 10 seconds of continual 90% or more decrease of airflow, hypopnea was defined as at least 10 seconds of continual 50% or more decrease of airflow due to this arterial oxygen saturation decreased by more than 4%. It was called a minor case when apnea-hypopnea index was between 5 – 15, it was called a moderate case when it was between 15 – 30, and if it was over 30 was classified as a major case and when it was over five it was diagnosed as obstructive sleep apnea syndrome in Figure 1.

2.3 Video-Fluoroscopy
The examination was conducted in supine position. In the imaging before anesthetic injection the patients were asked to open and close the mouth clearly checked the location of the soft palate and tongue root. For sleep induction Midazolam 3mg was intravenously injected and

Figure 1. Polysomnography.
if sleep induction failed 2mg was additionally injected. The imaging was ceased immediately after injection and then the patient was in full sleep the imaging started and it was conducted for about five minutes. Before the examination oxygen saturation equipment was attached to the fingers so that if the oxygen level rapidly decreased the prepared medical staff could conduct prompt emergency measures in Figure 2.

![Figure 2. Video-fluoroscopy.](image)

### 2.4 Statistical Analysis

The difference of gender was tested by Mann-Whitney U test, analyzed the difference of obstructive sleep apnea severity by ANOVA and for the relationship between fluoroscopic findings and polysomnography and operative findings was analyzed by Pearson’s chi-square test and Fisher’s exact test. A one-way analysis of variance test (ANOVA) was used to evaluate the effects of the variables on severity. The Tukey test was applied as a post hoc test. If the assumption that the variances were equal was broken by the Levene test, the Welch variance weighted ANOVA test was used. The Tamhane test was applied as a post hoc test. Statistical analysis was performed using SPSS (version 21.0, Chicago, IL, USA). The measured values are marked as mean ± Standard Deviation (SD). A p value of less than 0.05 was considered to be statistically significant.

### 3. Results

From the analysis according to the gender, from all people, the average age of men were 40.6±13.4 and women were 55.2±3.9, the average height for men were 173.6±7.2cm and women were 156.2±3.3cm, the average weight for men were 78.8±12.2kg and women were 65.6±9.1kg(p<0.05). Also, the average of BMI for men were 26.1±3.7kg/m² and women were 27.3±3.0kg/m², average oxygen saturation for men were 95.1±1.7% and women were 95.7±2.0%, minimum oxygen saturation for men were 82.6±8.0% and women were 86.3±5.7%, having not significant difference(p>0.05). In the average Apnea-Hypopnea Index(AHI), men were 31.7±25.1 and women were 23.6±20.6, having not significant difference(p>0.05).

When assorted by severity, mild was 8, moderate 12, and severe was 10 in Table 1. In the analysis was obstructive sleep apnea severity, there were difference in all clauses excluding age and height(P<0.05) in Table 2. There is a difference in the surgical therapy based on the diagnosis of the polysomnography obstructive sleep apnea (x² = 5.000, p = 0.046) in Table 3. In addition, there is a significant difference in polysomnography findings based on the video-fluoroscopy findings (x² = 10.866, p = 0.002) in Table 4. Finally, whether the operation in response to the video fluoroscopy findings also was a significant difference (x² = 19.201, p = 0.001) in Table 5.

All data are shown as mean±SD. Difference between means was assessed by Mann-Whitney U test (p<0.05). BMI: body mass index, SpO₂: O₂ saturation, AHI: apnea hypopnea index.

| Variables   | Total (n = 30) | Male (n = 24) | Female (n = 6) | t     | p-value |
|-------------|---------------|---------------|----------------|-------|---------|
| Age (yr)    | 43.5±13.4     | 40.6±13.4     | 55.2±3.9       | 0.026 | .026    |
| Height (cm) | 170.1±9.6     | 173.6±7.2     | 156.2±3.3      | 0.001 | .001    |
| Weight (kg) | 76.2±12.7     | 78.8±12.2     | 65.6±9.1       | 0.021 | .021    |
| BMI (kg/m²) | 26.4±3.5      | 26.1±3.7      | 27.3±3.0       | 0.364 | .364    |
| Mean        | 95.2±1.74     | 95.1±1.7      | 95.7±2.0       | 0.299 | .299    |
| SpO₂ (%)    | 83.4±7.6      | 82.6±8.0      | 86.3±5.7       | 0.350 | .350    |
| AHI (event/h)| 30.1±24.1     | 31.7±25.1     | 23.6±20.6      | 0.641 | .641    |

All data are shown as mean±SD. Difference between means was assessed by Mann-Whitney U test (p<0.05).

