Subjective Effects of Humidification of Oxygen for Delivery by Nasal Cannula*
A Prospective Study

Humidification of oxygen prior to administration by nasal cannula is an expensive practice which has been justified on the basis that it improves the comfort of patients receiving supplemental oxygen therapy. Routine humidification of low-flow oxygen (≤4 L/min) delivered by nasal cannula has recently been challenged based on theoretic grounds and on the results of a clinical study. Nevertheless, we found, in a telephone survey of medium-sized American hospitals, that routine humidification of nasal cannula oxygen remains a common practice. To further evaluate the necessity of oxygen humidification, we prospectively evaluated, on a daily basis, the subjective complaints of consecutive patients in our institution who were ordered to receive nasal oxygen at relatively high flow rates (5 L/min). Of the 185 patients evaluated over a period of three wintertime months, 99 received humidified oxygen and 86 received dry oxygen. Complaints, especially dry nose and dry throat (42.9 percent and 43.9 percent of the daily interviews, respectively) were common in both groups, but the symptoms were relatively mild and did not increase significantly when oxygen was administered without prior humidification. We conclude that routine humidification of oxygen for administration by nasal cannula is not justifiable, and that cessation of this practice would result in significant reductions in both time and material costs in respiratory care.

Standard respiratory care practices require that medical gases be humidified prior to patient contact. The rationale for this practice has been that medical gases are "dry," since they contain approximately 6 parts per million water vapor. It has been thought that the humidity deficit created by breathing dry medical gas might: 1) cause subjective discomfort related to drying of the respiratory mucosa; and also 2) lead to moisture depletion of the mucosa, thus adversely affecting the respiratory mucous blanket and ciliary activity.

When supplemental oxygen is provided by nasal cannula, patients inspire through an intact upper airway, so normal airway humidification mechanisms are intact. The sole justification for humidifying oxygen administered by this route is thus prevention of patient discomfort related to dehydration of the upper airway mucosa. The practice of routinely humidifying oxygen for relatively low-flow (4 L or less/min) via nasal cannula administration has been challenged based on both theoretic and clinical grounds. Indeed, the ACCP-NHLBI National Conference on Oxygen Therapy concluded that there was "no subjective or objective evidence that routine humidification of oxygen is necessary at flow rates of 1-4 L/min when environmental humidity is adequate." Nevertheless, routine humidification of oxygen delivered by nasal cannula may remain a common practice in the United States.

In view of the high costs of adding humidity to nasal oxygen and its questionable justification, we undertook a study of: 1) the frequency of routine humidification in a sample of medium-sized American hospitals, and 2) subjective complaints of patients receiving either humidified or dry supplemental oxygen by nasal cannula. The latter study was performed under worst-case conditions, i.e., during wintertime in a hospital heated by hot water/forced air, and in patients receiving relatively high oxygen flow rates (5 L/min). The results to be presented suggest that humidification of oxygen for nasal cannula administration remains a common respiratory care practice in American hospitals, and indicate that this practice cannot be justified on grounds of patient comfort.

Materials and Methods

Hospital Survey

Hospitals listed in the American Hospital Association Guide to Hospitals as having between 575 and 625 beds were contacted by telephone. The director of the hospital's respiratory therapy department, or other knowledgeable individual in the department, was asked about departmental policies for humidification of oxygen for delivery by nasal cannula. In those departments in which oxygen was not routinely humidified for all such patients, departmental criteria for selection of patients to receive humidified oxygen were learned.
Of the 59 hospitals of appropriate size, four did not have in-hospital respiratory therapy departments. Data from the remaining 55 hospitals were tabulated and analyzed.

Clinical Protocol

All patients ordered to receive supplemental oxygen at flow rates of 5 L/min or greater by nasal cannula at the Jewish Hospital at Washington University Medical Center during a period of 92 consecutive days (November 1, 1985 through January 31, 1986) were included. For administrative simplicity, patients in even-numbered hospital rooms were assigned to receive humidified oxygen, and those in odd-numbered rooms received dry oxygen. Nasal cannulae were obtained from Salter Labs (Arvada, CA). Bubble-Jet humidifiers were purchased from Travolent (Deerfield, IL). Oxygen flow meters were supplied by Puritan-Bennett Corporation (Kansas City, MO) and by Timeter Instrument Corp. (Lancaster, PA). The specified accuracies of the flowmeters were ±0.25 and ±0.35 L/min, respectively, at settings of 5 L/min.

