Brief Communication

Humming Greatly Increases Nasal Nitric Oxide

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The paranasal sinuses are major producers of nitric oxide (NO). We hypothesized that oscillating airflow produced by humming would enhance sinus ventilation and thereby increase nasal NO levels. Ten healthy subjects took part in the study. Nasal NO was measured with a chemiluminescence technique during humming and quiet single-breath exhalations at a fixed flow rate. NO increased 15-fold during humming compared with quiet exhalation. In a two-compartment model of the nose and sinus, oscillating airflow caused a dramatic increase in gas exchange between the cavities. Obstruction of the sinus ostium is a central event in the pathogenesis of sinusitis. Nasal NO measurements during humming may be a useful noninvasive test of sinus NO production and ostial patency. In addition, any therapeutic effects of the improved sinus ventilation caused by humming should be investigated.

Keywords: exhaled; sinus; sinusitis

The gas nitric oxide (NO) is released in the human respiratory tract. The major part of NO found in exhaled air originates in the nasal airways, and it can be measured noninvasively with different sampling techniques (1). A large production of NO takes place in the paranasal sinuses (2). The sinuses communicate with the nasal cavity through ostia, and the rate of gas exchange between these cavities is dependent, for example, on the size of the ostia (3). Proper ventilation is essential for maintenance of sinus integrity, and blockage of the ostium is a central event in pathogenesis of sinusitis (3, 4).

The concentrations of NO in the healthy sinuses are very high, sometimes more than 20 parts per million (2). We hypothesized that the oscillating airflow produced by humming would speed up the exchange of air between the sinuses and the nasal cavity and thereby increase nasal NO output.

METHODS

Ten healthy nonsmoking subjects (age 34–48 years, all males) without any history of allergy or airway disorder took part in the study. NO was measured in oral and nasal single-breath exhalations using a chemiluminescence system developed to meet the criteria of the guidelines of the American Thoracic Society (5) for exhaled NO measurements (NIOX, Aerocrine AB, Stockholm, Sweden). A tight-fitting mask covering the nose was used for nasal measurements, and a mouthpiece was used for oral exhalations. The subjects exhaled at a fixed flow rate (0.20 L/s) for 5 seconds either quietly or with nasal humming or oral phonation. NO levels were calculated as the mean concentration during the last 70% of the exhalation. The fixed flow rate was achieved by a dynamic flow restrictor in the analyzing system. An elastic membrane valve in the restrictor mechanically adjusts flow rate and keeps exhalation at 0.20 L/second within a range of exhalation pressures. The resulting mean exhalation flow rate was monitored, and variation was minimal (less than 0.02 L/second).

We also measured NO levels in a two-compartment model resembling the nasal cavity and one sinus. A syringe (the sinus), filled with 20 ml of NO gas (10 parts per million, AGA AB, Lidingö, Sweden), was connected vertically to a plastic cylinder (the nasal cavity) via a luer fitting. The diameter of the syringe tip (representing the ostium) was varied between 0 and 3.2 mm. A subject performed a single-breath oral exhalation (0.20 L/second) through the cylinder with or without phonation, and resulting NO levels were measured in the chemiluminescence system described previously here. To estimate the exchange of air between the two cavities, we also measured remaining NO levels in the syringe (ostial size, 2.4 mm) after a single full oral exhalation (20 seconds) with or without oscillating airflow (phonation).

RESULTS

Humming caused a 15-fold increase (range, 8–21) in nasal NO compared with quiet exhalation (Figure 1). Nasal NO output increased from 189 ± 30 nl/minute (17 ± 3 parts per billion) to 2818 ± 671 nl/minute (252 ± 63 parts per billion). In contrast, phonation during oral exhalations did not affect NO output compared with quiet exhalation (103 ± 43 versus 104 ± 48 nl/minute).

In the nasal airway model, resulting NO levels increased during phonation, and this increase was dependent on the ostium diameter (Figure 2). The reduction of NO in the syringe after a single full exhalation was 96% during phonation and less than 4% during quiet breathing (n = 6).

