The purposes of this study were to (1) describe the microenvironment in terms of oxygen concentration beneath the drapes of healthy subjects who were simulating patients undergoing minor surgical procedures with supplemental oxygen and to (2) evaluate the efficacy of using a scavenger system beneath the drapes. A convenience sample of 12 healthy volunteer subjects was studied in an ambulatory surgery center operating room, which was ventilated with 25 air exchanges per hour. The study was carried out in 2 parts. Each subject was supine, and oxygen was applied by a standard nondivided nasal cannula. The subjects were draped as routinely done for ophthalmic procedures. Oxygen concentrations were measured by using an Ohmeda Rascal II gas analyzer beneath the drapes and at the hypothetical surgical site with oxygen flow rates of 0, 1, 2, 3, and 4 L/min, allowing 5 minutes to elapse after a change in flow rate was made. Following a 10-minute break, the subjects were redraped, and the procedure was repeated using a scavenger system consisting of a suctioning system connected to wall suction at 170 to 190 mm Hg.

Although the mean ± SD oxygen saturation never fell below 95% (97.75% ± 1.54%), mean ± SD oxygen concentrations beneath the drapes were lower than normal room air concentrations (19.08% ± 0.51%) when no oxygen was delivered to the patient. With supplemental oxygen and no scavenger system, oxygen concentrations beneath the drapes were consistently elevated (as high as 45% with 4 L/min) compared with normal ambient concentrations (21%) or with concentrations obtained at the surgical site (as high as 23.4%). With the scavenger system in place, mean ± SD oxygen concentrations reached 34.08% ± 5.52% beneath the drapes. Statistical analyses revealed that significantly higher oxygen concentrations occurred beneath the drapes with each incremental change in oxygen flow rate, and regardless of the oxygen flow rate used, oxygen concentrations beneath the drapes were significantly reduced with the use of the scavenger system.

Key words: Anesthesia complications, fires, gas scavengers, oxygen, safety.
Introduction

A search of the Index Medicus and the Cumulative Index to Nursing and Allied Health Literature databases for the 15-year period of 1982-1997 revealed numerous case reports of small fires caused by the ignition of drapes and other fuels by cautery devices. Although the occurrence of these untoward events is well documented, the circumstances surrounding their development are not well known. Until the circumstances that cause these fires are better understood, preventive measures cannot be implemented systematically. The purposes of this study were (1) to describe the microenvironment in terms of oxygen beneath the drapes of healthy subjects who were simulating patients undergoing minor surgical procedures with supplemental oxygen, and (2) to evaluate the efficacy of using a scavenger system to lower these concentrations.

Literature review. It is difficult to accurately estimate the magnitude of the problem because there is no national mandatory reporting system for minor operating room fires. While one author cited as few as 10 fires involving ophthalmic surgery alone, another stated that approximately 20 to 30 fires occur per year. One report cited a patient undergoing cataract extraction under local anesthesia with supplemental oxygen per nasal cannula at 5 L/min during which a disposable cautery ignited a cellulose sponge, and the patient sustained first-degree burns. Another described 2 cases of fires in which the patients were undergoing minor operations with supplemental oxygen used throughout the case or at the beginning of the case and turned off before excision or cautery use. Both patients sustained second-degree burns to the face as a result of a cautery-produced spark followed by flash fires involving drape materials and nasal cannula tubing. A similar fire during a tracheostomy procedure was reported. Several other fires were reported, all of which were associated with supplemental oxygen or leaking endotracheal tubes, close ignition sources, and fuel, which when combined produced untoward effects for their patients. A few authors disputed the belief that elevated oxygen concentrations at the operative site were the cause of the fires they described, but most attributed their fires to oxygen-enriched atmospheres (OEs) beneath the surgical drapes or at the operative site.