All patients were evaluated daily for the entire duration of high-flow oxygen therapy by the same interviewer (P.C.S.), and responded to a questionnaire designed to elicit symptoms possibly attributable to therapy with dry oxygen. Symptoms of interest were: 1) dry nose; 2) dry mouth and/or throat; 3) chest discomfort; and 4) headaches. Patients were also given the opportunity to voice any other complaints during each daily interview which they felt might be related to oxygen administration. All complaints were graded by the patients on a scale from 1 (least severe) to 5 (most severe). The patients were blinded to the purpose of the interview, and the patient bias was thereby minimized.

Data Analysis

Results were compiled and analyzed with the assistance of the Washington University Department of Biostatistics. The duration of oxygen therapy was compared between humidified and non-humidified groups by t-test, and was confirmed by a nonparametric test (Van der Waarden scores) since the duration of therapy was skewed toward brief duration and not normally distributed. For analysis of subjective outcomes as a function of age, sex, duration of therapy, and method of oxygen administration (humidified vs. dry), t-tests were performed. Chi-square tests were used to test for differences in the number of individuals in different diagnostic categories receiving dry or humidified oxygen, and for category differences in males and females.

For analysis of the effect of duration of therapy upon the severity of subjective complaints, multiple repeated measures analysis of variance was performed. For analysis of severity of symptoms, a scale of 0 was assigned when no complaint was voiced. The resulting six-point rating scale therefore ranged from 0 (no discomfort) to 5 (maximum discomfort).

Patients Studied

Two hundred sixty-eight adult patients were enrolled in the study. Of this number, 93 were not included in the final results for the following reasons: 1) one or more interviews not completed (42 patients); 2) change in room such that confusion arose over humidification of oxygen (seven patients); 3) patient request for humidification of oxygen upon initiation of therapy (four patients); and 4) patient mental status not adequate to respond to questionnaire (28 patients). Results from a total of 185 patients were thus evaluated (69 percent of those enrolled), representing a total of 470 treatment days. Of these patients, 99 (53.5 percent) received humidified oxygen and 86 (46.5 percent) received dry oxygen. The greater number of patients in the former group resulted from a slight excess of even-numbered rooms in our hospital. All patients received 5 L/min of oxygen during the study period. No order for greater flow rates was received during the study period. The authors did not prescribe the oxygen therapy or decide the flow rate to be delivered.

Demographic characteristics, duration of oxygen therapy, and diagnoses of the study population are detailed in Table 1. Most (41 percent) of the patients were postoperative, with the most frequent surgery being coronary artery bypass grafting. T-tests indicated that the groups did not differ in age (p<0.702) or duration of therapy (p<0.863). Chi-square tests indicated no significant differences in the frequency of males and females (p<0.847) or the frequency of the various diagnoses (p<0.306) between humidified and nonhumidified oxygen groups. Van der Waarden scores of group differences in duration of therapy indicated no differences in duration (p<0.426).

Results

Hospital Survey

The results of the telephone survey are presented in Table 2. There was wide variability in the policies for routine oxygen humidification. In nearly half of the hospitals surveyed, all patients received humidified nasal oxygen, and only three hospitals did not routinely humidify nasal oxygen for at least some patients. Twenty-five of the 30 hospitals in which oxygen was not routinely humidified cited recent evidence indicating lack of justification.

Patient Complaints

Figure 1 shows complaints, by type, of the patients studied. Complaints, especially of dry nose and dry throat, were common in both treatment groups. Head-
ache and chest discomfort symptoms, however, were recorded in only 15.1 and 16.1 percent, respectively, of the treatment days. "Other" complaints were varied and included epistaxis, rhinitis, sputum production and discomfort of nasal cannula apparatus. No difference in either type or frequency of these other complaints was noted between treatment groups.

