Respiratory Symptoms and Peak Expiratory Flow in Survivors of the Nyos Disaster*

Emmanuel Afane Ze, MD; Nicolas Roche, MD; Guillaume Atchou, MD; Pierre Carteret, MD; and Gérard J. Huchon, MD, FCCP

In August 1986, gases from the Nyos volcanic lake killed 1,746 persons in northwestern Cameroon, but 1,500 others living in the affected area survived. Gas emanations contained carbon dioxide, sulfur dioxide, and hydrogen sulfide. The objective of this study was to evaluate the delayed respiratory consequences of the inhalation of such volcanic gases. Two groups of subjects living in the same area, exposed (Nyos group; n=381) or not exposed (control group; n=128) to Nyos gases, were evaluated with a short questionnaire and by measurement of peak expiratory flow (PEF, percent predicted) in March 1991. Eleven percent of the subjects smoked, more often men than women (23% vs 4%; p<0.001). In the whole population (exposed and unexposed), smoking was associated with a 3.6-fold increase in the frequency of cough (p<0.001) and with a 6-fold increase in the frequency of sputum production (p<0.005), but not with a decrease in PEF. There was no difference in the frequency of dyspnea, cough, sputum production, and PEF between Nyos and control groups. We conclude that 55 months after the emigration of gases from Nyos volcanic lake, there was no difference in respiratory symptoms and PEF between survivors who inhaled volcanic gases and control subjects, whereas smoking was associated with cough and sputum production. (CHEST 1996; 110:1278-81)

Key words: carbon dioxide; environmental health; hydrogen sulfide; peak expiratory flow; respiratory symptoms; sulfur dioxide; tobacco smoking

Abbreviations: PEF=peak expiratory flow

Volcanic eruptions may produce toxic gas emanations that constitute a potential respiratory hazard. On August 21 and 22, 1986, gases from Nyos volcanic lake (northwest Cameroon) killed 1,746 persons; death occurred principally in men (male/female ratio: 2/1) living in 4 villages of the area; the victims were mostly shepherds who guarded their flocks near the volcanic lake at the time of the disaster. At least 3,000 animals also died.1 Gases consisted mainly of carbon dioxide, and of traces of carbon sulfide, hydrogen sulfide, and sulfur dioxide.2 In the 4 concerned villages, there were 1,500 survivors who suffered transiently and in various degrees from cutaneous and mucous (especially conjunctival) burns, and from neurologic and GI symptoms. Acute transient respiratory symptoms such as cough, dyspnea, hemoptysis, and chest pain were also frequent. Radiographs of some survivors showed diffuse pulmonary infiltrates. At autopsy, one victim showed mild pulmonary edema.2 Survivors were rehoused in six other villages nearby.

Some of the gases that were contained in Nyos lake emanations, especially sulfur dioxide and hydrogen sulfide, are known to induce acute respiratory symptoms and impairment in lung function.3-9 However, their ability to induce chronic respiratory diseases has not been established.10,11 To evaluate the delayed respiratory consequences of such a short-term exposure to these volcanic gases, a case-control study of survivors from the disaster was conducted by recording respiratory symptoms and peak expiratory flow (PEF) rate in March 1991 (ie, 4½ years after the disaster).

Materials and Methods

Subjects

We studied subjects and control subjects from five of the six villages where the survivors of Nyos disaster were rehoused, as 1 of these villages was not easily accessible. Subjects older than 70 years and younger than 17 years (ie, who may describe their symptoms less precisely) were excluded. Subjects with thoracic deformations and known preexisting bronchopulmonary or cardiac disease were also excluded, as were pregnant women. We studied 381 survivors of the Nyos disaster still living in these villages (some survivors had left these villages after the disaster). The comparison group...
Table 1—Symptoms in the Nyos and Control Group, With Reference to Gender and Smoking

<table>
<thead>
<tr>
<th></th>
<th>Nyos Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>Smoking</td>
<td>Nonsmoking</td>
</tr>
<tr>
<td>Cough*</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>13.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Sputum*</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Chest pain*</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>12.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*p<0.05 between smokers and nonsmokers.

consisted of 128 unexposed persons living in the villages at the time of the disaster, these villages being out of the exposed area.

Questionnaire
Questions were asked on the following: demographic data, activity and location at the time of disaster and at the time of questioning; cardiac, respiratory, and general medical history; tobacco smoking and other exposures to vapors or dusts; symptoms before, during, and immediately after the disaster; and current and recent (during the past 4 years) respiratory symptoms. Recorded respiratory symptoms were cough, sputum production, chest pain, hemoptysis, dyspnea, and wheezing.

Measurement of PEF Rate
PEF was measured three times with a peak flowmeter (Mini-Wright), and the best value was used. Predicted values were those for white populations, corrected for ethnicity.12

Statistical Methods
The effect of gender, smoking, and exposure to toxic gases from Nyos lake on symptoms was assessed by measures of associations on multiway frequency tables. The effect of the same variables on PEF was studied by analysis of variance and covariance. Multiple regression analyses were also used to study the associations between symptoms and between symptoms and PEF. Statistical studies were performed with software (BMDP Statistical Software; Los Angeles).13 Results were considered significant when p was less than 0.05.

Table 2—PEF (Percent Predicted) in Exposed and Control Groups, With Reference to Gender and Smoking

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Smoking</td>
<td>Nonsmoking</td>
</tr>
<tr>
<td>Exposed</td>
<td>83.5±20.2</td>
<td>84.5±20.2</td>
</tr>
<tr>
<td>Control</td>
<td>94.5±13.4</td>
<td>87.4±18.2</td>
</tr>
</tbody>
</table>

*p<0.05 between men and women.

