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ORIGINAL REPORT

Dynamics and periods in the nasal cycle during night sleep by separate measurement of nostril respiration

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ABSTRACT

BACKGROUND. The registration of the nasal cycle by separate measurement of breathing through the left and the right nostril appears a non-invasive method, in which the passability of the nostrils is assessed by the respiratory amplitudes of the air.

OBJECTIVE. To present the dynamics and periods of the nasal cycle during night sleep using the Interface 2-Channel System Method.

MATERIAL AND METHODS. The recordings demonstrate the dynamics and periods of the nasal cycle during the night sleep of a healthy volunteer.

RESULTS. The patient respiratory and nasal cycle through the left and right nostril was measured separately for 10 hours. The entire record consisted of 3 large nasal cycles lasting 4.0h, 3.5h and 2.5h, separated by short awakenings, getting out of bed lasting no longer than 10 minutes. Each part was composed of smaller cycles that structure separate stages of the nasal and sleep cycles. The smallest period recorded in the nasal cycle was about 4 minutes long. Records show that the duration of the REM stage must be longer than 20 minutes to perform the nasal cycle reversal. In the presented records, the nasal cycle reversals were performed after a 30-minute duration of the REM stages. It has been found that nasal cycles can change fast (impulse change) and gradually (gradual change). The impulse change implies that the passability of only one nostril lasts for about 12 seconds, while the other nostril retains its passability. The slow gradual changes of the nasal cycle involve both nostrils and continue for about 4 minutes. Waking up and getting up of persons for about 10 minutes restarts the nasal cycle with potential for a new nasal cycle reversal.

CONCLUSION. The method provides an objective assessment of nasal resistance, which can be used in the diagnosis of patients with breathing disorders during sleep.

KEYWORDS: nasal cycle, sleep, method, period, medicine.

INTRODUCTION

The change of the airflow through the left and the right nostril is a phenomenon well known as nasal cycle (NC)[1-4]. During night sleep, the airflow through the nostrils alternatively changes, with an average period of about 3 hours[2,5,6]. The nasal cycle in norm and in various neurological diseases can be considered as a physiological mechanism that regulates airflow and metabolic activity of the brain[7-9]. The nasal cycle is related to the autonomic nervous system, asymmetry in hemisphere blood flow and asymmetry of EEG brain activity[4,7-9]. It is established that it is synchronized with the sleep cycle during the REM stage of sleep by the nasal cycle reversal (NCR)[5,10].

There are many methods for measurement and characterization of the nasal cycle. In our work we used an Interface 2-Channel System, the technical base for breathing registration separately through nostrils and the detection of the nasal cycle. This method has been used in the work of some researchers, but its various modifications continue to improve[11,12]. In this article, the full record of the nasal cycle during night sleep is presented for the first time using Interface 2-Channel System Method.

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MATERIAL AND METHODS

The aim of our research was to present the normal dynamics in the nasal cycle during night sleep and to test whether the method used to assess the dynamics of the nasal cycle during sleep is applicable in medical practice. In this sense, the study is an intermediate presentation of a patient whose nasal cycle is studied during night sleep.

Method for detection of the nasal cycle

Interface 2-channel System-Method was the technical base used for breathing registration separately through the nostrils. The main steps in making and using the device are described in our previous publication[12]. The method is not invasive and does not prevent the sleep of the volunteers. The REM/NREM sleep stages in the nasal cycle record were additionally identified by observation and registration of the breathing by the study assistant[5].

Subjects

The subject for the study was a 68-year-old healthy male volunteer, non-smoking, non-obese and non-snoring. The volunteer reported no complaints of sleeplessness during the last few years. The subject did not have a history of chronic rhino-pharyngeal or laryngeal disorders. He was not on any medications. The measurement was performed in June 2022 in an acclimatized room with temperature 24°C. The volunteer normally sleeps from 7 to 9 hours during the night, getting to sleep about 22:00-23:00 h. The volunteer sleeps on the right side of the body. The assistant took care of the technical equipment, observed the sleeping status of the subject.