The severity of symptoms experienced, as rated by the patients at each daily interview, is shown in Table 3. The patients tended to rate their symptoms as mild to moderate in severity. Figure 2 shows the mean discomfort ratings for the various symptoms reported by patients in the two groups. No significant difference in severity of symptoms between the humidified and non-humidified groups was noted for any complaint shown, as determined by t-test. Since the distribution of scores demonstrated a floor effect (frequency was greatest at lowest discomfort scores and was not normally distributed), nonparametric Van der Waarden scores were computed as well. The nonparametric tests confirmed the results of the t-test (dry nose, p<0.580; dry throat, p<0.457; headache p<0.465; chest discomfort, p<0.215).

Table 3—Severity of Symptoms Experienced by Patients Receiving Nasal Oxygen

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Humidified Oxygen</th>
<th>Dry Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Dry nose</td>
<td>22 23 39 7 50</td>
<td>1 48 40 3 13</td>
</tr>
<tr>
<td>Dry throat</td>
<td>0 36 53 11 26</td>
<td>0 23 40 10 31</td>
</tr>
<tr>
<td>Headache</td>
<td>2 4 9 4 8</td>
<td>0 13 18 1 6</td>
</tr>
<tr>
<td>Chest discomfort</td>
<td>1 2 16 5 14</td>
<td>0 8 10 0 9</td>
</tr>
</tbody>
</table>

*Data are number of patients rating symptoms at various degrees of severity at each daily interview. Severity scale ranged from 1 (minimal discomfort) to 5 (maximal discomfort).

We considered the possibility that the drying effect of non-humidified oxygen on the respiratory mucosa might be cumulative and that symptoms of dry nose and dry throat might thus increase with increasing duration of oxygen therapy. Figure 3 shows the severity of complaints of dry nose and dry throat as a function of duration of therapy. The first three days of therapy were analyzed, since only 17 patients received supplemental nasal oxygen at a flow rate of 5 L/min for four days or more. Severity of symptoms remained stable or decreased with time. Additionally (not shown), the number of patients in the non-humidified treatment group with complaints of severity 3 or greater decreased over the first three days of therapy.

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21573/)

![Figure 2](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21573/)

![Figure 3](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21573/)

**Figure 1.** Symptoms reported by patients receiving nasal oxygen, as determined by daily interviews. Results are expressed as percentage of total interviews in which the complaint was voiced. Solid bars: patients receiving humidified oxygen; hatched bars: patients receiving dry oxygen.

**Figure 2.** Symptom severity in patients receiving nasal oxygen. Results are means (± SEM) of individual patients' symptom severity scores as determined by a six-point rating scale ranging from 0 (no discomfort) to 5 (maximum discomfort). Each patient's severity score was averaged over the number of days he/she received oxygen therapy. Solid bars: patients receiving humidified oxygen; hatched bars: patients receiving dry oxygen. There was no significant difference in severity scores between humidified and non-humidified groups for any symptom shown.

**Figure 3.** Effect of duration of therapy upon severity of symptoms of dry nose and dry throat in patients receiving non-humidified oxygen. Patients receiving oxygen for less than three days were excluded. Hatched bars: dry nose; solid bars: dry throat. Rating scale is as described in Figure 2; n=33. Symptom severity remained stable or decreased with time.
for both symptoms. Analysis of the effect of duration of therapy upon symptom severity using multiple repeated measures design revealed no significant main effect of treatment (humidified vs non-humidified) upon level of discomfort for dry nose and dry throat. Our data thus do not support the possibility that increasing duration of nasal oxygen therapy results in increasing symptoms related to drying of the upper airway, nor do they suggest that long-term nasal oxygen therapy requires humidification of the delivered oxygen.

**DISCUSSION**

The results of our telephone survey indicated that respiratory therapy departments in medium-sized American hospitals vary widely with regard to their policies for routine humidification of nasal oxygen. Of 55 hospitals surveyed, nearly half humidified oxygen for all patients and most of the remainder delivered humidified oxygen to patients receiving oxygen flow rates in excess of 2-4 L/min. Only three surveyed hospitals did not routinely humidify nasal cannula oxygen at all. By the nature of the sample of hospitals selected, our survey included only urban hospitals from relatively large population centers, but this sample allowed us to perform a telephone survey and thereby obtain a response from all of the hospitals in the group. The respiratory therapy policies in these hospitals may or may not be representative of policies in the country as a whole, but our results suggest that: 1) considerable confusion exists regarding the advisability of routine oxygen humidification; and 2) routine oxygen humidification for some or all patients receiving oxygen by nasal cannula is a very common practice.