DISCUSSION

Here we show that nasal NO levels increases dramatically during humming compared with normal quiet nasal exhalation. This effect is likely due to increased contribution of NO from the paranasal sinuses. Humming causes the air to oscillate, which in turn seems to increase the exchange of air between the sinuses and the nasal cavity. This was also confirmed in the two-compartment model system where humming resulted in a great increase in NO levels (Figure 2). The volume in the syringe, the NO concentration, as well as the diameter of the syringe tip (representing the sinus ostium) were chosen because they resemble physiologic values for these parameters (2, 3). The normal size of an ostium is approximately 2.4 mm (3). Interestingly, NO levels were strongly dependent on the diameter of the syringe tip. This implies that the increase in nasal NO during humming is dependent on ostial size. In this first study, we used a rather fixed model, changing only the diameter of the syringe tip. It is possible that several other factors will influence the rate of exchange between the two cavities, for example, flow rate, pressure, sound frequency, and the volumes of the communicating cavities. Because nasal NO is known

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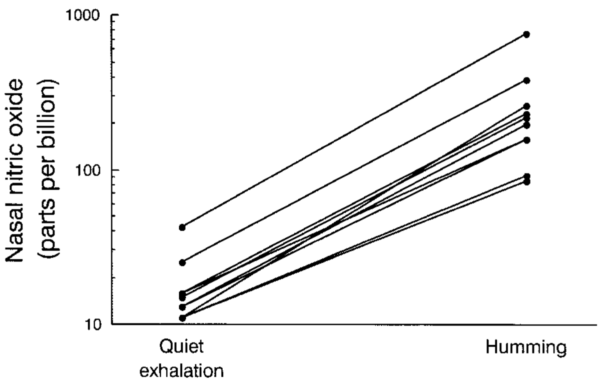

Figure 1. The effects of quiet exhalation and humming on levels of NO in nasally exhaled air. Each subject (n = 10) exhaled at a fixed flow rate of 0.2 L/s.

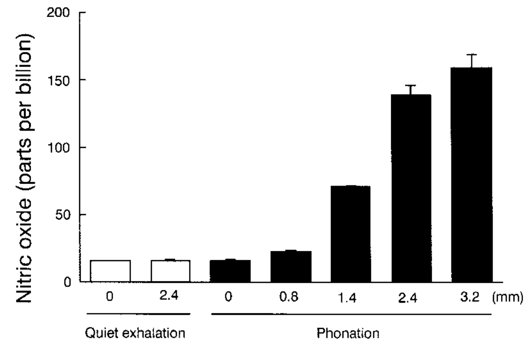

Figure 2. Dependence of ostium diameter (mm) and oscillating airflow (phonation) on NO release from the sinus in a model of the nasal airways (*see* METHODS section).

to be very flow-dependent, special care was taken to perform all measurements at a fixed exhalation flow rate. In this study, we used a flow rate of 0.20 L/second, and the variation was minimal. Naturally, the model we used here cannot be directly compared with the situation *in vivo*. For example, airflow is rather turbulent in the nasal passages, whereas the flow in the model cylinder during quiet breathing is probably more laminar. Moreover, the sinus ostia are complex structures that continuously undergo dynamic changes. Nevertheless, the model used here may be helpful in understanding some of the factors that determine nasal NO levels during humming. We cannot exclude that humming increases NO release also from other sources within the nose. For example, the sound waves may generally increase the release of NO solved in the epithelial cells and fluid linings.

Sinusitis is a very common disease causing much human suffering and enormous costs for society. The self-reported prevalence of chronic sinusitis in the United States is as high as 14% of the population (4). There are several problems involved in the diagnosis and treatment of this disorder. For example, headache, rhinorrhea, and nasal congestion are extremely common, but these symptoms do not necessarily imply sinusitis. Proper ventilation of the sinuses is essential for sinus integrity. In fact, occlusion of the ostia is considered a key factor in the pathogenesis of sinusitis (4). Such occlusion may be due, for example, to an acute viral infection causing swelling of the mucosa. The basic principles of treatment are to cure any infection present and to promote sinus drainage, for example, with nasal decongestants, sinus irrigation, or surgery (4).

Aust and Drettner have described a method to measure sinus ostial function (3). However, this test is invasive and somewhat cumbersome to perform. An easy noninvasive method that could be used to measure sinus ostial patency could be most useful. Such a test could help to identify subjects who are at risk of developing sinusitis. Also, it could be used to monitor the effects of surgical or medical interventions aimed for prevention of sinusitis. Obviously, further extensive studies are needed before we know whether the method described here fulfils the criteria of such a test. Nevertheless, it is tempting to speculate that measurements of nasal NO release during humming and quiet breathing can give important information about sinus ostial function.

The data presented here indicate that humming is an extremely effective means of increasing sinus ventilation. In fact, in our model system, almost the entire volume (96%) of a normal maxillary sinus (20 ml) was exchanged in a single exhalation during phonation, as compared with less than 4% during quiet exhalation. It will therefore be of great interest to study whether daily periods of humming can reduce the risk for sinusitis in patients susceptible to upper airway infections.

We conclude that humming causes a dramatic increase in sinus ventilation and nasal NO release. Measurement of nasal NO during humming is an easy noninvasive test that can give valuable information about ostial function and NO production in the sinuses.

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