REVIEW ARTICLE

The effect of body posture on sleep-related breathing disorders: facts and therapeutic implications

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The aggravating effect of the supine body position on breathing abnormalities during sleep was recognized from the earliest studies on sleep breathing disorders. Most of the anatomical and physiological correlates of this phenomenon appear to be due to the effect of gravity on the upper airway. Although few articles have been published on this topic, it has been shown in a large population of obstructive sleep apnoea (OSA) patients that more than half of them are Positional Patients, i.e. they have at least twice as many apnoeas/hypopnoeas during sleep in the supine posture as in the lateral position. This positional phenomenon is influenced by factors such as Respiratory Disturbances Index (RDI), Body Mass Index (BMI), age and sleep stages. The sleep supine posture not only increases the frequency of the abnormal breathing events but also their severity. This sleep posture also has a detrimental effect on snoring, as well as on the optimal CPAP pressure.

Positional Therapy, i.e. the avoidance of the supine posture during sleep, is a simple behavioural therapy for many mild to moderate OSA patients. Unfortunately, only a few studies, including only a few patients, have investigated this form of therapy. Although the results of these studies are promising, the lack of a reliable long-term evaluation of its efficacy is perhaps an important reason why this form of therapy has not been widely accepted. Since mild to moderate OSA patients are the majority of the OSA patients and since without treatment, a large percentage of them will develop a more severe form of the disease, a thorough evaluation with a major emphasis on the long-term effectiveness of this form of therapy is urgently needed.

Key words: positional therapy, sleep body position, sleep posture, supine, obstructive sleep apnoea treatment, behavioural therapy, sleep disorders

Introduction

Without question, the spouses of habitual snorers and obstructive sleep apnoea (OSA) patients were probably the first to identify the effect of body position on these breathing abnormalities many years ago. Indeed, a short letter was sent by a physician to the Editor of Chest in 1984 [1], and a member of the Editorial Board who received this
letter noted that “the contents of this letter may well prove to be useful for family
harmony.” The letter was published under the title “Patient’s wife cures his snoring”
and is a confirmation of the above statement. In this letter she wrote:

“In regard to my husband’s sleep apnoea—snoring problem, after we talked to
you, I invented a method to prevent my husband from sleeping on his back. I
sewed a pocket into the back of a T-shirt and inserted a hollow, lightweight plastic
ball (about the size of a tennis ball). I fastened one side of the pocket with safety
pins so that the ball can be removed to launder the shirt. It’s working beautifully.
In about two days, I could see a vast improvement in his energy level, alertness,
and interest in life. He no longer falls asleep while sitting straight up in a chair,
and the quiet, snoreless nights are great. I thought that this information might
be helpful to other patients with similar problems.”

Moreover, when one asks the spouses of habitual snorers and OSA patients about
the possible effect of body position on these sleep-related breathing disturbances, it is
quite common to hear some of the following descriptions: “Doctor!! My husband
snores so loudly when he sleeps on his back that I am sure that the snores are heard
by our neighbours” or “At the beginning he used to snore only when he slept on his
back, but now he snores, and snores loudly, in all body positions, and when he sleeps
on his back he seems to have breathing pauses lasting a few seconds”. All these
descriptions suggest that body position plays an important role in breathing functions
during sleep.

**Historical background**

In one of the first articles published on breathing abnormalities during sleep, Gastaut
*et al.*, in 1966 [2] already mentioned the aggravating effect of the supine posture on
sleep apnoea.

They thoroughly investigated a classical Pickwickian Syndrome patient with diurnal
and nocturnal polygraphic recordings. This very informative clinical study in one
patient (more than 30 years ago) described, in a very accurate way, most of what we
know today about OSA patients. In Figure 6 of their article, they showed the aggravating
effect of the supine position on oxyhaemoglobin desaturation during apnoic episodes
and verified an improvement by the adoption of the prone posture.

Thus, the effect of body position on breathing disturbances during sleep was already
described in one of the first articles on breathing disorders during sleep.

**Body posture effect on breathing function during sleep**

*Definitions and methodological aspects*

When we discuss the effect of body posture on sleep-related breathing abnormalities,
we refer mainly to the worsening effect of the supine posture on these abnormalities
and how the lateral, prone or sitting positions produce, in most of the cases, a significant
improvement and in some cases even a total elimination of these disturbances. Second,
we need to differentiate between the effect of body position on breathing function
during the awake state and during sleep. Third, we should distinguish between the
data from normal subjects and the data obtained from OSA and non-OSA snoring patients. It should be also mentioned that one limitation of most of the research in this topic is the lack of consideration of the head/neck position on the occurrence and severity of breathing abnormalities during sleep. Finally, we should remember that this discussion is based on data only from an adult population and, therefore, the conclusions should not be extrapolated to the effect of body position on breathing function during sleep in infants or children.

Without question the contribution to this topic of R. Cartwright and co-workers has been crucial and they deserve much of the credit for their investigations in this field. In her first article in 1984, Cartwright [3] defined Positional Patients (PP) as those OSA patients in whom the Respiratory Disturbances Index (RDI) or the Apnoea-Hypopnoea Index (AHI) was at least twice as high while sleeping in the supine position as in the lateral position. Those cases in which the RDI in the supine position was less than twice that in the lateral position were called Non-Positional Patients (NPP). These were arbitrary definitions that have been used by most, but not all [4] authors who have investigated this topic. The Standards of Practice [5] recommendation requires monitoring of body position in polysomnographic (PSG) studies, but it appears that not all Sleep Disorders Units record and analyse their breathing abnormalities data, including RDI, according to body position. A PSG without recording the body position changes or without having the patient sleep in the supine and lateral posture will in some cases miss an accurate diagnosis that may have important therapeutic implications. As we stated previously [6], the estimation of the results of any surgical or other intervention procedure for treating OSA patients will not be precise, without taking into account the sleep time spent or not spent in the supine posture in the pre- and post-intervention PSG evaluation. An inexplicable worsening after any type of OSA surgery in a positional OSA patient might not be necessarily related to a real
failure of the surgery, but only to a significantly longer supine sleep time in the post-
intervention PSG compared to the supine sleep time in the pre-surgery PSG evaluation. On the other hand, an apparent improvement of the sleep apnoea severity by using a new oral device, for example, could be partially or entirely related to the fact that in the first PSG without the device, the supine sleep time was significantly longer than that in the PSG evaluation with the device. Thus, these types of false positive or false negative results could eventually cause erroneous conclusions as to the real effectiveness of that particular intervention procedure. The crucial issue is that, for positional OSA patients, the severity of the disease is related mainly to the sleep time spent or not spent in the supine posture. On a night in which most of the sleep time is spent supine, the total RDI will probably reach values of severity of a moderate to severe degree. On the other hand, on a night spent sleeping in the lateral postures for most of the night, the total RDI most probably will not reach even the minimal threshold for the disease.