Our results regarding the subjective complaints of patients receiving supplemental oxygen by nasal cannula showed that such patients frequently voiced complaints relating to dry mucus membranes, but that these complaints were not alleviated by humidification of the oxygen prior to delivery. Under the indoor climate conditions studied, it might be expected that such complaints would be common in all of our hospitalized patients. We could not confirm this possibility because we surveyed only patients who were receiving nasal oxygen. Alternatively, the complaints (particularly dry nose and dry throat) might be related to nasal oxygen therapy but not alleviated by the incomplete humidification of medical gas achievable with the available devices. It is also possible that local discomfort from the presence of the cannula and/or the daily interview process itself called attention to nasal and other complaints that were voiced. Regardless of the cause of the frequent complaints, our study showed that these patients received no subjective benefit from oxygen humidification. Our results in this regard are in agreement with those of a previous study of a smaller patient population who received only low-flow nasal oxygen at flow rates of 4 L/min or less. Additionally, the severity of complaints related to drying of the upper airway mucosa appeared to be unrelated to the duration of oxygen therapy.

The assignment of patients to receive either dry or humidified oxygen was made on the basis of room number (odd vs even) for administrative simplicity, but we studied consecutive patients prospectively, and we have no reason to believe that the method of assignment to therapy modality affected the study outcome.

Our study of the subjective effects of humidification of oxygen is especially informative in comparison with the previously published study because of: 1) the large number of patients included in the present study; 2) our inclusion only of patients receiving high-flow oxygen (5 L/min); and 3) study under worst-case conditions (wintertime in a hospital heated by hot water/forced air).

It has been argued cogently that bubble-jet humidifiers are unlikely to be useful. Unheated bubble-jet humidifiers do not efficiently humidify the delivered oxygen, and the water-vapor content of the outlet gas falls as flow rate is increased. Low water vapor output is explained by the designs of the bubble-jet devices and by cooling of the device as much as 9°C by the flowing gas. Furthermore, only a small fraction of patients' inspired minute volumes is contributed by the oxygen flow. The humidity deficit created by inspirating dry oxygen is quite small in relation to that created by inspirating large volumes of room air of low relative humidity and at a temperature of approximately 22°C. The only subjective effect of dry oxygen that would be likely to be relieved by humidification of the delivered gas would be a very localized drying effect on the nasal mucosa. Although nasal symptoms were common in our patients, they were not relieved by oxygen humidification.

Lasky has stated the hope that we could "rationally determine for which patients' bubble-jet humidifiers should be used. The available data indicate that bubble-jet humidifiers are not useful for patients with intact upper airways who are receiving oxygen by nasal cannula. Our data, of course, do not apply to patients in whom the upper airway has been bypassed by endotracheal intubation or tracheotomy, in which case effective humidification of inspired gas is essential and achievable."

The present data, and other recent studies, indicate that cost savings may be achieved in respiratory care by judicious changes in the ways in which modalities are delivered. Additionally, consistent application of prescribed guidelines can result in marked decreases in respiratory therapy use without reductions in quality of care.
The manufacture of bubble-jet humidifiers is an $18 million industry in the United States. The present results indicate that discontinuation of routine humidification of oxygen administered by nasal cannula would not result in harm to patient comfort or outcome. Such action would result in considerable decrease in both time and material costs in respiratory care.

ACKNOWLEDGMENTS: The authors wish to thank Dennis Gelgut, R.R.T., for assisting with the hospital survey, Alexander Scott Kennedy for computer data input, and Phyllis Burch, C.R.T.T., for medical records research. We also appreciate the suggestions of Dr. R. M. Senior during the preparation of this manuscript.

REFERENCES
6. Lasky MS. Bubble humidifiers are useful—Fact or myth? Respir Care 1982; 27:735-36