Strategies to prevent fires in these circumstances have been suggested. One recommendation was that drapes should not be allowed to cover the face. This is based on the assumption that supplemental oxygen and exhaled oxygen and carbon dioxide would then mix with room air, which would reduce the occurrence of OEs beneath the drapes. If drapes over the face are necessary for sterile field purposes, several authors recommended tenting the drapes to allow the heavier oxygen molecules to sink to the floor near the operative site.

It has been suggested that the concentration of oxygen can be diluted with inert gases, such as nitrogen, air, or helium, or that room air should be circulated beneath the drapes, which in some cases could eliminate the need for supplemental oxygen altogether. In addition, supplemental oxygen should be used only when absolutely necessary at the lowest possible concentrations, and, if at all possible, room air should be used or the oxygen shut off at least 60 seconds before the use of heat-producing surgical instruments. Arguments for withholding oxygen are based on the premise that patients undergoing minor outpatient surgical procedures usually do not require oxygen. However, supplemental oxygen is desirable because of the possible respiratory depressive effects that conscious sedation produces. Furthermore, drapes placed over the face without supplemental oxygen have been associated with carbon dioxide accumulation and patient complaints of feeling suffocated. Under these circumstances supplemental oxygen may be desirable. However, given the risks, there may be a benefit to reducing, eliminating, or replacing oxygen with compressed room air.

An alternative approach to prevention of gas accumulation is the use of suction to eliminate both oxygen and carbon dioxide build-up beneath the drapes. One specific recommendation is to: “Poke a hole in the bottom of a Styrofoam coffee cup. Tape a piece of suction tubing into the hole and connect the other end to suction. Tape the cup to the patient’s chest with the open end right under his chin.” The originator of this approach is unknown, and there are no published data to support its effectiveness.

Numerous authors advise against use of cautery (especially on the higher cutting modes) when the surgical field is in proximity to an oxygen source or, at the very least, that bipolar rather than unipolar electrocautery be used to minimize leakage of current. The use of disposable cautery units is not recommended, but if used, the lowest tip temperature should be selected.
ther strategies to separate oxygen-enriched areas from operative areas use incised or occlusive drapes. Finally, preventive measures, such as dampening towels, sponges, and packing material, to lower chance of combustion, are highlighted.

The theoretical underpinnings for the present study arise from the theory of combustion and the role of oxygen in supporting a fire. The production of a fire requires the simultaneous combination and proportion of 3 essential components including heat, fuel, and oxidizer. The theory of combustion can be summarized graphically using a fire triangle as in Figure 1, each side of which is controlled by a member of the surgical team. One important property of oxygen is its ability to support a fire. Materials that burn in room air will burn much more vigorously and create higher temperatures in the presence of OEs. Because oxygen is heavier than ambient air, it is capable of collecting in low-lying areas and is retained by some materials for longer periods. Oxygen-enriched atmospheres are defined by the National Fire Protection Association as “any atmosphere in which the concentration of oxygen exceeds 21% by volume or the partial pressure of oxygen exceeds 160 mm Hg, or both.” In some situations, this definition has been modified to 23.5% to account for the upper limit of oxygen concentration in compressed air.

Empirical studies. Only 1 study was found that specifically addressed the issue of OEs beneath surgical drapes and at the operative site. Twelve volunteer subjects were draped as though for surgery, and oxygen was supplied to each subject at various flow rates by nasal cannula. Oxygen concentrations were measured beneath the drapes near the chin and above the drapes near the forehead every 5 minutes. The subjects were monitored with pulse oximetry and were not sedated. The rate at which concentrations declined after cessation of oxygen supplementation also was studied. The study revealed several noteworthy findings. In the control group, which had no supplemental oxygen, mean ± SD concentrations of oxygen beneath the drapes were lower (17.2% ± 1.7%) than room air concentrations of oxygen. With supplemental oxygen, concentrations beneath drapes were consistently higher than ambient concentrations, reaching as high as 53.5%, with the operative site reaching 26.3%. Oxygen concentrations at the operative field took 30 seconds to return to ambi-

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**Figure 1. The fire triangle**