Before the examination, the patient's nose was cleaned with saline nasal spray.

Local status: external nose without visible pathology, nasal moves symmetrical with normal patency, conchae of normal size, nasal septum without distortion, pale pink nasal mucosa with preserved turgor. There was no pathological secretion.

RESULTS

Figure 1 presents the 10-hour recording of the nasal cycle of a volunteer during a night's sleep from 10PM in the evening to 8AM. The record of the nasal cycle consists of 3 parts (I, II, III) with a duration of 4.0h (from 0 min to 245 min), 3.5h (from 245 min to 450 min) and 2.5h (from 450 min to 600 min) respectively. These three parts are separated by short awakenings (Awake), getting out of bed lasting no longer than 10 minutes.

On Figure 1(a), the records of the left (L) and the right (R) nostrils are given on a single coordinate axis with equal amplitude scales. In this case, the records of both nostrils are mapped on top of each other and can be compared in amplitude and periods. On Figure 1(b), the records are given on two axes so as to see more clearly the nostril record with a smaller amplitude. In this case, the amplitudes are not at the same scales and need to be calibrated further.

On record I and record III the L nostril dominates (i.e., it has greater passability and less resistance in comparison to R nostril), while on the record II the R nostril dominates.

It can be seen from Figure 1(b) that in all three records (I, II and III) the R nostril shows a similar dynamic of the nasal cycle in time. There are similar pattern and amplitudes, while L nostril has different dynamics in the three records. The NCR was observed only in record I and record II, but not in record III. This may mean that every time you wake up and get up from sleep, your nasal cycle restarts with the possibility of a new NCR.

REM stages of sleep on the records can be identified in three ways: 1) by the increases in temperature in the nostrils, which are registered as one or more peaks on the record during the expiration phases; 2) by irregular breathing and apneas during REM stages; 3) by observing the NCR (which is not necessarily present in every REM stage).

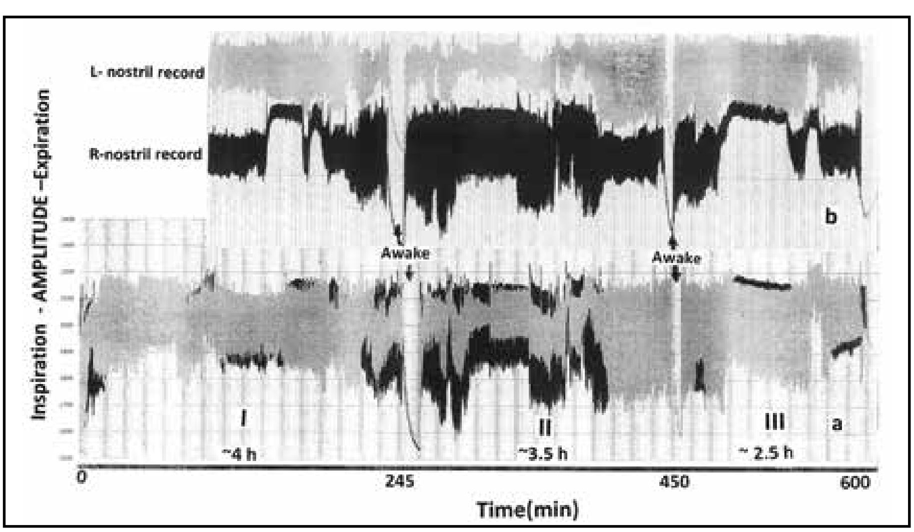

Figure 1. Record of NC during night sleep, by separately recording breathing form the left (L) and right (R) nostrils: **a)** Records of the nasal cycle of the L and R nostril on the same axis. **b)** Records of the nasal cycle of the L and R nostril on two parallel axes.