It should be also emphasized that PI? differ from NPP mainly in the severity level of the lateral RDI. In other words, both type of patients will have a similar RDI in the supine posture, but in the lateral position the positional patients will be free or almost free of breathing abnormalities while the non-positional patients will still show a RDI similar to that in the back posture. Moreover, there is already some evidence in NPP suggesting that interventions that produce an improvement in the severity of OSA such as losing weight [6], using a tongue-retaining device [7], or surgical procedures such as uvulopalatopharyngoplasty (UPPP) [8], will produce a much greater decrease in the lateral RDI than in the back RDI.

Practice Points

1. The recording of body position should always be included in the diagnostic evaluation of sleep-related breathing disorders.

2. During the diagnostic evaluation, sufficient sleep time in the supine and lateral postures are necessary to avoid an inaccurate diagnosis.

3. When you evaluate any treatment procedure on sleep breathing disorders, be sure to evaluate the supine sleep time before and after the treatment in order to avoid erroneous conclusions. The analysis of the data should include RDI according to body positions.

4. For positional OSA patients the severity of the disease is related mainly to the sleep time spent or not spent in the supine posture.

Prevalence of positional OSA patients

The prevalence of PP within an OSA population varies in different reports from 9–60% [3,4,6,9,10–13]. This variation is probably due to the small numbers of patients and the different types of OSA patients studied. Cartwright in 1984 [3] published the first paper describing the posture effect on the severity of sleep apnoea and showed that 14 (58.3%) of 24 OSA patients had an AHI at least twice as high while they slept in the back posture as compared to when they slept in the lateral position. Eight (33.3%) of these patients would have been considered in the normal range (AHI ≤10) if they had slept only in the lateral posture. We recently confirmed Cartwright’s data in a large unselected OSA population (574 consecutive patients) diagnosed in our sleep unit [6], and found that 55.9% of the patients were positional. In other words, PP
represent the majority of the OSA patients. In a later part of this article we will discuss the factors that determine the prevalence of positional OSA patients.

**Mechanisms**

Although several studies have shown a marked improvement in breathing function by avoiding the supine posture during sleep, the anatomical and physiological mechanisms responsible for this phenomenon have not yet been sufficiently clarified.

**The supine gravity effect**

The effect of gravity on the upper airway (UA) when adopting the supine posture is most probably the most dominant factor responsible for the anatomical and physiological changes observed in this posture.

**Anatomical correlates.** Several techniques such as the acoustic reflection technique (ART), cephalometry, conventional and fast computerized tomography (CT) and magnetic resonance imaging have been used to evaluate the UA in OSA patients. Unfortunately most data have been obtained during the awake state.

**Awake data.** By using the ART, Brown et al. [14], found a decrease in the pharyngeal area when OSA and snoring patients changed from sitting to the supine posture. Yildrim et al. [15], using lateral cephalometry, studied the effect of body posture on airway dimensions in normal subjects and OSA patients. In both groups uvular width was increased and a widening of the retroglossal airway was seen by adopting the supine posture. Only in OSA patients, however, was the widening of the uvula associated with narrowing of the retropalatal airway. In comparison with normal subjects, OSA patients had significantly longer and wider uvulas with a tendency to have a shorter distance between the uvular protrusion and pharyngeal wall. In normal subjects, Jan et al. [16], also using the ART, showed that even though the pharyngeal areas were smaller in the supine than in the sitting position, no differences were found between the lateral and supine postures. In normals, snorers and OSA patients and using the same methodology, Martin et al. [17], found that, although in the seated position OSA patients had smaller UA cross-sectional areas than normals and snorers, no difference between the groups were observed in the mean and minimal pharyngeal cross-sectional area in the lateral and supine posture. Compared with normals subjects and snorers, OSA patients had smaller decreases in the oropharyngeal junction area when changing from sitting to either supine or lateral postures, suggesting that OSA patients had to defend their UA upon lying down more than snorers and normal subjects. Supporting this notion, using lateral cephalograms, it was shown recently [18] that OSA patients maintain the upright tongue posture when moving from upright to the supine posture in contrast to non-apnoeic snorers who had significant dorsal movement of the superior-posterior portion of the tongue. This suggests that OSA patients, at least in the awake state, may tend to protect themselves against UA collapse secondary to the increased gravitational load on the tongue.

**Sleep data.** Only a few studies have investigated the UA dimensions during sleep, and unfortunately, studies comparing the pharyngeal cross-sectional areas in the lateral versus supine position in OSA patients during sleep are lacking and are urgently needed.
Shepard et al. [19], using intra-oesophageal pressure measurements during sleep, found in most of the OSA patients, that the site and extent of the UA collapse were similar in the supine and lateral position independent of the sleep stage. This suggests that although body position plays an important role in determining whether or not UA collapse occurs, when it does, the anatomical location and the extent of the collapse is similar in both postures.

**Positional (PP) versus Non-positional (NPP) OSA patients.** Two studies, and only during the awake state, have examined the anatomical changes in the UA in a PP group and compared them to either unselected OSA patients or to a NPP group.

Kovacevic-Ristanovic et al. [20], found that the PP group had a significantly larger posterior airway space, a less elongated soft palate and somewhat more prominent retrognathia than unselected OSA patients. In an excellent study, using fast-CT, Pevernagie et al. [21], have described the differences in the size and shape of the UA in PP ($n = 6$) and NPP ($n = 5$) patients while awake. The differences were found mainly in the velopharyngeal segment of the UA (the retropalatal area) where the minimal cross-sectional area (MCA) is normally located. The size of the UA at this level was significantly different in the two groups. The MCA of the PP group was almost twice that of the NPP group in both the supine and right lateral positions. The UA shapes of the two groups were also different—elliptical (with the long axis oriented laterally) in the PP group, and circular in the NPP group. The differences in shape were predominantly due to the significantly greater lateral UA diameter in the PP group. The antero-posterior (A-P) dimensions of the UA were no different in the two groups. These data suggest that during sleep in the supine position, both PP and NPP patients will have breathing abnormalities due mainly to the gravity effect on the UA soft tissues which reduces the A-P diameter significantly. When the PP group adopts the lateral position, the A-P diameter is increased, and since the lateral walls are far enough apart, sufficient airway space is preserved to avoid a complete collapse of the UA. In the NPP group, changing to the lateral position will still cause pharyngeal collapse since the lateral diameter in these patients is not sufficiently large to prevent it.