BMI: body mass index, SpO₂: O₂ saturation, AHI: apnea hypopnoea index.
Usefulness of Video-Fluoroscopy in Assessment of Obstructive Sleep Apnea Syndrome

Obstructive Sleep Apnea (OSA) can be caused by gender, age, obesity degree interaction and in this research, the people were above BMI 25, and by looking at the fact that bigger the Apnea-Hypopnea Index (AHI) is, the BMI was bigger. We can see from this that obesity and sleep apnea has close relation. Browman says that obesity is an important factor to cause or aggravate sleep apnea, for a mild case, by just losing weight, they can improve snoring and sleep apnea. Video-fluoroscopy can check the dynamic change in the upper airway when sleeping, and it is non-invasive. Especially, it can find the closure site that happens at the same time easily. Like this, because it shows structural correlation well, it is useful when deciding surgical treatment. Tongue rear part space has relationship with sleep apnea moderate and the hyoid bone's position is the way of distinguishing the patient of sleep apnea and normal person. From the video-fluoroscopy research, Suratt said that closure starts from the soft palate and goes to under part of the hypopharynx. Pepin said that closure is usually in the part of the epiglottis, so when doing test while sleeping, the soft palate touches the wall of posterior pharynx and tongue, which is connected to closure. Walsh said that closure starts from the soft palate and goes to under part of the hypopharynx. We can see from this that obesity and sleep apnea moderate and the hyoid bone's position is the way of distinguishing the patient of sleep apnea and normal person. From the video-fluoroscopy research, Suratt said that closure starts from the soft palate and goes to under part of the hypopharynx. Pepin said that closure is usually in the part of the epiglottis, so when doing test while sleeping, the soft palate touches the wall of posterior pharynx and tongue, which is connected to closure. Walsh said that closure starts from the soft palate and goes to under part of the hypopharynx.

4. Discussion

All data are shown as mean±SD. One-way analysis of variance (ANOVA) was done. Multiple comparison test was done by Tukey test (p<0.05). Welch variance weighted ANOVA was used. Multiple comparison test was done by Tamhane test (P<0.05). SD: standard deviation, BMI: body mass index, SpO2: O2 saturation, AHI: apnea hypopnea index.

**Table 2.** Polysomnographic data of the subjects according to the ahi dependency

| Variables | AHI Group | Mean | SD | F  | p-value |
|-----------|-----------|------|----|----|---------|
| Age (yr)† | Mild      | 43.5 | 12.2 | 0.361 | .702    |
|           | Moderate  | 45.8 | 15.5 |     |         |
|           | Severe    | 40.7 | 12.5 |     |         |
| Height (cm)‡ | Mild | 168.7 | 10.9 | 0.594 | .559    |
|            | Moderate  | 168.8 | 9.9  |     |         |
|            | Severe    | 172.9 | 8.8  |     |         |
| Weight (kg)‡ | Mild | 66.7  | 8.3  | 11.910 | .001   |
|            | Moderate  | 72.8  | 8.7  |     |         |
|            | Severe    | 87.8  | 11.4 |     |         |
| BMI (kg/m²)‡ | Mild       | 23.4  | 1.5  | 13.066 | .001 |
|            | Moderate  | 25.7  | 2.7  |     |         |
|            | Severe    | 29.5  | 3.3  |     |         |
| Mean SpO2 (%)‡ | Mild       | 96.8  | 0.6  | 20.492 | .001 |
|            | Moderate  | 95.2  | 1.8  |     |         |
|            | Severe    | 93.9  | 1.3  |     |         |
| Minimum SpO2 (%)‡ | Mild       | 92.5  | 1.8  | 46.527 | .001 |
|            | Moderate  | 82.4  | 5.9  |     |         |
|            | Severe    | 77.2  | 5.2  |     |         |
| AHI (event/h)‡ | Mild     | 8.3  | 4.5  | 40.547 | .001 |
|            | Moderate  | 22.4  | 3.0  |     |         |
|            | Severe    | 56.8  | 23.5 |     |         |