Oxidizers (contributed by anesthesia personnel)
- Oxygen
- Nitrous oxide

Heat and ignition sources (contributed by surgeons)
- Sparks from any piece of equipment
- Fiberoptic light sources and cables
- Argon beam coagulators
- Laser contact tip or fiber
- CO₂ laser handpiece
- Electrosurgical units
- Electrocautery units
- Bare laser fiber
- Heated probes
- Drills and burs
- Defibrillators

Fuels (contributed by nursing personnel)
- In or on patient (hair, gastrointestinal tract gases)
- Prepping agents (degreasers, aerosols, adhesives, alcohol, tinctures)
- Linens (drapes, gowns, masks, hoods, caps, shoe covers, instrument drapes/cover, egg crate mattresses)
- Ointments (petroleum jelly, tincture of benzoin, aerosols, paraffin white wax)
- Equipment/supplies (gloves, disposable packaging, materials, etc.)

*This is a pictorial summary of concepts related to the theory of combustion as depicted by the fire triangle. Note that each member of the surgical team controls a side of the triangle by contributing an oxidizer, fuel, or heat source, the combination of which is necessary to produce a fire.*
ent concentrations of oxygen once the oxygen supply was discontinued. In contrast, beneath the drapes it took 60 seconds to reach room air levels after discontinuation of oxygen when flow rates were less than 3 L/min and even longer at higher flow rates. These findings support the belief that oxygen pools beneath the drapes and poses a fire hazard. However, replication is indicated to validate these findings and test possible solutions.

Further evidence supports the assumption that pooling of oxygen beneath the drapes is likely a problem and potential fire hazard as several authors experimentally attempted to reproduce a fire in room air and found that they usually were unable to do so. However, their attempts to create a fire with supplemental oxygen present were successful. Unfortunately, few of these authors published empirical data relevant to their experiments.

An alternative observation suggests that oxygen pooling is not the primary suspect in these fires. This conclusion was based on a study designed to determine whether cautery devices are capable of igniting cotton gauze and other operating room materials in room air or whether supplemental oxygen is necessary for ignition. The ignitability of 8 common operating room materials was tested using 2 cautery devices in room air, a high-temperature device (1200°C), and a low-temperature device (680°C). The high-temperature cautery device was capable of igniting cotton gauze, paper tape, cotton towels, and Weck-Cel (Xomed Surgical Products, Inc., Jacksonville, Fla) sponges in the absence of an OEA. These findings suggest that fires may be secondary to the combination of high-temperature cautery units and flammability characteristics of operating room materials alone.

A similar study investigated the ignitability of different surgical drape materials, both disposable and reusable, using lasers (carbon dioxide, Nd:YAG, potassium tattanyl phosphate, and argon) as the ignition source both in room air and in 100% oxygen. Results of this experiment showed that in room air, most drape materials melted, charred, or developed holes, and some burned. In 100% oxygen, all drape materials burned with frightening ease. The study acknowledged the inherent risks of combining lasers with drape materials, but also supported the need to minimize OEAs whenever possible.

The role of nasal cannula placement on fire susceptibility was tested using a fiberglass model of a man’s head and neck region to represent a surgical patient. Oxygen was delivered to the undraped model using a properly placed nasal cannula, a displaced nasal cannula at the chin level, and oxygen delivered by an adapted suction tubing. The study groups were based on the different oxygen delivery methods; the control was a model with no supplementary oxygen. Oxygen in the other 3 groups was delivered at flow rates varying from 2 to 5 L/min, and an electrosurgical unit was introduced to all 4 groups at varying levels of intensity. Ignition at variable distances from the oxygen sources was noted. No flash fire occurred in the control group. The groups with a displaced nasal cannula and the adapted suction tubing both resulted in a fire. The minimum requirements for combustion were an oxygen flow of 2 L/min, an electrocautery coagulation level of 30 W, and a distance of 5 cm from the oxygen source in the midline or 2 cm on either side of the model’s midline. Interestingly, the group with a properly placed nasal cannula had no fire even with maximum oxygen flow and coagulation levels. Although the study did not consider human factors, such as respiration or facial hair, it pointed out the need to be vigilant when placing the nasal cannula and advised against using make-shift oxygen delivery devices.