Unfortunately, these interesting data refer to the awake state. No data exist on the anatomical changes of the UA during sleep in these two OSA patients groups.

The upper airway shape data provided by these authors are interesting especially in the light of a recent report by Leiter [22], who suggests that consideration of the shape of the UA in addition to its size and the activity of the pharyngeal muscles, will allow a better understanding of the pathogenesis of OSA. Other authors [23], have found that some OSA patients have an elliptical shape of the pharynx orientated in the A-P dimension, which will more easily cause the collapse of the lateral walls (the collapsible segments of the pharynx). These OSA patients are probably the typical severe NPP who have breathing abnormalities in all body postures. However, as Pevernagie et al. described [21], there is another important group of OSA patients (PP) with their UA elliptical shape oriented in the lateral axis, which allows them to sleep in the lateral posture without causing the collapse of the airway.

**Physiological correlates**

By measuring supraglottic pressure and airflow at the nose, Anch et al. [24], demonstrated that the airflow impedance of the supraglottic airway while awake is greater in normal subjects when adopting the supine posture and even three to four times greater than normal in OSA patients. These results are consistent with the greater
narrowing of the UA in USA patients and suggest that sleep and posture may work synergistically to compromise the UA in USA patients. This study and others [25] demonstrate also that by adopting the supine position one major physiological change occurs: an increase in the UA resistance. The direct consequence of this is that breathing during sleep becomes more difficult, increasing the occurrence of episodes of partial UA obstruction (manifested as snoring and/or hypopnoeas) or complete UA obstruction (manifested as apnoeas). Lung volumes decrease during sleep [26] and also by assuming the supine posture [27], this decrease in lung volume also produces a narrower upper airway which will again increase the UA resistance. Douglas and co-workers in several studies [28–30] investigated the effect of body posture on the activity of different UA muscles in the awake state. These studies demonstrated that UA muscles show respiratory activity and are activated by negative UA pressure, but only the genioglossus activity is modulated by body posture. Both peak inspiratory and tonic expiratory genioglossal activity are greater in the supine posture in normal and OSA patients. This increase in genioglossal activity is probably needed to defend the airway and prevent the pharyngeal collapse [31] but since the activity of this muscle is decreased in sleep, the shape of the UA may again be a critical factor in determining the pharyngeal patency in different body postures.

Factors influencing the positional dependency

The effect of RDI on positional dependency

We recently [6] investigated the effect of OSA severity, expressed by RDI, on the distribution of PP and NPP OSA patients. Our data showed that RDI has a major effect on positionality. Five hundred and seventy four adult OSA patients were divided into four different RDI categories (10–19.9, 20–29.9, 30–39.9–39.9, ≥40) and the prevalence of PP and NPP in each category was calculated. But before that, since the sleep time spent in the supine position is a major factor correlating with RDI, we evaluated the sleep time in the supine position for the four RDI categories in a random sample of 20 patients in each group. No significant differences for sleep time in the supine position was found between the two groups, P=0.35). The mean sleep time spent (min ± SD) in the supine position for the four RDI categories was: 131.0 ± 72.1, 165.4 ± 95.8, 148.2 ± 82.6, and 174.4 ± 81.4 minutes respectively.

The PP prevalence remained high and fairly steady (between 65.1% and 69.0%) in the mild–moderate categories, but showed a marked and significant reduction to 32.4% in the most severe category. Although a positive trend towards an inverse relationship was obtained, this result suggests that rather than an overall inverse relationship with positional dependency, RDI showed a threshold effect on it. A test for the identification of the threshold revealed that the RDI threshold point, which maximized the chi-square test for the positional dependency, was an RDI of 40. A univariate and multivariate stepwise logistic regression analysis of the data demonstrated that RDI was the most dominant factor that could predict the positional dependency phenomenon. Thus, an OSA patient with a severe RDI is less likely to be positional than an OSA patient with a mild to moderate RDI.

Based on these results and the already described physiological effects of adopting the supine posture, we suggest [6] that the supine posture during sleep could be a major contributing factor to the Upper Airway Resistance Syndrome (UARS) [32] which
appears to be the mildest form of UA disturbance during sleep, occurring even in non-snoring sleepy patients. Perhaps avoiding the sleep supine posture may represent a simple and effective therapy for the majority of these patients. This needs to be proven.

**The effect of BMI on positional dependency**

In the same study [6] we also evaluated the correlation of BMI with positional dependency in OSA patients. The entire group was first divided into five different BMI categories (20–24.9, 25–29.9, 30–34.9, 35–39.9 and ≥ 40) and the percentage of PP in each category was calculated. A steady, marked, and significant reduction was observed in the prevalence of PP with the increase in BMI in the five categories: 70.5%; 67.6%; 46.3%; 34.8%; and 33.3%, respectively. Thus, BMI showed an inverse relationship to positional dependency. A non-obese OSA patient is more likely to be positional than an obese one and the prevalence of PP in a OSA population will decrease as the mean BMI increases and vice versa. We also investigated the effect of weight loss on positional dependency in four severe OSA patients who refused nasal continuous positive airway pressure (nCPAP) treatment but successfully lost weight by changing their eating habits. Three important findings were observed from the data of these patients: In all four patients the lateral RDI fell (mean reduction 91.1%) to the so called “normal level” (RDI <10); the supine RDI remained high (only a 38.9% reduction) even after weight loss, and the three patients who were non-positional became positional after losing weight.

**The effect of age on positional dependency**

We also evaluated in this study [6] the effect that age may have on positional dependency in OSA patients. The prevalence of PP and NPP in three different age categories was first calculated. The two youngest categories (age 20–39.9 and 40–59.9) showed an equal prevalence of PP (59.2%) while in the 60+ group the PP prevalence decreased to 48.6%. These differences were found to be only of borderline statistical significance but when the entire group was divided into a Younger (age ≤ 60) and Older (age >60) group, the difference between the groups (59.2% compared with 48.6%, respectively) reached statistical significance.

Thus, age is a much weaker contributing factor than the previous two factors for positional dependency, but older OSA patients are still less likely to be positional than younger ones.

