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Drug-Induced Sleep Endoscopy: New Insights in Lateral Head Rotation Compared to Lateral Head and Trunk Rotation in (Non) Positional Obstructive Sleep Apnea Patients

Patty E. Vonk, MD ©; Megan J. van de Beek; Madeline J.L. Ravesloot, MD, MSc, PhD; Nico de Vries, MD, PhD

INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep-related condition characterized by recurrent episodes of a decrease in airflow caused by a partial or complete collapse of the upper airway. This results in oxygen desaturation, respiratory arousals, and insufficient sleep due to frequent awakenings. In the majority of OSA patients, disease severity is influenced by body position in which the supine position is usually the worst sleeping position (WSP).1 According to Cartwright's definition, patients are deemed to have position-dependent OSA (POSA) when they meet the following criteria: an apnea-hypopnea index (AHI) greater than 5 and an at least twofold difference between supine and nonsupine AHI.3

Over time, various modifications have been introduced, including various parameters such as the overall AHI, AHI in the supine and non-supine position, and time spent in various body positions.4–10 Patients diagnosed with POSA (PP) benefit from avoiding the supine position, which can be achieved through positional therapy (PT). Various forms of PT exist, varying from the so-called tennis-ball technique to a new generation of PT: vibrotactile feedback devices. A recent meta-analysis by Ravesloot et al. showed that new-generation devices are effective in reducing the AHI during short-term follow-up.11

Currently, evidence is growing that POSA is not only dependent on body position, but also on head position. Van Kesteren et al. reported that the majority of PP are trunk supine-dependent, of which in 46.2% head position was of considerable influence on the AHI. Furthermore, they reported that 6.5% of their study population was head supine-dependent alone.12 These findings were endorsed by Zhu et al., who analyzed the effect of lateral head rotation with the trunk in the supine position on OSA severity by using polysomnography (PSG), including visual inspection of the PSG video recording. They concluded that there was a significant decrease in OSA severity when the head was rotated from the supine to lateral position, in nonobese patients in particular.13

Although increasing evidence shows that head rotation can influence OSA severity, there is actually a lack of information on the effect of head rotation on upper airway patency. Drug-induced sleep endoscopy (DISE) is a

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dynamic endoscopic tool to observe the upper airway during propofol-induced sleep, which can be used to gain more information on upper airway collapse in OSA patients. To the best of our knowledge, only one previous study has evaluated lateral head rotation and the effect on upper airway patency during DISE. This two-part study by Safruddin et al. first analyzed the influence of different head positions on upper airway collapse in 60 subjects and found a significant improvement on upper airway patency when the head was rotated to lateral position compared to the supine head and trunk position. No differences were found when comparing rotation to the left or right side. In the second part of their study, lateral head rotation alone was compared to lateral head and trunk position. They concluded that these two maneuvers were comparable when focusing on the level(s) and configuration(s) involved in upper airway obstruction in OSA patients. Therefore, it was concluded that these two positions are comparable during DISE, and that there is no need to assess the upper airway in lateral head and trunk position.

In a previous study, we introduced a 3-point scale to retrospectively evaluate the effect of different passive maneuvers during DISE on upper airway patency. One of these maneuvers was lateral head rotation. When comparing the improvement on upper airway patency while performing lateral head rotation, the effect was less (<50%) than what was previously expected based on currently available literature on treatment outcome of PT in PP.

Bearing this in mind, the first aim of this study is to compare the effect of lateral head and supine trunk rotation to lateral head and trunk rotation on upper airway patency during DISE, distinguishing between nonpositional OSA patients (NPP) and PP, with particular focus on the severity of collapse at the four levels of obstruction according to the VOTE classification system. We hypothesize that in case of NPP, lateral head rotation is similar to lateral head and trunk rotation. In case of PP, we hypothesize that the effect on upper airway patency of lateral head rotation only will be less compared to both lateral head and trunk rotation. We also hypothesize that the more OSA severity is influenced by sleeping position, the less comparable is lateral head rotation to both lateral head and trunk rotation.