While many ways to change practice are suggested in the literature, only 1 study was found that examines the effectiveness of a technique for minimizing OEAs. The study evaluated the use of compressed air instead of oxygen during ophthalmic operations. The objective of the study was to determine the patient’s tolerance for receiving compressed air compared with oxygen. This prospective study included a large sample (n=100) and excluded patients with preexisting pulmonary problems. Random assignment was used, and room air or oxygen was delivered by nasal cannula at various flow rates. Study results revealed that while on average, the patients receiving compressed air had lower oxygen saturation (94.1%) than did the patients receiving oxygen (97.76%), there were no clinically or statistically significant differences between the 2 groups. The results of the study suggest that substituting compressed air for oxygen may be an effective alternative that would reduce the risk of fire hazard for some patients.

Empirical data reveal a controversy over whether fires involving the ignition of surgical drapes, patient hair, or other forms of operating room fuel by electrocautery or electrosurgical devices are actually due to the presence of OEAs beneath surgical drapes. Furthermore, efficacy of
methods to circumvent the potential problem of oxygen pooling beneath the drapes has not been documented.

The present study addressed the following research questions:

1. Do OEA's (oxygen concentration >21%) develop and exist beneath the surgical drapes of subjects who are simulating the conditions of patients undergoing routine facial or ophthalmic procedures?

2. How does administration of varying flow rates of supplemental oxygen beneath surgical drapes, as previously described, affect the oxygen concentration beneath the drapes?

3. Does the presence of a scavenger system beneath the drapes, as previously described, reduce the oxygen concentrations?

Materials and methods

■ Sample. Institutional review board approval was obtained. The study was carried out after hours and on weekends in an ambulatory surgery center operating room that ventilates with 25 air exchanges per hour based on manufacturer’s specifications. A convenience sample of 12 healthy volunteers (10 women, 2 men), ranging in age from 25 to 55 years (mean ± SD, 34.33 ± 11.18 years), were recruited. Each subject consented to participate in the study and signed a human subjects consent form. Of the 12 subjects, 2 were tobacco users (≤ 1/2 pack per day), 2 were taking antidepressant medication, and 3 were taking oral contraceptives. All subjects were of average weight. Eligibility for inclusion in the study required only that the subject be older than 21 years without serious medical conditions and be capable of lying supine for approximately an hour and a half.

■ Instruments. The research variable was operationally defined for the study as oxygen concentration in the environment and was measured by an Ohmeda Rascal II gas analyzer (Ohmeda, Madison, Wis) and the oxygen sensor on the Narkomed anesthesia machine (North American Drager, Telford, Pa). According to manufacturer’s specifications Rascal II gas analyzers perform an automatic self-calibration and are capable of analyzing 0 to 100 vol% oxygen with accuracy at the 99.7% confidence level (±3 SD) for oxygen at greater of ±2 vol% or 5% of reading. Manufacturer specifications for the oxygen sensor on the Narkomed machine include a range of 10% to 100% with accuracy of ±3 vol% for oxygen following a manual calibration after exposure of the sensor to room air. Both systems provide a continuous oxygen concentration reading displayed in percentage of oxygen. Initial baseline room air oxygen concentrations were measured by the Rascal II and verified using measurements obtained by the oxygen sensor.

■ Data collection procedures. Data for sample characteristics were collected on each subject entering the study, including date of study, sex, age, and any medications. This information and all relevant data regarding the surgical microenvironment were recorded on a data collection form designed specifically for the present study.