It should be noted that this investigation was carried out in a group of adult OSA patients (>18 years old). Thus, the conclusions reached in this research are limited to this age group. But positional effects may be important in OSA in children as well [33]. During recent years many articles related to the effect of body posture on sudden infant death syndrome (SIDS) have been published [34]. The general conclusion of all these publications is that changing the baby’s position from the well-known prone position to the lateral or, even better, to the supine posture during sleep, has resulted in a dramatic decrease in the incidence of SIDS cases in many countries. These results are probably due to the lightening of sleep in this supine posture (25% less quiet sleep) partially associated with an increase in the number of arousals (40% more than in the
prone position) [35]. Clearly this topic has tremendously important implications on health in the community. It is too early to know what the effect of the supine posture during sleep will have on the breathing function and general health and development of these babies.

**The effect of sleep stage on positional dependency**

George et al. [11], examined the effect of sleep stages on the body posture effect in 11 polysomnograms of seven grossly obese and severe OSA patients. They concluded that AI is higher in the back posture than in the lateral posture only in NREM sleep and that the duration of apnoeas are longer during REM sleep regardless of the body position. Their conclusions were criticized by others [36] who argued that their data do not support these conclusions mainly due to the small number of patients (only five patients had REM sleep on their back). Nevertheless, as George et al. themselves pointed out, the marked obesity and severity of their OSA patients appear to be important factors which contributed to their results and they stated: “It is therefore the less obese and the less severe patients that will likely benefit by sleeping on the side.” In 24 OSA patients Cartwright and Lloyd [37] concluded that although the AHI is higher in REM versus NREM sleep, the back side differences are similar for those two sleep types. On the other hand, Pevernagie and Shepard [4] investigating this and other issues in 31 OSA patients who had enough data in both sleep stages and body postures, found that nine (41%) of the 22 patients with a positional effect in NREM sleep lost this effect during REM sleep. Thus, it appears that the positional effect is clear in NREM sleep but some patients lose their positionality while in REM sleep. Body weight and the total severity of the disease seem to play a critical role in this interaction.

**Positional dependency—the natural development of sleep related breathing disorders**

As was discussed previously [6], if mild–moderate OSA patients are mainly positional, it could also mean that “positionality” is a characteristic of the natural development of the OSA entity and as the severity increases (as occurs with increase in weight), the PP is converted into a NPP. The reverse is also true and this was demonstrated in those obese patients who after losing weight were converted from NPP into PP. With this reasoning in mind, it is also possible that alcohol intake and sleep deprivation could convert a PP into a NPP, but this has to be proven. A similar parallelism appears to exist in the natural development of snoring. The spouse/partner of a typical snorer patient usually tells us that: “at the beginning, he/she snored only when sleeping on the back but lately (after gaining weight) this occurs on the sides as well.” Since UARS appears to be the mildest form of sleep related breathing disorders, this notion also gives support to the suggestion that the sleep supine posture is perhaps a major contributing factor to UARS.

**The effect of sleep body posture on the severity of breathing abnormality events**

Most of the publications relating to the effect of body posture on sleep apnoea have suggested that sleeping in the supine posture produces an augmentation of the severity
of sleep apnoea. However, in most of the studies the severity has been expressed as an increase in the number of breathing abnormalities per hour of sleep. This is certainly an important expression of severity but it is not the only one. Another way of assessing severity would be to find out if the apnoea and/or hypopnoea event themselves are more severe when they occur in the supine compared to the lateral position. Although only few data related to this topic have been published, even back in 1978, Harper and Sauerland [38], while studying the role of the tongue in sleep apnoea, described a 52 year-old obese OSA patient in whom the supine posture produced longer and more severe apnoeas. Similar cases have been reported by others [39,40].

We recently evaluated the severity of apnoeas occurring in the supine versus lateral posture in 30 severe, non-positional OSA patients (in preparation). The polysomnograms of 30 OSA NPP were reanalysed and 30 apnoeas in the supine posture and 30 apnoeas in the lateral posture during sleep stage 2 were evaluated for the following parameters: length; minimum oxygen desaturation; delta oxygen desaturation; length and occurrence of arousals; snoring loudness; and delta brady/tachycardia. Each of the above parameters showed that apnoeas in the supine posture were significantly more severe than those occurring in the lateral posture. Thus, even for non-positional OSA patients, the supine posture aggravates the breathing abnormalities during sleep.

The effect of body posture on snoring

As discussed in an excellent review by Hoffstein [41], the research on snoring is based mainly on subjective reports and a validated standard method for the measurement of snoring is lacking. Although some anecdotal reports have mentioned that snowing for some patients appears to be louder and more frequent in the back posture compared to the side, not much objective data exists on this issue. In 20 asymptomatic male snorers, Braver and Block [13] reported that the frequency of snoring did not change significantly when the patient assumed the lateral position compared to the supine posture. No data on snoring loudness was provided.

In a recent study (in preparation) we investigated the effect of body position, sleep stages and sleep cycles on snoring and the arousals caused by it in a group of 15 continuous snorers.

The major effects of body posture on snoring parameters were the following:

1. There was a large inter-subject variability for all snoring parameters (described below) in these continuous snorers patients.
2. SI (Snoring Index), the total number of snores/sleep hour was significantly higher in the supine posture than in the left and right postures as a whole and when the comparison was evaluated for the Stage 2 and REM sleep but not for SWS.
3. NSA (the number of snores that produce arousals) was significantly higher in the supine posture than in the left and right postures, but only during Stage 2.
4. As a whole, the ASI (the arousal snore index or the number of snores that produce arousal/sleep hour), was significantly higher in the supine posture than in the lateral ones. However these differences were not significant when the comparison was evaluated for each sleep stage independently.
5. The percentage of snores causing arousal/sleep hour (PSA) did not reach statistical significance between the different body positions as a whole and also when the comparisons were carried out taking each sleep stage independently.

These data demonstrate that in continuous snoring patients the supine posture has a general detrimental effect on snoring and on the arousals from it, but the inter-patient data variability as well as the effect of sleep stages on the different parameters of snoring are considerable.

**The effect of body posture on CPAP pressure**

Again, only a few studies have addressed this issue. Pevernagie and Shepard [4] in a retrospective study of 100 OSA patients, compared the optimal CPAP (OpCPAP) pressure (the pressure that eliminated sleep-disordered breathing events and snoring in the supine position) in 79 patients who had enough data for the analysis. The 49 (62%) PP had a significantly lower OpCPAP pressure (8.0 ± 2.2) than the 30 (38%) NPP (9.1 ± 1.8). This difference between PP and NPP was significant but small. This is not surprising since the AHI in the back posture was similar for both groups of patients. Unfortunately, not enough data was available for the comparison of the OpCPAP pressure in the lateral posture. They also found a significant correlation between the OpCPAP level and the AHI in NREM sleep for the entire group.