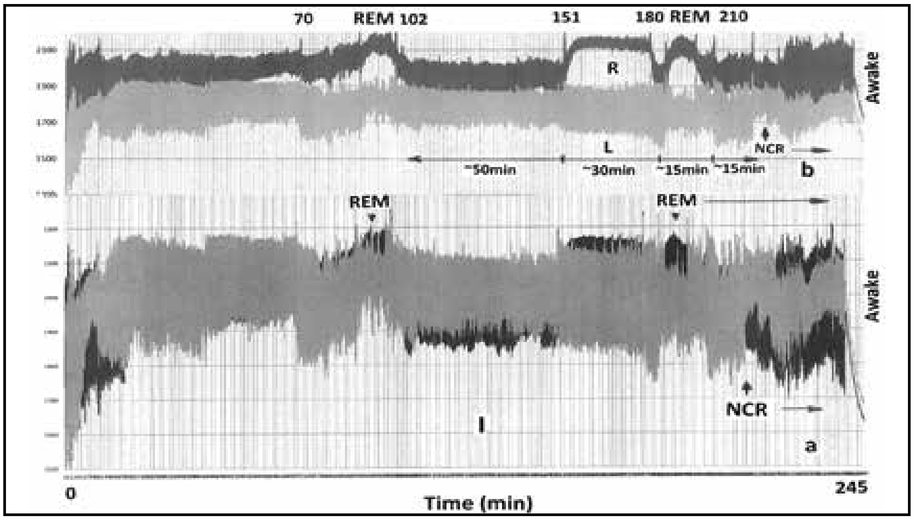

Figure 2. First part (I) of the record of the nasal cycle from 0 to 245 min (a, b). REM stages are signed on the nasal cycle record. During the second REM stage, NCR can be observed.

On Figure 2(a,b), the periods of record I of the nasal cycle, with a duration from 0 to 245 minutes, have been identified. There is a period, lasting 70 minutes, after which dreaming takes place (first REM stage from 70 minutes to 102 minutes) without NCR.

After a period of another 50 minutes, a second REM stage (from 151 to 210 min) can be observed, during which the NCR is performed. Before the NCR itself, the two nostrils changed their amplitudes from 151 to 180 minutes. After 180 minutes, the NCR is performed with alternative change of amplitudes of the L and R nostrils. Then an AWAKE stage follows, with the subject waking up and getting out of bed for about 10 minutes.

Figure 3(a,b) provides a more detailed representation of the periods identified on record I. On Figure 3(a), from 10 to 18 minutes, the NCR is observed, due to the change in posture for sleep at bedtime (from standing to lying on the right side of the body). Two cycles of about 25-30 min each follow (from 18 min to 43 min and from 43 min to 70 min). From 70 to 102 minutes, a REM period without NCR is observed, with the REM period itself lasting about 20 minutes.

On Figure 3(b), a 50-minute period (from 102 to 151 minutes) is observed, followed by a 30-minute period (from 151 min to 180 min) and a new subsequent 30-minute period (180 min to 210 min). This last period is divided into two 15-minute periods. In 210 min a NCR is performed, in which from a dominant L nostril (with greater passability) a transition to a dominant R nostril (with greater passability) is performed.

