# Incidence and reduction of formaldehyde-induced symptoms in gross anatomy laboratories

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Formaldehyde is a major component of mixtures used to embalm cadavers for dissection in gross anatomy laboratories. Symptoms attributable to low level formaldehyde exposure include eye irritation, headaches and nausea, even though ambient levels are below that of the acceptable limit. Possible interventions for the reduction of the frequency of these symptoms are improved ventilation systems, embalming mixtures with lower levels of formaldehyde, education, and enforcement of laws. Evaluation of these strategies can be done by monitoring formaldehyde levels as well as frequencies of symptoms after implementation of the interventions.

Formaldehyde (HCHO) is a colourless, flammable gas with a strong pungent odour. It is extremely soluble in water and the aqueous solution containing 37% formaldehyde is called formalin. Since its tissue hardening properties were discovered and its efficacy as a preserving and embalming agent realized, it has gone into widespread use as a constituent of embalming fluids. Its use in this manner eliminated the health hazards associated with the previously used metal-based (arsenic, lead, mercury or zinc) solutions but formaldehyde's own potential health hazards were not known at that time.

In the United States, the current permissible exposure limit (PEL) to formaldehyde was set to 3 parts per million (ppm) for an eight-hour time-weighted average (TWA). In 1992, the American Conference of Governmental Industrial Hygienists adopted a change to a 1 ppm TWA based on suspected carcinogenicity (1). Exposure to concentrations ranging from 0.01 to 5 ppm can cause eye irritation and irritation of the upper respiratory tract. Exposure to higher concentrations can produce coughing, tightness in the chest, headache, nausea and sleeplessness. Chronic effects of continued exposure to formaldehyde include chronic airway obstruction, dermatitis, asthma, bronchitis, rhinitis, pharyngitis, menstrual disorders, reproductive disorders, and possibly cancer(2). Table 1 demonstrates these effects.

**Table 1: Adverse effects of inhaling formaldehyde at increasing concentration (3).**

| Formaldehyde conc. (ppm) | Adverse effects on health |
|---|---|
| 0.05 - 1.0 | Odour threshold |
| 0.05 - 2.0 | Eye irritation, neurophysiologic effects |
| 0.10 - 25 | Nose and throat irritation |
| 5 - 20 | Maximal tears within a few minutes, lower airway and pulmonary effects (dyspnea, coughing, burning of nose, eyes, pharynx) |
| > 20 | Pulmonary edema, pneumonia |

Although the health effects of formaldehyde exposure have been studied in the occupational setting, recent interest has developed in the possible health effects of formaldehyde exposure in the gross anatomy laboratories of medical schools. Human cadavers are preserved in a formalin solution, with phenols added as a bleach and germicide. The

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concentration of formaldehyde in air is greater when students dissect the body cavity or deep structures, and lower when more superficial structures are being dissected(1). Medical and other health professions students are therefore exposed to varying concentrations of formaldehyde during dissections, depending on the site of the cadaver being dissected. Results of studies of formaldehyde levels in gross anatomy labs have shown that they are below the current PEL and ideally, students and lab technicians should not experience adverse health effects with repeated exposure(4). At the Dalhousie medical school, there is one gross anatomy laboratory, containing approximately 15 cadavers and many prosections. During the anatomy unit, there were two three-hour scheduled lab periods per week. When not in use, the cadavers were wrapped in embalming fluid-soaked cloth and enclosed in plastic. This paper will attempt to report the incidence of formaldehyde-induced symptoms in medical students at Dalhousie University due to exposure in the gross anatomy laboratory.

## METHODS

A self-administered questionnaire was provided to first year medical students after the gross anatomy unit to determine whether or not he/she had experienced symptoms representative of formaldehyde exposure: eye irritation, sneezing, headache, coughing, sinus problems, nose irritation, sleep disorders, nausea, throat irritation, and chest tightness. The frequency with which each of the symptoms had occurred (always, sometimes, rarely or never) was also obtained.