All comparison between polysomnography findings and surgical treatments assessed by Pearson’s chi-square test (p<0.05). OSA: obstructive sleep apnea.

**Table 3.** Comparison between polysomnography findings and surgical treatments

| Polysomnography Findings | Surgical treatments | Total | X²(P) |
|--------------------------|---------------------|-------|-------|
|                          | Non-operative       | Operative |       |
| Sonring_OSA              | 7                   | 2      | 9(100%) | 5.000 |
| Sonring                  | 7                   | 14     | 21(100%) | (.046) |

Comparison between polysomnography findings and surgical treatments assessed by Fisher’s exact test (p<0.05). OSA: obstructive sleep apnea.

**Table 4.** Comparison between polysomnography findings and video-fluoroscopy findings

| Polysomnography Findings | Video-fluoroscopy findings | Total | X²(P) |
|--------------------------|----------------------------|-------|-------|
|                          | Sonring                    | Snoring_OSA |       |
| Sonring                  | 8                          | 1      | 9(100%) | 10.866 |
| Sonring_OSA             | 5                          | 16     | 21(100%) | (.002) |

Comparison between polysomnography findings and video-fluoroscopy findings assessed by Fisher’s exact test (p<0.05). OSA: obstructive sleep apnea.
therapy can refer to Stanford University method\textsuperscript{23}. By this, in this research, we tried to analyze the relationship between those patients who got treated and closure site, video-fluoroscopy and polysomnography, as a result, there were positive correlation between them. Especially for video-fluoroscopy, it has strong positive correlation, so we could learn that it is useful for clinical index. For last, induced sleep can be different from the real sleep\textsuperscript{24}. Normally, we inject sleeping pill such as Midazolam, the 3 step sleep and REM sleep doesn’t emerge, so the real closure site might not be found\textsuperscript{25}. In this research, we also injected Midazolam, so there can be difference from the real sleep and there is limit of sampling number.

5. Conclusion

For diagnosis of snoring and obstructive sleep apnea syndrome, various examination findings of polysomnography and radiological findings of videofluoroscopy examination is clinically useful in diagnosing the level of obstruction and location of obstruction in the upper respiratory tract and it could be seen that as a surgical index it had close relevance with surgical treatment planning.