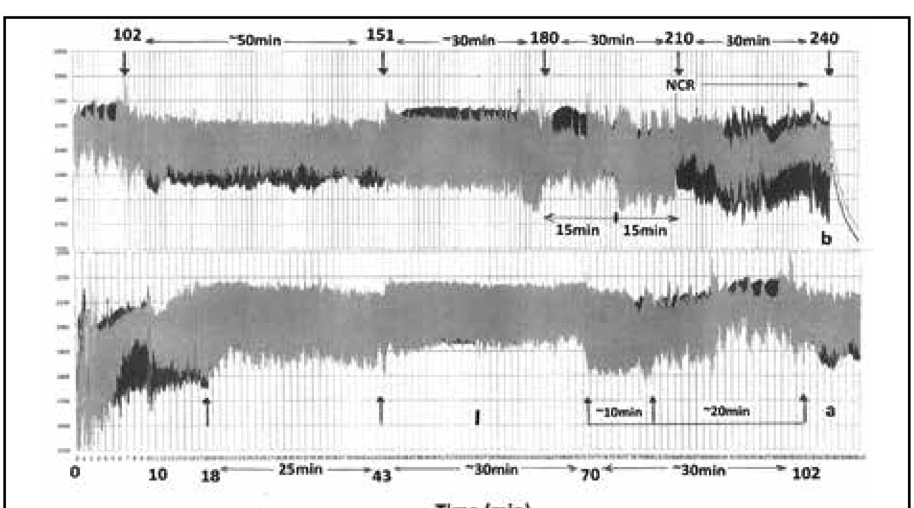

Figure 3. Record I with signed periods of the NC (a, b).

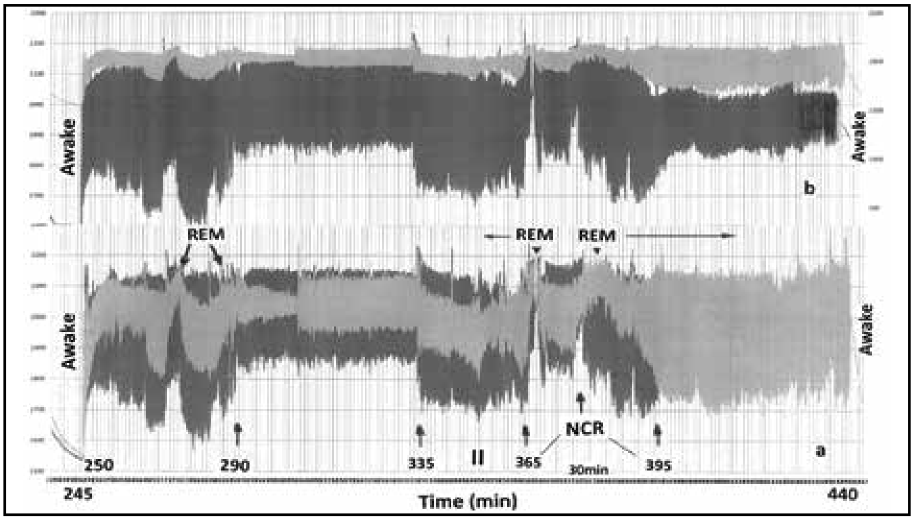

Figure 4. Second part (II) of the record of NC (from 245 to 440 min) (a, b). REM stages of the sleep are signed. During the second REM stage, NCR can be observed.

On Figure 4 and Figure 5, the record II of the nasal cycle (from 250 min to 440 min) is presented. Figure 4(a) shows the records of the L and R nostrils on the same axis and at the same scale, while on Figure 4(b) the records are represented on two parallel axes of different scale.

On Figure 4(a), between 250 and 290 minutes, two peaks of very short REM stages without NCR are observed, while between 365 and 395 minutes a continuous REM stage with the implementation of the NCR is observed. There is a transition from a dominant R nostril to a dominant L nostril. After 395 minutes, a dominant L nostril was observed until awakening (AWAKE) at 440 minutes.

On Figure 5(a,b) are recorded the shortest periodicities of NC (about 4 min) in the range from 260 to 276 min. The record from 290 min to 335 min shows that L and R nostril periods may differ in the same REM stage of sleep. While the duration of the R nostril is 45 minutes, the L nostril has two periods of 15 minutes and 30 minutes, superimposed on the 45-minute period of the R nostril.

Figure 6(a,b) presents the record III of the NC (from 448 min to 584 min). On Figure 6(a), only the record of the dominant L nostril is given, while on Figure 6(b) the records of the L and R nostril are given on two parallel different axes.