RESULTS

Three hundred eighty-one exposed subjects were studied; there were more women (252) than men (129). Twenty-six percent of men and 4.8% of women were smokers. The control group consisted of 44 men (15.9% of whom were smokers) and 84 women (2.4% smokers). Smoking was more frequent in men than in women (p<0.0001).

Symptoms are shown in Table 1. There was no difference in cough and sputum production between the Nyos and control groups or between men and women. These symptoms were more frequent in smokers than in nonsmokers. Smoking was associated with a 3.6-fold increase in cough and a 6-fold increase in sputum production. Chest pain was also more frequent in smokers (15.6% in the Nyos group and 22% in the control group) than in nonsmokers (5% in the Nyos group and 0.8% in the control group), but it was not influenced by sex or inhalation of Nyos gases. Dyspnea was not related to smoking, inhalation of Nyos gases, or gender. Reporting of hemoptysis and wheezing was too rare to be analyzed. There was a significant association among cough, sputum production, dyspnea, and chest pain.

As shown in Table 2, PEF was not influenced by smoking or exposure to toxic gases from Nyos lake. PEF (expressed as percent predicted) was higher in women than in men (p=0.02) and was influenced by weight (p<10^-6), which was higher in women (p<10^-6). There was no interaction between the effects of gender or weight and the effects of smoking or exposure to Nyos gases. PEF was significantly lower in subjects who reported cough and dyspnea than in those who did not (75±5% vs 87±3%; p<0.05).
We conducted a retrospective analysis of symptoms and PEF in 381 subjects who inhaled toxic gases from Nyos lake during 1 night, as assessed by their geographic situation and symptoms at the time of the disaster. When compared with 128 control subjects living in the villages where survivors of Nyos gas emanations were rehoused, there was no difference in the amount of cough, sputum production, dyspnea, chest pain, and in PEF. However, cough, sputum production, and chest pain were more frequent in smokers in both groups than in nonsmokers, whereas PEF was similar in smokers and in nonsmokers. There was no difference in the proportion of smokers between Nyos and control groups. Smoking was more frequent in men than in women.

This study was done in a rural area of a developing African country; therefore, some limitations have to be considered. The first is the difference in culture, language, and perception of disease and symptoms between peoples of such a country and those of an industrialized white nation, which may account for the surprising effect of tobacco smoking on chest pain: this word may have been used to describe a “sensation of disease” rather than a real pain. As this study was retrospective and performed more than 4 years after the disaster, we also could not determine accurately which acute symptoms subjects suffered from at the time of the toxic gas emanations, the precise location of the subjects at the time of the disaster or the precise concentrations of toxic gases the subjects inhaled. This would have been helpful, as these symptoms may reflect the levels of sulfur dioxide and hydrogen sulfide to which these subjects were exposed. These limitations prevented us from analyzing the relationship between symptoms and levels or duration of exposure to volcanic gases. Another limitation of our study, which is also related to its location, is the method used to assess ventilatory function: PEF measurement is less accurate than spirometry for the detection of obstructive pulmonary disease.\(^\text{14,15}\) Moreover, the formula used to calculate predicted values of PEF may be inadequate for this ethnic group, which may explain the effect of gender and weight/ideal weight on PEF. Another possible source of bias is that we could not study all survivors of the disaster: some had left the rehousing villages and others were rehoused in a village to which we did not have access. There may be a difference in the level of exposure and/or the frequency of symptoms and lung function abnormalities in these subjects when compared with those that we studied. Unfortunately, we have no way to test this hypothesis so that our results apply only to the studied population.

We hypothesized that short-term exposure to toxic gases from Nyos would have long-term respiratory consequences, as among these gases were sulfur dioxide and hydrogen sulfide. Exposure to these gases induces functional and histologic changes in bronchial mucosa (mucous gland secretion and hypertrophy, smooth muscle contraction and hypertrophy, and impaired mucociliary clearance),\(^\text{16-18}\) increased death rates,\(^\text{6}\) transient respiratory symptoms\(^\text{14,15}\) and impairments in pulmonary function,\(^\text{7}\) especially in patients with asthma,\(^\text{8,9}\) and pulmonary edema and asphyxia at high concentrations.\(^\text{5,19}\) However, our data do not show a long-term deleterious effect of the short-term exposure to nonlethal levels of these gases. This lack of significant effect of exposure to Nyos gases may be related to an inadequate number of subjects studied (although this number was sufficient to detect an effect of smoking on symptoms), and/or to a low level of exposure in most subjects, although the concentration of gases was sufficient to induce mucous burns, acute respiratory symptoms, and pulmonary edema in some subjects.

The lack of effect of smoking on PEF is likely to be related to a too-low number of smokers (n=54), especially as these subjects were young (35 ± 17 years),\(^\text{14,15}\) and to the low sensitivity of PEF for detection of mild changes in pulmonary function.

In conclusion, our data suggest that an exposure to a mixture of gases containing carbon dioxide, sulfur dioxide, and hydrogen sulfide did not cause delayed respiratory symptoms or affect pulmonary function (assessed by PEF measurement) in survivors from the Nyos lake disaster. Conversely, tobacco smoking induced cough and sputum production in these subjects and in control subjects, without reducing PEF.

REFERENCES
17 Amdur MO, Underhill DW. The effect of various aerosols on the response of guinea pigs to sulfur dioxide. Arch Environ Health 1968; 16:460-68