MATERIALS AND METHODS

Patients
We performed a prospective, single-center cohort study, including a consecutive series of patients who underwent DISE in the department of otolaryngology, head and neck surgery of the OLVG (Onze Lieve Vrouwe Gasthuis) (Amsterdam, the Netherlands) between August 2017 and November 2017. All patients were diagnosed with OSA by PSG. Patients were excluded from this study when they were not willing to sign informed consent or in case of physical disabilities (e.g., back and/or neck problems) when they were therefore unable to rotate the head to lateral position or to lie in a nonsupine position. When there was no data available of both the supine and nonsupine AHI or sleeping position, patients were also excluded from this study.

Definitions
When patients met the inclusion criteria, patients were classified as NPP or PP. POSA was defined using a modified version of Cartwright’s criteria: a difference of 50% or more in AHI between the supine and nonsupine positions.

Drug-Induced Sleep Endoscopy Procedure
DISE procedure was performed according to the practice guidelines as recommended in the European position paper on DISE (update 2017).

Indication
The main reason to perform DISE was eligibility for upper airway surgery. Other indications included patients eligible for oral appliance therapy (OAT) or combination therapy (e.g., OAT + PT).

Setting
All patients underwent DISE in daycare in a safe outpatient endoscopy setting with standard anesthetic equipment. DISE was performed by one experienced resident at the department of Otorhinolaryngology Head and Neck surgery (P.E.V.), with a trained nurse anesthetist managing sedation and monitoring blood pressure, electrocardiogram, and oxygen levels.

Sedation
The drug of choice for sedation was propofol. The level of sedation was controlled by a target-controlled infusion pump using the methods described by Schnider et al. to calculate the effective dose. Prior to the intravenous (IV) infusion of propofol, 2 cc lidocaine was given IV to prevent pain caused by the infusion of propofol. In some patients, glycopyrrolate was given IV to prevent mucosal hypersecretion because this could interfere with the quality of the endoscopic assessment. Proper sedation levels were achieved when the patient showed hyporesponsiveness to verbal and tactile stimuli or when the patient began to snore.

Patient positioning
Ideally, the patient should be positioned mimicking sleeping habits during natural, but due to the nature of this study, DISE was performed in both the supine position and the lateral head (and trunk) rotation.

Initially, subjects were placed in the lateral head and trunk position. When a proper level of sedation was achieved, the upper airway was assessed at four different levels (velum, oropharynx, tongue base and epiglottis) according to the VOTE classification system. Patients were then tilted to the supine position with the head rotated to the right side, and finally the upper airway was observed in the supine position of both head and trunk. Jaw thrust was performed in all positions to evaluate the effect on upper airway patency; however, it was not the purpose of this study to analyze this maneuver.

Classification system
To report on the anatomical structures causing upper airway collapse, the VOTE classification system was applied. The VOTE classification system distinguishes between four different levels and structures that may be involved in upper airway collapse, namely velum (V), oropharynx (O), tongue base (T), and epiglottis (E). To define the degree of obstruction, three different categories are used,
namely no obstruction, with a collapse less than 50%, a partial obstruction with a collapse between 50% and 75% and typically with vibration, or a complete collapse in which a collapse is seen of more than 75%. An X is used when no observation can be made. Depending on the different site(s) involved in upper airway obstruction, the configuration may be anteroposterior, lateral, or concentric. In Table I, an overview is given of the degree and possible configurations of obstruction at each level.

In accordance with the Declaration of Helsinki, the study protocol was approved by the local medical ethical committee. Patients signed informed consent previous to the procedure. Data on study subjects was collected and stored anonymously to protect personal information.

Statistical analysis
Statistical analysis was performed using SPSS 21 (SPSS Inc, IBM Corp., Armonk, NY). Quantitative data are reported as mean ± standard deviation or as median (Q1, Q3) when not normally distributed.

A P value of <0.05 was considered to indicate statistical significance.