In the case of the record III, the periods of the L and R nostrils coincide. No NCR was observed, and the L nostril dominated with higher passability until wake. On Figure 6(b), an AWAKE period lasting about 10 minutes is applied, after which it can be seen that, during sleep from 448 minutes to 480 minutes, the amplitude of the R nostril increases, but the amplitude of the L nostril does not change. From 480

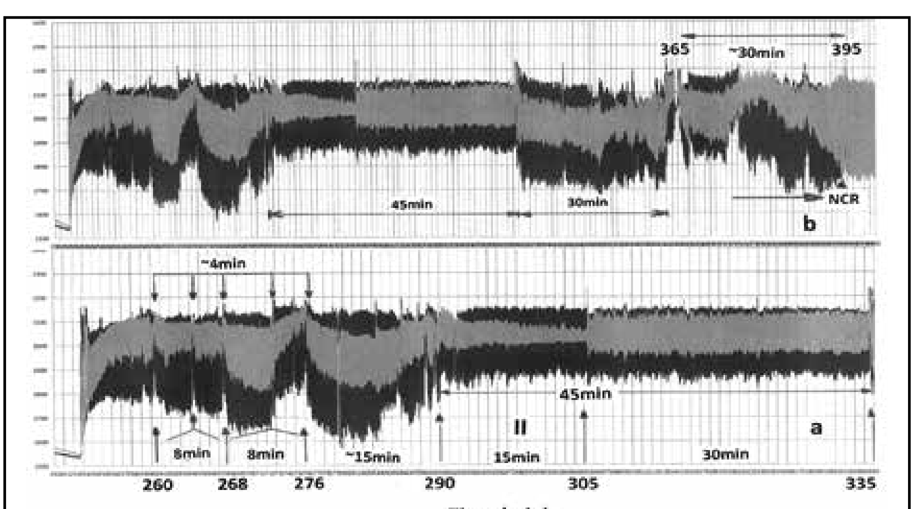

Figure 5. Record II with signed periods of the nasal cycle (a, b).

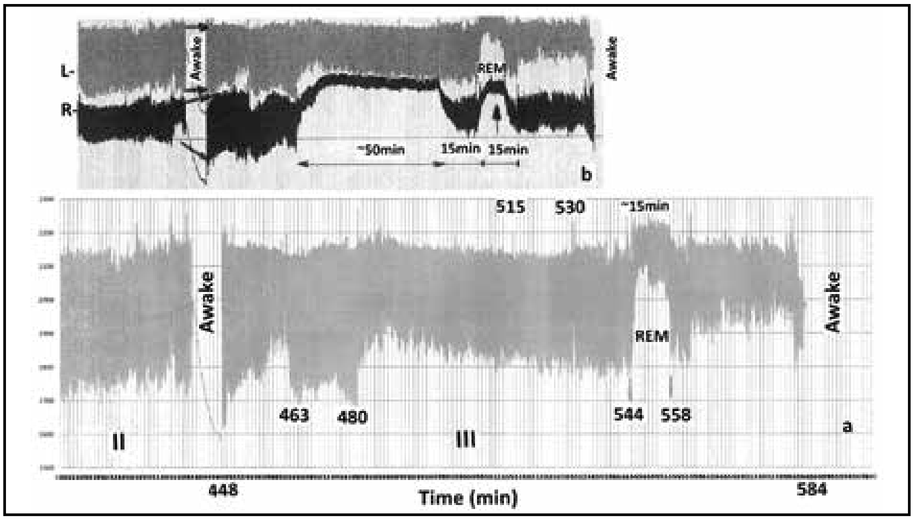

Figure 6. Part (III) of the record of NC from 448 to 584 min (a, b). The REM stage of the sleep is signed.

min to 544 min, the amplitude of the R nostril is very small compared to the amplitude of the L nostril. A REM stage was observed from 544 min to 558 min without NCR, followed by a wake and end of recording at 584 min.