In another study in our unit (in preparation) we evaluated the impact that body position has on the OpCPAP (the minimal pressure that overcomes the breathing abnormalities, desaturations and arousals related to them and eliminated snoring in most of the cases), and how REM-NREM sleep, BMI, RDI and Age are related to this effect. Data of 60 patients who spent at least 30 min of sleep in either the supine (Sup) and the lateral (Lat) position and data of 45 patients who have also data during REM and NREM sleep were analysed. The mean OpCPAP was significantly higher in the Sup (10.00 ± 2.20) than in the Lat posture (7.61 ± 2.69). In most, 52 (86.7%) of the patients, the OpCPAP was obtained when the patient slept in the supine posture. The OpCPAP was higher in the supine posture in both REM and NREM sleep and presents the following sequence: Sup REM>Sup NREM>Lat REM>Lat NREM. Patients with higher BMI required higher OpCPAP but there also the effect of body posture was dominant and showed the following sequence: Sup Obese (BMI>40)>Sup NonObese (BMI<40)>Lat Obese>Lat NonObese. The OpCPAP was highest in the most severe RDI group (RDI ≥ 40) than in the less severe group (RDI<40), but again in both groups, the OpCPAP values were higher in the supine than the lateral position. No significant differences were seen between the two age groups (younger and older than 60 years old) but in both groups the OpCPAP values were higher in the supine than the lateral position.

Thus, the supine posture is a dominant component for the adequate titration of OpCPAP. This is true for REM and NREM sleep, for obese and non-obese patients, for young and old OSA patients and for OSA patients with different degree of severity. No titration for the OpCPAP should be considered adequate without the patient having slept in the supine posture and during REM sleep. By demonstrating that the OpCPAP varies for different body postures and sleep stages, these results give support for the use of the Smart CPAP machines that dynamically provide the OpCPAP according to the needs of the OSA patient.
In a recent important study, Neil et al. [42] compared the upper airway closing pressure (UACP)—the mean of the minimum pressures generated in the last two breaths before an arousal occurred in a nasal occlusion test—and the upper airway opening pressure (UAOP) and the minimal CPAP level required to prevent apnoeas and hypopnoeas in 8 male, obese and severe OSA patients in three postures (supine, supine elevated to 30° and lateral) during NREM sleep. They found that the upper airway became less collapsable (reduced UACP) and more easy to open (reduced UAOP) in the 30° elevated posture compared with the supine sleep posture. Compared to the supine posture, the lateral posture had a similar UACP but did allow the upper airway to open more easily (reduced UAOP). Both the elevation and lateral positioning produced a reduction of about 50% in the therapeutic CPAP pressure compared to the supine posture. This study and the previous one from the same group [43] confirms also our clinical impression that, for the most severe OSA patients, especially in those with the overlap syndrome, the best posture for sleeping, until CPAP or BIPAP is instituted, is in the reclining sitting position which allows the UA to be more stable and less prone to collapse. However, this sitting position should be used by these types of patients only for short periods since long-term use may cause orthostatic oedema.

The eight patients in the above study were obese and severe OSA patients and six were found to be non-positional patients. It would be of interest to carry out a similar study using the same protocol but investigating only positional OSA patients. It would be expected that in this population, the adoption of the lateral posture would demonstrate a significant improvement in UACP. Issa and Sullivan [44], described three OSA patients in whom the UACP was significantly lower in the supine posture compared to the lateral position in all sleep stages. Although details of the weight and severity of these patients was not provided, it appears that they were less obese than the patients of Neil et al., and so it is probable that they were positional OSA patients, which would explain the differences in the results.

Sleep body posture and daytime sleepiness

Although there are a few reports claiming subjective improvement in daytime alertness after avoiding the supine posture during sleep, we found only one study describing effects of positional therapy on daytime sleepiness using objective measurements. Klimaszewski et al. [45], in a short report, compared 2 weeks of positional therapy to 2 weeks of CPAP in 10 mildly obese positional OSA patients. With the CPAP treatment, the RDI was lower than for positional therapy (2.8 vs 8.1) and the minimum overnight oxygen saturation was higher (89 vs 85%). However there were no objective differences in sleep architecture, total sleep time, Epworth Sleepiness Scale scores, Maintenance of Wakefulness Test, sleep latencies, psychometric test performance, mood scales or quality of life measurements between the two groups. Interestingly, at the end of the study, 50% of the patients preferred nCPAP, 30% position therapy and 20% had no preference.

We have recently shown [6] in a large number of OSA patients that PP were subjectively less sleepy (fewer patients complained of excessive daytime sleepiness) compared to non-positional patients and this was corroborated by objective measurements (MSLT).
Body position and sleep apnoea

Avoiding the sleep supine posture and blood pressure

In several articles we have discussed and argued that sleep related breathing disorders are most probably the major contributing factor for the development of essential hypertension [46]. If this is so, the effective treatment of these disorders should improve blood pressure (BP) values. Several studies have already demonstrated that CPAP treatment reduces blood pressure. We [47] recently investigated the effect of avoiding the supine position during sleep for a one-month period on 24-h blood pressure (BP) in 13 positional OSA patients. In all the patients (hypertensives and normotensives) there was a reduction in the 24-h mean BP values. A significant reduction was observed for the mean 24 h, the mean awake BP and the mean asleep BP (see Fig. 2). BP variability and BP load also fell significantly. Since the majority of OSA patients have supine-related breathing abnormalities and since about a third of all hypertensive patients have OSA, avoiding the supine position during sleep, if confirmed by future larger studies, could become a new non-pharmacological form of treatment for many hypertensive patients.

Supine sleep time: laboratory versus home data

Some authors have claimed that due to the electrodes and other sensors attached to the patients during PSG evaluations, they spend much more time in the supine posture than they do naturally at home. If this is true, this may result in an erroneous conclusion about the severity of OSA in positional patients. A confirmation of this notion was provided by Metersky and Castriotta [48], who found in 12 positional mild–moderate OSA patients, that the time spent in the supine position when the patients were having a standard PSG was 56% more than it was on two additional nights in the laboratory but with no PSG leads attached to the patients (non-PSG nights). Since both their self-reported quality of sleep and estimated hours of sleep suggested that the subjects slept better in the non-PSG night, they concluded that the subjects slept better in the non-

Practice Points

1. Positional patients (PP) are on the average thinner and younger than non-positional patients (NPP). They had fewer and less severe breathing abnormalities than NPP, their nocturnal sleep quality is better preserved and accordingly they are less sleepy during daytime hours.