The study was carried out in 2 parts. The microenvironment beneath the drapes was studied first without a scavenger system and then repeated with a scavenger system. The draping techniques and monitoring equipment were assembled identically for each phase, as depicted in Figure 2 and as described herein. Before beginning data collection for each subject, the oxygen sensor on the anesthesia machine was calibrated to room air and compared with readings obtained with the Rascal II gas analyzer, which performs an initial self-calibration test. Each subject was asked to lie supine on the operating table with a pillow beneath the head for comfort. Oxygen from the anesthesia machine flowmeter was applied by a standard nondivided AirLife Nasal Cannula (Baxter Healthcare, Valencia, Calif). A 4-way stopcock was attached to standard gas sampling tubing, which was connected to the Rascal II gas analyzer. One small-bore 36-in intravenous extension tubing then was connected to the side port of the stopcock, and the distal end of the tubing was taped to the patient’s cheek (site 1, beneath drapes). A towel was draped horizontally with the edge across the bridge of the nose, and a large Kimberly-Clark Corporation (Dallas, Texas) polypropylene drape was used to cover the entire body from the bridge of the nose down to the end of the operating table, as conventionally done for routine ophthalmic procedures. The distal end of a second small-bore 36-in intravenous extension tubing was taped to the drape at the level of the patient’s cheek (site 2, hypothetical surgical site), while the proximal end of this tubing was attached to the other stopcock port of the Rascal gas sampling tubing.

Data collection began once the subject was draped and a preliminary oxygen concentration was obtained and recorded with the Rascal II at sites 1 and 2. The data collector controlled the oxygen flow rates by using the oxygen flowmeter.
Measurements were recorded for each site at nasal cannula oxygen flow rates of 0, 1, 2, 3, and 4 L/min allowing a 5-minute equilibration period to elapse after each change in flow rate was made. Following a 10-minute break, the subject was redraped and the procedure was repeated with a scavenger system in place to remove waste gases from the microenvironment beneath the surgical drapes. The scavenger system was assembled as follows: one end of suction tubing was inserted through a hole and secured in the bottom of a 4-oz specimen cup, while the other end of the tubing was connected to high continuous wall suction (170-190 mm Hg). The cup then was secured to the subject’s chest below the surgical drapes with the open end under the subject’s chin.

Overall, 10 pairwise comparisons were conducted with an alpha of 0.005 (0.05/10) for each test. Measurements made before draping using the oxygen sensor were compared with those obtained by the Rascal II. Both consistently measured room air oxygen concentrations of 21%.

Mean oxygen concentrations before draping and at various oxygen flow rates following draping are given in Table 1. Although the mean ± SD oxygen saturation never fell below 95% (97.75% ± 1.54%) in the study sample, mean ± SD oxygen concentrations beneath the drapes were lower than normal room air concentrations (19.08% ± 0.51%) when no oxygen was delivered to the patient for just 5 minutes. With supplemental oxygen and no scavenger system, oxygen concentrations beneath the drapes rose steadily and were consistently elevated (as high as 45% with oxygen at 4 L/min) compared with normal ambient concentrations (21%) or with concentrations obtained at the surgical site (as high as 23.4%). Repeated-measures analysis of variance revealed that different oxygen flow rates significantly increased the oxygen concentration beneath the drapes ($F_{a} = 213.00; P<.0001$) (Table 2). Five paired $t$ tests were used to

**Figure 2. Draping technique and depiction of monitoring locations and scavenger system used in the study**

![Draping technique and scavenger system](image)
compare specific oxygen flow rates using an overall alpha of 0.05 (2-tailed) and a Bonferroni procedure to control the type I error rate. The results of these post-hoc analyses are given in Table 3. The draping condition significantly increased oxygen concentrations from those before draping ($t_{11} = 12.89; P < .0001$). Pairwise comparison of different oxygen concentrations revealed that significantly higher oxygen concentrations occurred beneath the drapes with each incremental change in oxygen flow rate (Table 3).