Figure 7(a,b) shows the two observed ways of changing the nasal cycle. On Figure 7(a) a slow transition of the nasal cycle lasting about 4 minutes is given, and on Figure 7(b) a fast (impulse) cycle transition lasting about 12 seconds is given. On Figure 7(a), there is a slow decrease in respiratory amplitude of the L nostril (from 272 min to 276 min), then a slow increase in breathing amplitude (from 276 min to 280 min).

On Figure 8, which is a repetition of Figure 7(b) with a scale unfolded in time, it can be seen that the L nostril with small initial amplitude, after 2 breathing cycles with a duration of 12 seconds, sharply increases its amplitude about 2 times. During this change, the amplitude of the R nostril remains almost the same.

DISCUSSIONS

The large nasal cycles of records I, II and III, lasting 4h, 3.5h and 2.5h, are made up of cycles of shorter durations that make up separate stages of the nasal cycles. The durations of these short cycles are 70 min, 50 min, 45 min, 30 min, 20 min, 15 min, 10 min, 8 min and 4 min. The shortest cycle has a duration of 4 min. All the larger cycles can be considered with some approximation as multiples of this cycle of 4-minute duration. Changes in the nasal cycle of the nostrils (their passability in time) can be gradual and impulsive. The shortest

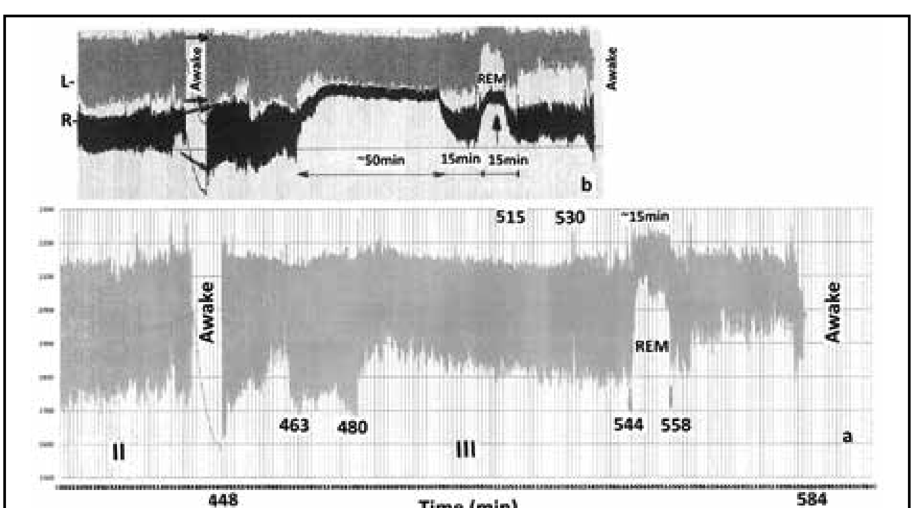

Figure 7. a). Slow transitions in the nasal cycle of both nostrils. b). Impulse transition of the nasal cycle of the left nostril during a night's sleep.