2. Obese, severe OSA patients are in general NPP. If they are not compliant with CPAP treatment, losing weight may convert them into PP and avoiding the sleep supine posture may then represent a valuable therapy for them.

3. Positional therapy improves snoring and the arousals caused by it, mainly in supine snoring patients, but since many patients continue to snore in the lateral posture, this is usually not a radical solution for snoring.

4. An adequate CPAP titration should always include the evaluation of the patient in the supine posture during REM sleep.
Figure 2 Graphic demonstration of the effect of avoiding the supine posture during sleep for a 1-month period on 24 h (left), awake (middle) and sleep (right) systolic (●) and diastolic (○) blood pressure in 13 OSA patients. (*P = 0.001; †P = 0.022; ‡P = 0.006; §P = 0.002; NS = non-significant. Values are mean ± SD). (Reproduced from Berger et al., J Human Hypertens 1997; 11: 657–664.)

PSG night, they concluded that standard PSG may overestimate the severity of OSA in some positional patients. Their conclusions are most probably correct, but it should be clarified that the above data refer to total time in the supine posture (awake + sleep) and no data on the supine sleep time (the important supine time) was provided for the non-PSG nights. They also found that during PSG recordings, the time spent in the prone position was significantly reduced, an observation that is probably common to most sleep disorders units. An investigation of the effect of the prone position on the occurrence and severity of breathing abnormalities was not performed. Hartse et al. [49] found in 16 consecutive OSA patients low percentages (10.4%) of supine sleep time at home compared to that time during PSG evaluation (60.8%) and suggested that home monitoring may not produce an accurate diagnosis in positional patients due to this small supine sleep time. On the other hand, Nau et al. [50] in two samples of 25 patients found that about one half of the total recording time at home was spent in the supine posture and concluded that supine sleep time at home is adequate to provide a diagnosis of positional apnoea.

Thus, although there is still insufficient and contradictory data on this issue, it seems that some patients spent more time supine in the lab than they do at home. For positional patients this may cause an overestimation of the severity of OSA.
Sleep body posture: central versus obstructive breathing events

Since obstructive events are the most dominant type of sleep-related breathing abnormalities, most of the studies that describe the effect of body position during sleep refer to these obstructive events. Nevertheless, although based on only a few reports, the body position effect also appears to affect breathing disturbances of the central type, or with a central component in it. Smith and Fortin [39] reported one patient who had central and mixed apnoeas mainly in the supine posture and the mean apnoea duration in the lateral position was shorter than the mean apnoea duration in the back position (14.6 vs 25.9 s, respectively). Issa and Sullivan [51] successfully treated with CPAP eight patients with predominantly central apnoeas. Five patients had obstructive episodes in the lateral posture. CPAP abolished these events, but when they turned to the supine posture, in all patients, irrespective of the sleep stage, within 1 to 3 min, central and/or mixed apnoeas appeared. A higher CPAP pressure was needed to eliminate all type of apnoeas in the supine posture. They suggested that in the supine posture the collapse of the UA structures reflexly caused inhibition of inspiratory efforts.

We described the effect of body position in a 61-year-old female CVA patient with Cheyne-Stokes Breathing (CSB) (in preparation). Two complete PSGs and four overnight pulse oximetry (PO) recordings together with the simultaneous recording of the body posture were performed. The first PSG, two months post-stroke, revealed a severe, continuous and clear CSB pattern during NREM sleep (mainly with central apnoeas) and OSA during REM sleep, independent of body position (Sup RDI = 85.2, Lat RDI = 95.4). The second PSG three months later, after an overall clinical improvement, revealed a complete disappearance of breathing abnormalities in her lateral posture (Lat RDI = 0) but only a slight improvement in her back posture (Sup RDI = 73.2). The CSB was now less severe and characterized mainly by central hypopnoeas. Two PO recordings between both PSGs showed similar improvement trends. Two additional PO recordings after the last PSG revealed a more significant improvement. Thus, body posture appears to influence not only OSA but other types of sleep-related breathing abnormalities as well.

The effect of UA surgery on the positional effect

Katsantonis et al. [8] studied the effect of UPPP on the distribution of apnoeas and hypopnoeas according to body positions in 17 patients. The surgery resulted in a significant improvement of the AH1 only in the lateral posture and the best responders were those who had a big fall in the AH1 in the lateral position. The authors concluded that UPPP enhances the position effect on OSA and suggest positional therapy as an adjunct to it.

Most probably, the improvement in breathing function while lying in the lateral position observed after UPPP, is due to the enlargement of the posterior airway space in these patients, since a larger posterior airway space has been observed in PP than in NPP by both cephalometric [20] and fast-CT [21] studies.

These data also provide support for the concept that any manipulation which will produce an improvement in the severity of OSA, is first reflected by an improvement during sleep of breathing function in the lateral position. Our data on weight loss [6] also support this concept.
Positional therapy—avoiding the supine posture during sleep

Interventional studies

In 1982, two abstracts reported a marked improvement in OSA patients condition simply by shifting from the back to the side position during sleep [52,53]. Kavey et al. [53] mentioned, perhaps for the first time, the tennis ball technique as a method of avoiding the supine posture during sleep. They followed two of their three patients for 8 months and 2 years, respectively. At this time a marked reduction in the number of apnoeas was objectively seen. Cartwright et al. [54] used an alarm system to avoid the supine position in 10 moderately obese positional OSA patients. With the use of this device the average supine sleep time fell from 51.4% to 2.1% and the AHI fell from 54.7 to 21.4. Five of the eight patients in whom the initial total AHI was more than 10 achieved an AHI of 10 or less. Without the device but instructed to sleep only on the side for a 3-month period and tested afterwards, the supine sleep time fell from the initial 51.4% to 24.1% and five of the 10 patients had less than 10% of the total sleep time in the supine posture. Kavey et al. [10] reported data on two patients who used the tennis ball technique and on two others who were simply instructed to avoid the supine posture. An evaluation carried out 4 months to 3 years after starting this treatment showed a marked reduction in the supine sleep time, a reduction in A1 and a subjective improvement in daytime alertness. Thus, these two small studies suggest that it is possible for positional OSA patients, independent of whether a device is used or not, to learn to avoid the supine posture for a relatively long period of time.