With the addition of the scavenger system beneath the drapes, oxygen concentrations also rose beneath the drapes, but reached only mean ± SD concentrations of 34.08% ± 5.52% (Table 1). Oxygen concentrations at the surgical site (site 2) remained at 21% when oxygen was delivered at 0 to 2 L/min regardless of whether a scavenger system was used. Without a scavenger system, the mean ± SD levels increased slightly to 23.42% ± 1.93%, while the mean ± SD levels for the group with a scavenger system in place reached only 22.17% ± 0.94%. Using a Bonferroni procedure and an overall alpha of 0.05 (1-tailed), 5 paired $t$ tests were used to analyze the effect of using the scavenger system on oxygen concentrations beneath the drapes. Regardless of the supplemental oxygen flow rate used, oxygen concentrations beneath the drapes were reduced significantly with the use of the scavenger system (Table 4).

### Discussion

Results from the present study indicate that oxygen concentrations beneath surgical drapes drop to levels below atmospheric concentrations. The finding of oxygen concentrations of approximately 19% beneath the drapes without use of supplemental oxygen supports continuation of the practice of using oxygen when the face is covered. Although the oxygen saturation never fell below 95% in this healthy sample, the hypoxic environment may be poorly tolerated by elderly patients or patients with cardiopulmonary compromise.

When supplemental oxygen was added beneath the drapes, OEs developed with mean ± SD oxygen flow rates as little as 1 L/min (24.92% ± 1.56%). Furthermore, they increased significantly with each incremental increase in flow rate. Even more compelling is the finding that flow rates of 2 L/min, which are commonly used in practice, produced alarmingly elevated mean ± SD OEs (30.83% ± 3.35%). Unfortunately, there are no clear guidelines regarding the level of OEA at which precautions are indicated. Some regulatory bodies require that precautions be implemented for oxygen concentrations of 24.9%, while others are concerned when OEs reach 26% to 28%, which is known to accelerate the speed of combustion significantly above that of room air. The present study demonstrated that patients may be experiencing OEs at or very near this critical threshold with commonly used

<table>
<thead>
<tr>
<th>Table 1. Mean ± SD of oxygen concentrations beneath the drapes without and with scavenger system (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental condition</strong></td>
</tr>
<tr>
<td>No drape</td>
</tr>
<tr>
<td>Draped</td>
</tr>
<tr>
<td>Draped</td>
</tr>
<tr>
<td>Draped</td>
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<td>Draped</td>
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<td>Draped</td>
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<table>
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<tr>
<th>Table 2. Analysis of variance with repeated measures to determine differences in oxygen concentrations across various oxygen flow rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>Subject</td>
</tr>
<tr>
<td>Between group</td>
</tr>
<tr>
<td>Within group</td>
</tr>
</tbody>
</table>
oxygen flow rates. Therefore, it would seem prudent to initiate procedures to reduce the oxygen concentrations beneath the drapes to minimize risk to patients.

The presence of the scavenger system was effective in lowering, but not eliminating, elevations in oxygen concentrations beneath the drapes. The scavenger system not only lowers the oxygen concentrations, but does so without posing risks to the patient or adding appreciable costs. Based on these results, we believe that the benefits of providing 1 L/min of supplemental oxygen to patients to prevent development of a hypoxic environment outweighs the risks.

We acknowledge several limitations of the present study. First, because a convenience sample was used for this quasi-experimental study, there are limitations in the ability to generalize findings to other populations inherent in the design of this investigation. However, by using each subject as his or her own control, relative equivalence is established. Any differences found should be secondary to the presence or absence of the independent variable and not to subject variability.

Second, although one would presume that results obtained in the present study would reflect outcomes obtained in the operating room with patients undergoing routine facial and ophthalmic procedures, several variables could alter these findings and limit their generalizability. For example, different draping materials and techniques may affect the degree to which oxygen is trapped beneath the drapes. In the present study, differences in draping were controlled for by using the same materials and techniques for every subject. Furthermore, patients with preexisting pulmonary disease may inhale and exhale air and supplemental oxygen differently than patients without pulmonary involvement. This theoretically could affect concentrations of gases beneath the drapes. The present study was limited to responses as they occurred in healthy subjects.