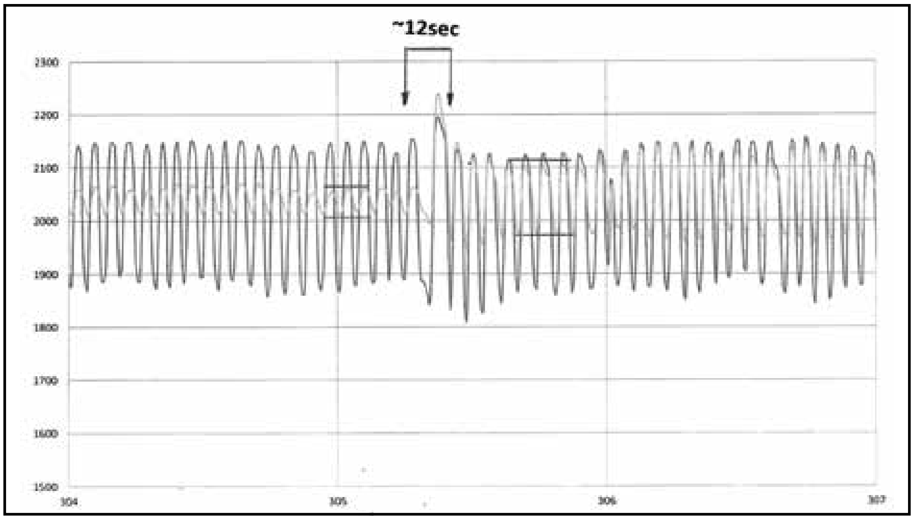

Figure 8. Impulse transition of the NC of the left nostril during a night's sleep.

cycle of 4 min was recorded in the gradual changes of the nasal cycle of the nostrils (Figure 7). An impulsive change of the nasal cycle affects only one nostril and lasts about 12 seconds, while the passability of the other nostril remains unchanged. What physiological processes may these transition periods be associated with? It can certainly only be said that these periods are associated with cyclic changes in breathing. This follows from the method used, in which nasal cycles are measured by registration of inhalation and exhalation. On the other hand, some authors associate nasal cycles with the activity of the left and right hemispheres of the brain[13-15]. By the same token, it can be assumed that periods of nasal cycles are related to the neurological or metabolic activity of the brain. In the impulse change of the nasal cycle, the minimum period of 12 seconds is associated with 2 respiratory cycles, while the 4-minute period is associated with a gradual change in the amplitudes of inhalation and exhalation. The remaining larger cycles are also associated with an increase or decrease in respiratory amplitude.

According to the scientific literature, depriving brain tissue of oxygen within 8-10 seconds leads to unconsciousness, and lack of oxygen for 4-6 minutes to brain death[15]. Could impulse and gradual changes of the nasal cycle be related to these metabolic limits?

Another issue is related to the overlay and synchronization of the periods of nasal and sleep stages. How are the nasal cycle superimposed on the sleep NREM and REM stages or vice versa? To answer this question, it is necessary to make simultaneous records of the nasal and sleep cycles. The records on Figure 3 show that for the implementation of the NCR it is necessary that the duration of the REM stages be longer than 20 min. In the present record, the NCR was performed after about 30-minute REM stages. The issue of REM/NCR duration is also new and has not been discussed in the scientific literature. For the nasal cycle during sleep, there are a limited number of publications, and in some of them only the final results are given without publication of the primary records[5,10,16,17]. From the records it can be seen that, after each REM stage, the changes in the amplitude of the nasal cycle are registered (although after each REM stage no NCR is performed). From records I, II and III, it is also seen that after each awakening accompanied by a change of posture, the next nasal cycle is restarted, with potential for a new NCR. Each awakening and rising from sleep also have an effect on the amplitudes of the nasal cycle of both or only one nostril (Figure 6). What REM and Awake have in common, is that they are a conscious state. This confirms the hypothesis that NCR takes place during REM consciousness as primary consciousness and Awake consciousness as secondary consciousness[18,19].

NCR is also observed immediately after bedtime, in which the posture of the body changes from a vertical to a horizontal position. In this case, the NCR is carried out within 10-20 minutes immediately after bedtime. For comparison, the NCR during REM sleep is performed after a REM stage greater than 20 minutes. Another important problem is the comparison of nasal cycles in norm and pathology – stroke, coma, etc. –, where the nasal cycle can serve as an indicator of conscious states of the brain[18,19]. In the previous study, the author and co-authors have shown that the recovery of a sick 90-year-old woman with a stroke is accompanied by a transition to a normal nasal cycle[17]. In the case of sick patients, the study of the nasal cycle is also of interest in parallel with other already established methodologies (EEG, EOG, ECG) in the case of patients with metabolic diseases[20].

CONCLUSIONS

1. The proposed method makes it possible to record in detail the dynamics of the nasal cycle during sleep.
2. The method can find suitable application in the diagnosis of patients with various breathing disorders.

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