## RESULTS

The results from the survey are shown in Table 2:

**Table 2 : Distribution of reported formaldehyde-related symptoms in gross anatomy laboratories (2) at Dalhousie University (n=67).**

| Symptoms | % Responding "Always" or "Sometimes" |
|---|---|
| Eye irritation | 52.2% |
| Sneezing | 31.3% |
| Headache | 70.1% |
| Coughing | 19.4% |
| Sinus problems | 26.9% |
| Nose irritation | 44.8% |
| Sleep disorders | 10.4% |
| Nausea | 34.3% |
| Throat irritation | 34.3% |
| Chest tightness | 6.0% |

## DISCUSSION

While formaldehyde levels in gross anatomy labs are at levels below the PEL, many students still experienced some form of acute irritation. This presents a problem because the impact of formaldehyde levels may be not only on their learning ability, but also on their general well-being.

The response rate was 81.7% and symptoms were self-reported. The survey did not provide clear definitions of reported symptoms and consequently some of the percentages may be misleading (for example, constant sniffling could have been considered as nose irritation or as a sinus problem). There were wide variations as to when and to what extent people realized symptoms of irritation; in some the effects were forgotten, others may have had different thresholds, while some may have had symptoms before exposure to formaldehyde. Number of hours spent in the lab by each student was not obtained which is significant because symptoms may be related to the number of hours spent in the lab. Students were present in the lab during scheduled and non-scheduled periods for different amounts of time.

This study has limitations, but it may be more significant to note that people did complain of at least one symptom or another which indicates a compromise of their physical well-being. Of the first year medical students at Dalhousie who responded to the survey, only 9.0% reported to have experienced none of the symptoms during the course. The question remains whether there are any actions which can be undertaken to alleviate, or possibly eliminate the irritation without diminishing the embalming capabilities of formaldehyde. The following interventions are suggested:

1. Ventilation - The use of an effective ventilation system would make it possible to lower the concentration of formaldehyde in the gross anatomy laboratory. The anatomy laboratory operational status should be monitored, especially during times when students are in the labs. There are two main systems to consider: local and general(5). Local exhaust systems are designed to capture contaminants as close to their source as possible and direct the flow away from the worker or student. General ventilation involves the pumping in of fresh air with the hopes of diluting the concentration, the effectiveness being dependent on the number of air changes per day. Since there are a number of cadavers per anatomy lab, the sources of formaldehyde are spread out so that general ventilation may be the more practical approach. As of 1989, no standards have been set for ventilation systems or other mechanisms for control of ambient levels of formaldehyde in laboratories.

   To complement the effects of overall ventilation

systems, more local extraction of formaldehyde vapour is often appropriate. The vapour should be carried away and diluted before discharge to the atmosphere. These devices incorporate absorption filters to removes gases and vapours from the air before returning it to the laboratory. On the other hand, there are a number of significant problems which should be considered if it is to be safe and effective at removing formaldehyde and maintaining the concentration below the correct threshold limit. Adequate containment of fumes at the front must be achieved by generating an inflow velocity of at least 0.5 m/s. As well, in order to remove the fumes using the filter, the contact time must be sufficient for adequate absorption to take place and there should be a reliable indication of filter saturation (sense of smell has been suggested to be a good determination of end-point of filter life)(6).

The major factor limiting the use of a good ventilation system is the cost, not only for instalment, but also for maintenance and testing. The anatomy lab at Dalhousie University recently installed a new ventilation system, but as of December, 1994 its effectiveness at diminishing formaldehyde levels had yet to be measured. Information about its mechanism or its cost was not obtained.

2. Education - Steps should be initiated to inform students and technicians about the significance of formaldehyde levels and the consequences of exposure. Detailed discussions with all technicians and students should take place before the start of the course, with the aim of achieving a more critical attitude toward the health hazards of formaldehyde in gross anatomy laboratories . Potentially students will wish to take necessary precautions such as wearing lab coats and gloves to prevent skin irritation, or wearing goggles if their eyes are sensitive. The feasibility of this strategy is reasonable; only one hour per course is necessary to warn students of the potential dangers. At present, the Dalhousie Department of Anatomy recommends the wearing of lab coats and gloves, but the description of formaldehyde induced symptoms should be made clear to students. Currently goggles are available, and students are warned about possible irritation related to the wearing of contact lenses.
3. Alternative embalming solutions - If an embalming solution is lower in formaldehyde but is as effective, it could be an effective means of lowering formaldehyde levels, bearing in mind the potential hazards of the other components of which the volumes would have to increase to compensate (e.g. phenol). O'Sullivan(7) showed that varying the composition of embalming fluids can still result in apparently good fixation, particularly in one with lower formaldehyde and distilled water proportions and raised industrial methylated spirit (IMS) and glycerol proportions.