Another consideration is that the implementation of conscious sedation by the anesthesia care provider and subsequent varying levels of sedation achieved by the patient during actual surgical procedures may produce subtle variations in the results obtained. These sources of variability were not evaluated in the present study. In addition, the possibility exists that the instrument chosen to measure oxygen concentrations itself will cause a small reduction in actual concentrations of oxygen due to the gas sampling method used by Rascal II gas analyzers. This could mimic, though to a lesser extent, the effects of a scavenger system. These dif-

Table 3. Differences in oxygen concentrations at various oxygen flow rates

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Mean difference</th>
<th>df</th>
<th>t*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No drape and no supplemental oxygen vs drape</td>
<td>1.917</td>
<td>11</td>
<td>12.89</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>and no supplemental oxygen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drape and no supplemental oxygen vs drape and 1</td>
<td>-5.83</td>
<td>11</td>
<td>-11.55</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>L/min supplemental oxygen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drape and 1 L/min supplemental oxygen vs drape</td>
<td>-5.92</td>
<td>11</td>
<td>-7.05</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>and 2 L/min supplemental oxygen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drape and 2 L/min supplemental oxygen vs drape</td>
<td>-6.92</td>
<td>11</td>
<td>-6.51</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>and 3 L/min supplemental oxygen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drape and 3 L/min supplemental oxygen vs drape</td>
<td>-6.92</td>
<td>11</td>
<td>-8.33</td>
<td>&lt;.0001</td>
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<tr>
<td>and 4 L/min supplemental oxygen</td>
<td></td>
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<td></td>
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* Bonferroni correction

Table 4. Differences in oxygen concentrations beneath drapes with and without the scavenger system at various oxygen flow rates

<table>
<thead>
<tr>
<th>Oxygen flow rates (L/min)</th>
<th>Mean difference</th>
<th>df</th>
<th>t*</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>-0.50</td>
<td>11</td>
<td>-2.17</td>
<td>.9737</td>
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<tr>
<td>1</td>
<td>1.83</td>
<td>11</td>
<td>4.75</td>
<td>.0030</td>
</tr>
<tr>
<td>2</td>
<td>5.08</td>
<td>11</td>
<td>4.99</td>
<td>.0002</td>
</tr>
<tr>
<td>3</td>
<td>6.67</td>
<td>11</td>
<td>3.97</td>
<td>.0010</td>
</tr>
<tr>
<td>4</td>
<td>10.58</td>
<td>11</td>
<td>5.43</td>
<td>.0001</td>
</tr>
</tbody>
</table>

* One-tailed for dependent groups with Bonferroni correction
ferences should be relatively small since the Rascal II draws a continuous 200 to 300 mL gas sample (which may be reduced further by the addition of the small bore extension tubing), and the scavenger system theoretically would draw a much larger volume of air. It is believed that the protocol for the present study can be replicated with actual surgical procedures and patient populations and thus enhance generalizability of the findings.

Finally, measurement intervals used in the study (every 5 minutes) were based on the method used in a previous study. It is possible that with a longer duration at any particular oxygen flow rate, oxygen concentrations may accumulate to even higher levels than were measured by the present study. There may be some merit in replicating the present study and allowing more time to elapse between measurements.

Summary

The findings of the present study replicate the results obtained in a previous study and reinforce the suggestion that OEs develop and exist beneath drapes during facial and ophthalmic procedures. Therefore, anesthesia care providers must be aware that the potential for disaster exists and take precautions to minimize risk to patients. Although the scavenger system examined in this study must be evaluated further in actual surgical conditions to confirm efficacy, we believe that this or some other means of preventing OEs from developing beneath surgical drapes during such cases should be considered. Finally, while simply discontinuing the supplemental oxygen may initially seem the most straightforward solution, this should be done with caution in the light of the hypoxic mixtures that have been shown to exist beneath surgical drapes.

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