To determine whether the effect on upper airway patency during lateral head rotation is similar to lateral head and trunk rotation, the degree of obstruction according to the VOTE classification system was compared by using the Wilcoxon signed rank test in NPP and PP. To analyze the influence of the degree of position dependency, a ratio for position dependency was calculated by dividing nonsupine AHI by supine AHI; this implicates a ratio > 0.5 for nonposition-dependent OSA. The closer the ratio is to 1, the less OSA severity is influenced by body position.

RESULTS
A total of 109 patients were invited to participate in this study. Five patients declined after receiving additional information. In four patients, DISE results could not be analyzed due to physical agitation or mucosal hypersecretion, which rendered DISE outcomes unreliable. In one subject, body position during the PSG night could not be determined due to malfunction of the PSG apparatus, and in seven patients supine AHI could not be determined due to a total sleep time (TST) of zero per cent in the supine position. Therefore, only the results of the remaining 92 subjects were analyzed.

Seventy-five patients were male (82%). The mean age was 47.2 ± 11.3 years, with a body mass index (BMI) of 27.0 ± 3.3 kg/m² and a median AHI of 16.7/hour (8.7, 26.5), a median supine AHI of 31.9/hour (16.5, 53.5), and a median nonsupine AHI of 8.1/hour (3.1, 15.2). Patients spent a median percentage of TST in the supine position of 34.0% and the median oxygen desaturation index was 19.5/hour (11.9, 29.2).
Twenty-five percent of all patients were NPP. When comparing baseline characteristics between NPP and PP, PP had a significantly lower nonsupine AHI, as expected. The supine AHI was higher in PP compared to NPP but not statistically significant. The percentage of male subjects was significantly higher comparing NPP to PP, namely 65.2% versus 87.0%. An overview of baseline characteristics of the total population and subgroups is presented in Table II.

In NPP, lateral head rotation alone was comparable to lateral head and trunk rotation concerning the degree of obstruction at velum, tongue base, and epiglottis levels. In PP, lateral head rotation alone significantly differed at all levels observed during DISE compared to lateral head and trunk rotation. An overview is given in Table III and Table IV.

Unfortunately, the data extracted to analyze the influence of the degree of position dependency were not reliable due to the small sample size in the different subgroups. Therefore, the statistical power was not high enough.

<p>| TABLE I. The VOTE Classification System.19 |</p>
<table>
<thead>
<tr>
<th>Structure</th>
<th>Degree of Obstruction</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velum</td>
<td></td>
<td>A–P Lateral</td>
</tr>
<tr>
<td>Oropharynx</td>
<td></td>
<td>Concentric</td>
</tr>
<tr>
<td>Tongue base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epiglottis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Degree of obstruction: 0 = no obstruction; 1 = partial obstruction; 2 = complete obstruction.
†Configuration noted for structures with degree of obstruction > 0.
‡Oropharynx obstruction can be distinguished as related solely to the tonsils or including the lateral walls.
A–P = anteroposterior; VOTE = velum (V), oropharynx (O), tongue base (T), and epiglottis (E).

**DISCUSSION**
This study describes the effect of lateral head rotation compared to lateral head and trunk rotation concerning the degree of obstruction at velum, tongue base, and epiglottis levels. In PP, lateral head rotation alone significantly differed at all levels observed during DISE compared to lateral head and trunk rotation. An overview is given in Table III and Table IV.

Unfortunately, the data extracted to analyze the influence of the degree of position dependency were not reliable due to the small sample size in the different subgroups. Therefore, the statistical power was not high enough.

| TABLE II. Baseline Characteristics Total Population and NPP Versus PP. |
|-----------------------|-------|-----|-----|-----------------|
| Number (%)            | Total | NPP | PP  | NPP vs. PP P Value |
| Number (%)            | 92    | 23  | 69  | 23 vs. 69       |
| Age (years)           | 47.2 ± 11.3 | 44.9 ± 13.4 | 48.0 ± 10.5 | 0.248 |
| Male/female           | 75/17 | 15/8 | 60/9 | 0.019*          |
| BMI (kg/m²)           | 27.0 ± 3.3 | 27.3 ± 3.8 | 26.9 ± 3.1 | 0.664 |
| Total AHI (events/hour)| 16.7 | 21.5 | 15.7 | 0.262          |
| Supine AHI (events/hour)| 31.9 | 25.2 | 37.0 | 0.081          |
| Nonsupine AHI (events/hour)| 16.3 | 5.7 | 0.000* |
| Supine sleeping time (%) | 34.0 | 37.0 | 31.0 | 0.050          |
| ODI                    | 19.5 | 19.5 | 19.5 | 0.317          |