Chaudhary et al. [55], instructed four positional OSA patients to avoid the supine posture without any device and followed three of them for 1, 2 and 3 years, respectively. All three improved their symptoms and two remained asymptomatic but there was no follow-up by a sleep study in any patient. Cartwright [56], used the alarm system continuously for 8 weeks in 20 OSA positional patients. All patients had less than 5 min of supine sleep on the night when the alarm device was used, but on a subsequent night without the alarm, only 11 patients (55%) had less than 5 min of supine sleep. In the other nine patients (45%), supine sleep time ranged from 11.5 to 172 min, and five of them (25% of the whole group) still slept for about 1–3 h in the supine posture. In a subsequent study [57], the same group reported a comparison of behavioural treatments used for 8 weeks, in four groups (15 patients each) of positional ASO patients. The groups were: (A) positional therapy alone with the alarm system; (B) the use of a tongue retaining device alone; (C) a combination of the above two; and (D) general health advice including the avoidance of the supine position. Twenty eight (93.3%) of the 30 patients (groups A + C) who used the alarm system had less than 6.5 min of total supine sleep time, but on a subsequent night without the alarm, only 17 (56.7%) patients had less than 5 min of supine sleep time and 6 (20%) had about 1–3 h of supine sleep time. In group D, 10 of the 15 patients (66.7%) had less than 16.5 min of supine sleep time, but 5 (33.3%) had supine sleep times ranging from 40 to 148.5 min.

It would appear from these two previous studies that about two-thirds of the patients will successfully learn to avoid the supine posture with or without the use of a device, but the other third of the patients will require the continuous use of some type of device in order to avoid effectively the supine position during sleep.

Freebeck and Steward [58,59], reported the use of a novel device to avoid the supine
posture in 20 positional OSA patients, consisting of a rectangular shaped foam material surrounding a hard cylindrical core and secured to the back of the patients with elastic straps. Ninety per cent of the patients reduced the supine sleep time to less than 5% of total sleep time by using the device. Eighty per cent of them reached an AHI of less than 5 events/h and an improvement in the minimal oxygen desaturation was also observed. In a subsequent study the device was then given to 18 patients for 6 weeks and 17 complied. Thereafter they were retested at home using position sensors when not wearing the device. Fifteen of the 17 (89.4%) reduced the supine sleep time to less than 10% of total sleep time. By wearing the device only once per week for an additional 6-week period, 71% of the patients were able to maintain less than 10% supine sleep time when not wearing the device. Thus, this encouraging short study, as the previous one, suggests that after a relatively short learning period, about two-thirds of the OSA patients learned to reduce supine sleep time to less than 10% of total sleep time without the use of the device.

Hurry et al. [60] reported the use of two tennis balls in nine overweight positional OSA patients. After three nights of using the tennis balls, the percentage of sleep time spent in the supine position had dropped from 34.96 to 3.79%. The next day however, when the patients slept without the balls, the sleep time spent supine increased to 16.57%.

Thus, the previous studies suggest that by using any device for avoiding the supine posture during sleep, supine sleep time is practically eradicated, whereas after simple instruction or after a short learning period with some device to avoid this supine posture, about two-thirds of the patients are able to effectively avoid this sleep posture.

**Practice Points**

1. Position therapy—the avoidance of the supine posture during sleep—is simple, inexpensive and represents an effective form of therapy for positional OSA patients who have a non-pathological RDI in the lateral posture.

2. Positional OSA patients may solve their sleep-related breathing disorders merely by avoiding the sleep supine position but a close follow up of the efficacy of this therapy is mandatory.

**Choosing the right patient for positional therapy**

The first thing is to adequately select the optimal patients for this type of treatment. Based on our study [6], a PP relatively young, thin and with a mild–moderate degree of severity, is probably the best patient type for this form of treatment. It is important that the lateral RDI should be less than 10 to bring the patient into the normal range. A positional patient who has a lateral RDI above 10 is not an ideal candidate and should be offered other types of therapy or positional therapy should be used as an adjunct therapy. Also a supine snorer, a patient who snores mainly or only in the supine posture, is certainly a very good candidate for this therapy. Clearly, a positional OSA patient who shows a good initial enthusiasm regarding this therapy is more likely to succeed with it.
Improving patients' acceptance of positional therapy

In order to improve patient compliance with positional therapy we have found it useful to show the patient just how striking the positional effect is on their breathing function during sleep. For that purpose, we present to the patients a small graphic summary of four major parameters recorded during the PSG evaluations. In parallel to the polysomnographic recording, we also register in a chart recorder at a paper speed of 10 cm/h, the body position changes, the output of the Oximeter (SaO₂ and HR), and the output from the Sound Level Meter for a calibrated snoring assessment. The display of this compressed data showing the profound effect that the body position has on their breathing abnormalities during sleep is very easily understood and helps patient acceptance of this form of therapy. We ourselves manufacture the tennis ball belts. The belt is offered to the patients and if they are interested, we sell it for a low price. Thus, the patients receive a complete explanation of the results of the sleep evaluation test and if accepted, they go home with a very simple, non-invasive, inexpensive and an effective form of treatment.

For whom is this therapy not indicated?

This form of therapy is not adequate for NPP who showed similar amounts of breathing abnormalities in the supine and lateral position. This is also not the treatment of choice for patients who are looking for a radical solution for their snoring. Although an improvement is usually observed, in most of the cases, snoring also continues in the lateral positions although usually less loudly and frequently. Patients who have shoulder problems or any other physical disability that interferes with their sleep in the lateral position are not candidates for this type of treatment. Also, patients who insist on using a very soft mattress or a water-bed to sleep on will probably not benefit from this treatment.

Devices for positional therapy

We have used the tennis ball technique in positional therapy [47], where a tennis ball is placed into a pocket of a wide cloth band or belt attached around the abdomen so that the ball lies in the centre of the back. When the patient rolls onto the back he feels the pressure of the ball and instinctively rolls back onto his side again. Several other methods have been used. Some may use a T-shirt with a long vertical pocket holding three or four tennis balls along the back. This is perhaps less likely to slip out of place during sleep.

An alarm system which momentarily wakens the patients whenever they lay on their back has also been used successfully [54]. Others have found that a large device consisting of a PVC pipe about 12 inches long (30 cm) and 8 inches (20 cm) in diameter wrapped in foam (about the size of an American football) is quite effective, more so than the tennis ball [58]. It appears that different people have used different devices but almost no data on the long-term efficacy of these devices (including body position recording in the home) has been reported. A comparison between all these devices on effectiveness, acceptance and compliance would be beneficial.
Positional therapy as an adjunct to other therapies

Cartwright [7], by using the tongue-retaining device (TRD) in 16 OSA patients, found that the best results with it were obtained in positional OSA patients and when positional therapy was added to the use of TRD the results were even better than using each therapy alone. These results were confirmed in a later study [57]. The only study that investigated the effect of surgery on the distribution of breathing disturbances according to body position [8] showed that UPPP produced a significant improvement in the AHI in the lateral position. Thus adding positional therapy after UPPP may lead to a major benefit in the OSA condition.