Papst(3) reported that the use of an embalming fluid consisting of 86.5% ethanol, 8.1% formalin, 2.75% glycerol and 2.7% phenol, and subsequent storage for at least 3 months in 70% ethanol resulted in a formaldehyde level which never exceeded 0.2 ppm. In light of these stunning results, labs still do not choose to change embalming mixture; it may be due to the increased amount of time that would be needed in order to change mixtures, or perhaps due to the availability or costs of the separate components. The Dalhousie University Department of Anatomy uses a mixture of formaldehyde, phenol, propylene glycol, sodium acetate and water, and claims the ambient formaldehyde level of the lab is under the set standard. Information about the amounts of each in the mixture was not obtained.

4. Enforcement - At present, the Department of Labour does not monitor the formaldehyde levels in gross anatomy labs; this task is left to the University. The Department of Anatomy at Dalhousie conducts such tests once every two years, and the lab staff itself monitors levels on its own approximately once a month. If the provincial government, specifically the Department of Labour was to set up legislation for mandatory testing, it would compel the labs to increase the frequency of their own testing and thus better protect the students and staff. The concept of surprise visits would also act in this manner.

The Occupational Health and Safety Act (OHSA) provides the authority to regulate the ceiling formaldehyde level at 0.3 ppm, but this only applies to paid staff. In simple terms this means that it is not required by law that formaldehyde levels be below the ceiling limit for the sake of students' safety, and technically, students can be exposed to higher levels without any legal repercussions. The Department of Labour knew of no legal act which protected the students in a similar manner as the OHSA protects workers, but if one was implemented, it would certainly force labs to take extra precautions. However, students are able to participate in the discussions of a joint committee between the Department of Labour and the University, and this may be an avenue through which students can relay concerns of formaldehyde exposure in hopes of achieving a reduction in their levels.

5. Miscellaneous equipment - Goggles, face masks and appropriate respirators should be made available to all students, or if expenses are to be minimized, to those who feel they might be susceptible to eye irritation or breathing problems. At the very least, their availability should be clearly made to every student. The argument against this is the increased cost of having the supplies in the lab. Providing a mask to every student for every lab session requires a substantial number of masks to be purchased. Also, the paper face masks are impractical because they do not filter out formaldehyde fumes and also muffles

voices, impeding communication amongst students. Charcoal filled masks would more adequately filter fumes, but are much more costly.

The effectiveness of ventilation and altered embalming solutions can be evaluated simply by monitoring the ambient levels of formaldehyde to see if they are decreasing as a result of the strategies. If so, there should be a decrease in the frequency of symptoms. Essentially, the success of these particular interventions can be judged by observing their effectiveness at reducing ambient levels of formaldehyde, and whether such improvement justifies the amount of effort required to implement a change. In contrast, improvements that might be gained through better enforcement and education can be determined directly within a given laboratory by repeatedly tabulating the number of people complaining of eye irritation, headaches, nose irritation, etc., to see whether there is an improvement.

No matter what the intervention though, there is a trade off between the amount of input (cost, effort) required to set it up and the benefits that will result. It is worthwhile not only to look at the absolute improvements of each strategy, but also the improvement in relation to what is required to initiate the changes. For example, ventilation may improve air quality, but may be too expensive to install. New embalming mixtures require more care and effort to make up than previously prepared solutions. Education and enforcement only work if the involved people are willing to put in extra time to warn students or make extra measurements of formaldehyde levels. Therefore, there is no easy method of determining which intervention is better than the other because each one differs in the set-up 'expense'. It may be up to the individual lab to decide the relative value of pursuing each option.

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