*Median (Q1, Q3).
†P value <0.05.
‡AHI = apnea–hypopnea index; BMI = body mass index; NPP = nonposition-dependent obstructive sleep apnea patients; ODI = oxygen desaturation index; PP = position-dependent obstructive sleep apnea patients.

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only is similar to both lateral head and trunk rotation at each possible level of obstruction with exception of the oropharynx. This does not apply for PP, in which significantly different results were found at all four possible levels of obstruction.

The percentage of PP in our study group was relatively high, namely 75%. This could be explained by the fact that the prevalence of POSA decreases as the severity of OSA increases and that the majority of this study population was diagnosed with mild to moderate OSA. In case of severe OSA, continuous positive airway pressure is the first therapy of choice, which does not require DISE. The percentage of male subjects was significantly higher in PP compared to NPP, a finding not described previously in literature. This difference could not be explained by confounders such as BMI or age.

The underlying pathophysiological mechanism explaining the different patterns of upper airway collapse in the supine and nonsupine position remains in question. Van Kesteren et al. suggested that with the head in the supine position, the tongue and to a lesser extent the soft palate fall backward due to gravitational forces and muscle relaxation. This effect would presumably be smaller when the head is rotated to lateral position.12 These findings were strengthened by a study of Lee et al. They evaluated the changes in obstruction site according to sleep position to determine which obstructions are responsible for obstruction in lateral body position. They concluded that obstruction due to the tongue base and larynx improved dramatically when moving from the supine to lateral body position and that recurrent obstruction in lateral body position was mainly caused by lateral wall collapsibility. They additionally assume that displacement of the tongue base alters lateral wall tension and causes a secondary collapse of the oropharyngeal walls.21 The findings of these studies could explain the fact that we found a significant difference at oropharynx level when comparing lateral head rotation alone to both lateral head and trunk rotation because the oropharyngeal collapse in NPP is enhanced by lateral body position.

The results of this study are in contrast to what was previously described in an earlier study from our group by Safruddin et al. They concluded that the occurrence of a partial and/or complete collapse during DISE was similar comparing lateral head rotation to lateral head and trunk rotation, with exception of the palate. Nevertheless, there are some critical comments to be made. First, a small study population was used (n = 60), of which only 38% of all patients was diagnosed with POSA. This percentage is much lower than the prevalence of POSA found in literature and in the present study. This combined with the fact that no distinction was made between NPP and PP might explain the different results.15

**Limitations**

This study is not without limitations. First of all, we intended to evaluate the effect of position dependency by

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**TABLE III.**

DISE Results Comparing Lateral Head Rotation Versus Lateral Head and Trunk Rotation in NPP.

<table>
<thead>
<tr>
<th>Level</th>
<th>Configuration (%)</th>
<th>Lateral Head Rotation</th>
<th>Lateral Head and Trunk Rotation</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
<td>Partial</td>
<td>Complete</td>
</tr>
<tr>
<td>Velum</td>
<td>A–P</td>
<td>10</td>
<td>4</td>
<td>6</td>
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<tr>
<td></td>
<td>Concentric</td>
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<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Oropharynx</td>
<td>Lateral</td>
<td>7</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Tongue base</td>
<td>A–P</td>
<td>13</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Epiglottis</td>
<td>A–P</td>
<td>14</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

*P values are Wilcoxon signed rank test.

A–P = anteroposterior; DISE = drug-induced sleep endoscopy; NPP = nonpositional obstructive sleep apnea patients.

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**TABLE IV.**

DISE Results Comparing Lateral Head Rotation Versus Lateral Head and Trunk Rotation in PP.