Braver et al. [13] showed that the combination of nasal spray and positional therapy produced a small but significant improvement in the AHI of 20 asymptomatic snorers. The combination of these therapies did not produce an improvement in snoring in those patients. In a subsequent study [61], however, they reported that by the combination of very mild weight loss, nasal spray and sleeping in the lateral posture it is possible to improve the AHI in asymptomatic snorers and in some cases reduce the frequency of snore events.

Comparison of positional therapy with other therapies

Cartwright et al. [57] compared different behavioural treatments in four groups of positional OSA patient (see details of the groups in the section “Interventional studies”). In the single treatment groups, 53–60% of the patients reached a normal AHI (<5.5). No significant differences were observed between the groups. There was an additive effect of positional therapy and TRD. In a few patients the combined three therapies (A + B + D) gave a success rate of 73%.

One study compared 2 weeks of positional therapy with 2 weeks on CPAP treatment in 10 mildly obese positional OSA patients [45]. CPAP treatment was more effective than positional therapy in reducing respiratory events and preventing desaturations, but the treatments have similar efficacy in terms of sleep quality and daytime functioning. The results of this study suggest that one could offer the patient a short trial with positional therapy followed by a short trial of CPAP or vice versa. In that case you give the patient the opportunity to choose the most adequate therapy for him/her based on their own experience. This perhaps will be reflected in better compliance.

Advantages and disadvantages of positional therapy

Positional therapy is a simple, non-invasive, inexpensive and an effective form of treatment for many positional OSA patients. Although only a few investigations of this therapy have been published up to now, no side effects have been reported.

Most of the positional patients are mild-to-moderate OSA patients and since many of these patients will progress to more severe stages of this disease, a simple therapy like this may prevent the development of many of the detrimental clinical consequences of this condition. Another advantage of this therapy is that it can be used as an adjunct therapy to any other form of therapy for OSA patients. Positional patients are the most likely to benefit from a tongue-retaining device. The optimal CPAP pressure
needed to overcome the breathing abnormalities is in most cases lower (sometimes up to 4.0 cmH₂O) in the lateral posture than in the supine posture.

Losing weight produces an overall improvement of OSA but the effect is mainly observed during sleep in the lateral posture. Thus, an obese, severe, non-positional patient who cannot tolerate CPAP, will likely, by losing weight, become positional and positional therapy will then become a feasible treatment option. Since UPPP also produces a more significant improvement in the lateral RDI, avoiding the sleep supine posture will enhance the effect of surgery.

Since as we mentioned previously, the majority of OSA patients are positional, this form of therapy, if confirmed by good long-term studies, could represent an important therapy for this disease.

In our opinion this therapy has two major disadvantages although these have not been well investigated. (1) It rarely provides a radical solution for snoring. Most of the patients continue to snore (although in general, less loudly and less frequently) in the lateral postures and since a considerable number of patients are seeking a complete solution for snoring, this treatment usually does not solve their problem. (2) As we said previously, this therapy is mostly adequate for positional patients who are in most cases mild to moderate OSA patients. These patients do not always suffer from severe daytime sleepiness and therefore, the clinical improvement by the use of this therapy may not be clearly perceived by them. Thus, without solving the snoring problem and without perceiving a clear clinical benefit, these patients may lose the motivation to comply with this therapy over the long term.

**Side effects, cautions and complications**

No side effects of the different devices to avoid the supine posture during sleep have been objectively reported. However, several anecdotal complications have been described. In our experience, some patients complained that the tennis ball device caused discomfort. As with CPAP, if the patients do not feel comfortable with it, independent of how effective it is, the compliance with it will be very poor.

Sometimes the tennis ball moves to the side of the back during the night causing a lack of effectiveness. Obese patients may simply not feel the pressure of the ball and sleep right on it. This also holds true if the mattress is very soft. In our experience, one patient continued to sleep on his back with one and two tennis balls, and also with a baseball.

The position alarm system has been effective but may not be heard by those patients who snore loudly or are hard of hearing.

One major caution with this positional therapy could be related to the lack of close follow-up of the patients. It is crucial to follow up the patients closely in order to obtain subjective feedback on the effectiveness of the technique from them and their bed partners. In some cases a PSG reevaluation with and without the device may be required. Since we still do not know enough about the progression of the disease, regular follow-up every 6 months or at least once per year are probably appropriate in order to assess whether patients treated only with positional therapy are still within normal limits.

Increasing weight, as well as alcohol intake and sleep deprivation will all likely worsen the severity of OSA and may convert the positional patient into a non-positional one so that the positional therapy will no longer be effective. These issues are very
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important and should be clearly explained to the patient before starting the positional therapy. Patients who do not comply with the technique should be offered a trial of CPAP or some other type of therapy.

Conclusions

The supine sleep posture produces a detrimental effect on breathing function. This body position worsens the breathing function of the majority of OSA patients. Positional OSA patients are those who have more than twice as many apnoeas/hypopnoeas in the supine as compared to the lateral position. Since most of the positional OSA patients have only a mild to moderate form of the disease, and since they are the majority of the OSA patients, positional therapy—the avoidance of the sleep supine posture—is an important form of therapy for a large number of OSA patients. Consequently, this form of therapy should be evaluated more extensively with special emphasis being placed on its long term effectiveness.

Research Agenda

1. Well-controlled, long-term evaluation of the efficacy of positional therapy in a large population of positional OSA patients is urgently needed.
2. We showed [47] that 1 month of avoiding the supine posture in positional OSA patients was effective in lowering blood pressure in hypertensive and normotensive individuals. Since the majority of OSA patients are positional and since about a third of all hypertensive patients have OSA, avoiding the supine position during sleep, if confirmed by future well-controlled larger studies, could become a new non-pharmacological form of treatment for many hypertensive patients.
3. A comparison of patient acceptance between positional therapy, oral device therapy and CPAP treatment should be performed in mild OSA patients.
4. More investigations on the effect of body position on upper airway dimensions and on the activity of upper airway muscles during sleep in positional as well as non-positional OSA patients is needed.
5. Future studies should consider the effect of head/neck position on the occurrence and severity of breathing abnormalities during sleep.

References

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*The most important references are denoted by an asterisk.


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