6. References

1. Shepard JW. Cardiopulmonary consequences of obstructive sleep apnea. Mayo Clin Proc. 1990; 65:1250–9.
2. The report of an American academy of sleep medicine task force. Sleep-related breathing disorders in adults: Recommendations for syndrome definition and measurement techniques in clinical research. Sleep. 1999; 22:667–89.
3. Guilleminault C, Tilkian A, Dement WC. The sleep apnea syndromes. Annu Rev Med. 1976; 27:465–84.
4. Lee YK, Myung H, Hwang SJ, Seo BM, Lee JH, Choung PH, Kim MJ, Choi JY. Clinical study of surgical treatments for snoring and obstructive sleep apnea. J Kor Oral Maxillofac Surg. 2008; 34:435–44.
5. Friedman M, Lin HC, Venkatesan TK, Gurpiner B. Sleep apnea and snoring: First edition. 2009; 17:111–9.
6. Azagra-Calero E, Espinar-Escalona E, Barrera-Mora JM, Llamas-Carreras JM, Solano-Reina E. Obstructive Sleep Apnea Syndrome (OSAS). Review of the literature, Med Oral Patol Oral Cir Bucal [Epub ahead of print]; 2012.
7. Namgung Caples SM, Rowley JA, Prinsell JR, Pallanch JF, Elamin MB, Katz SG, et al. Surgical modifications of the upper airway for obstructive sleep apnea in adults: A systematic review and meta-analysis. Sleep. 2010; 33(10):1396–407.
8. Powers DB, Allan PF, Hayes CJ, Michaelson PG. A review of the surgical treatment options for the obstructive sleep apnea / hypopnea syndrome patient. Mil Med. 2010; 175(9):676–85.
9. Riley RW, Guilleminault C, Herran J, Powell NB. Cephalometric analysis and flow-volume loops in obstructive sleep apnea patients. Sleep. 1983; 6:303–11.
10. Haponik EF, Smith PI, Bohiman ME. Computerized tomography in obstructive sleep apnea. Correlation of airway size with physiology during sleep and wakefulness. Am Rev Respir Dis. 1983; 127:221–6.
11. Lee CH, Hong SL, Rhee CS, et al. Analysis of upper airway obstruction by sleep video-fluoroscopy in obstructive sleep apnea: A large population-based study. Laryngoscope. 2012; 122(1):237–41.
12. Kushida CA, Littner MR, Morgenthaler T, et al. Practice parameters for the indications for polysomnography and related procedures: An update for 2005. Sleep. 2005; 28:499–519.
13. Iber C, Ancoli-Israel S, Chesson A, et al. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications. American Academy of Sleep Medicine. Westchester: American Academy of Sleep Medicine; 2007.
14. Lee CH, Mo JH, Kim BJ, Kong IG, Yoon YJ, Chung S, et al. Evaluation of soft palate changes using sleep video-fluoroscopy in patients with obstructive sleep apnea. Arch Otolaryngol Head Neck Surg. 2009; 135(2):168–72.
15. Seo EW, Lee HK, Han MW, et al. Cephalometric predisposing factors of the snoring and obstruction sleep apnea. J Korean Assoc Oral Maxillofac Surg. 2013; 35:161–6.
16. Browman CP, Sampson MG, Yolles SF. Obstructive sleep apnea and body weight. Chest. 1984; 85:435–6.
17. Lee CH, Hong SL, Rhee CS, Kim SW, Kim JW. Analysis of upper airway obstruction by sleep video-fluoroscopy in obstructive sleep apnea: A large population-based study. Laryngoscope. 2012; 122(1):237–41.
18. De Berry-Borowiecki B, Kukwa A, Blanks RH. Cephalometric analysis for diagnosis and treatment of obstructive sleep apnea. Laryngoscope. 1988; 98(2):226–34.
19. Suratt PM, Dee P, Atkinson RL, et al. Fluoroscopic and computed tomographic features of the pharyngeal airway in obstructive sleep apnea. Am Rev Respir Dis. 1987; 127:487–92.
20. Walsh JK, Katsantonis GP, Schweitzer PK, et al. Somno-fluoroscopy: Cineradiographic observation of obstructive sleep apnea. Sleep. 1985; 8:294–7.
21. Pepin JL, Ferretti G, Veale D, et al. Somno-fluoroscopy, computed tomography and cephalometry in the assessment of the airway in obstructive sleep apnea. Thorax. 1992; 47:150–6.
22. David WH. Treatment of obstructive sleep apnea. Chest. 1996; 109:1346–58.
23. Lee YK, Myung H, Hwang SJ, Seo BM, Lee JH, Choung PH, Kim MJ, Choi JY. Clinical Study of surgical treatments for snoring and obstructive sleep apnea. J Kor Oral Maxillofac Surg. 2008; 34:435–44.
24. Agrawal S, Stone P, McGuinness K, et al. Sound frequency analysis and the site of snoring in natural and induced sleep. Clin Otolaryngol Allied Sci. 2002; 27(3):162–6.
25. Stuck BA, Maurer JT. Airway evaluation in obstructive sleep apnea. Sleep Med Rev. 2008; 12(6):411–36.