<table>
<thead>
<tr>
<th>Level</th>
<th>Configuration (%)</th>
<th>Lateral Head Rotation</th>
<th>Lateral Head and Trunk Rotation</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
<td>Partial</td>
<td>Complete</td>
</tr>
<tr>
<td>Velum</td>
<td>A–P</td>
<td>16</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Concentric</td>
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<td>Tongue base</td>
<td>A–P</td>
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<td>22</td>
<td>8</td>
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<tr>
<td>Epiglottis</td>
<td>A–P</td>
<td>42</td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>

*P values are Wilcoxon signed rank test.

A–P = anteroposterior; DISE = drug-induced sleep endoscopy; PP = position-dependent obstructive sleep apneas patients.
calculating a ratio dividing nonsupine AHI by supine AHI. Although we still believe our hypothesis is potentially true, we could not confirm this by statistically analysis of our data. There were a number of problems encountered when analyzing the results. When dividing the total study population into different subgroups to compare the differences in degree of obstruction for each different level, our sample size was too small. Secondly, the degree of obstruction during DISE according to the VOTE classification system consists of only a 3-point system: 0 (< 50% obstruction), 1 (between 50%–75% obstruction), or 2 (> 75%). In theory, this could mean that, although a different degree of obstruction is seen during DISE (e.g., 50% vs. 70%), both will be scored the same.

Thirdly, DISE can also be hampered by interobserver and intraobserver variability. A previous study showed that this variability seems to be less significant in experienced endoscopists. Therefore, to minimize the impact of these findings on how to perform DISE

At our center, DISE currently is performed in the supine position followed by assessment of the upper airway with the head rotated to the lateral position with and without jaw thrust. The results of this study suggest that this maneuver mimics the effect of the nonsupine sleeping position on upper airway patency, with the exception of the level of the oropharynx in NPP. This does not apply for PP. Although lateral head rotation alone is much more practical, the lateral head and trunk position in PP seem to be more representative for lateral sleep position.

Therefore, we suggest that in NPP, DISE should be performed in the supine sleeping position with and without lateral head rotation to mimic the nonsupine sleeping position. This allows the physician to evaluate the upper airway patency in both positions. We believe that this maneuver can be of added value in case combination therapy with OAT + PT is considered or to evaluate possibilities to perform less aggressive forms of upper airway surgery when combined with PT.

In PP, we recommend that DISE is performed in both the supine position and lateral head and trunk rotation to gain more sufficient information on the upper airway collapse patterns in the nonsupine sleeping position.

CONCLUSION

The effect of lateral head rotation and lateral head and trunk rotation on upper airway patency during DISE is significantly different in PP. In NPP, similar results were found at the level of the velum, tongue base, and epiglottis. In NPP, lateral head rotation only seems sufficient to mimic the nonsupine sleeping position. In PP, we recommend that DISE is performed in both the lateral head and trunk position.

Clinical Relevance

Currently, the effect of body position, either head or head and trunk, on disease severity is gaining renewed attention. In addition, PT is becoming a more accepted treatment in PP as a standalone treatment or in combination with other treatment modalities. Historically, recommendations were to perform DISE in the WSP, which is usually the supine position. But especially in PP, in which OSA severity is influenced by body position, lateral assessment of the upper airway is just as important as assessment of the supine position during DISE. For example, when PP tolerate PT, less aggressive forms of upper airway surgery can be applied.

Although it is clear that lateral assessment of the upper airway is of added value in PP, it must be kept in mind that not meeting Cartwright’s criteria for position dependency does not necessarily mean that OSA severity in NPP cannot be influenced by sleeping position. Therefore, it is believed that lateral assessment of the upper airway in NPP can still be of added value.

Impact of these findings on how to perform DISE

At our center, DISE currently is performed in the supine position followed by assessment of the upper airway with the head rotated to the lateral position with and without jaw thrust. The results of this study suggest that this maneuver mimics the effect of the nonsupine sleeping position on upper airway patency, with the exception of the level of the oropharynx in NPP. This does not apply for PP. Although lateral head rotation alone is much more practical, the lateral head and trunk position

Acknowledgments

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

BIBLIOGRAPHY


