J Occup Health 2005; 47: 450–453

Short Communication

A Novel Local Ventilation System to Reduce the Levels of Formaldehyde Exposure during a Gross Anatomy Dissection Course and its Evaluation Using Real-Time Monitoring

Hiroshi Yamato[1], Tamiji Nakashima[2], Akio Kikuta[2], Naoki Kunugita[3], Keiichi Arashidani[3], Yoshihiro Nagafuchi[1] and Isamu Tanaka[1]

[1]Institute of Industrial Ecological Sciences, [2]Department of Anatomy and Anthropology, School of Medicine and [3]School of Health Sciences, University of Occupational and Environmental Health, Japan

Key words: Formaldehyde, Local ventilation, Working environment, Sick-house syndrome, Anatomy dissection, Real-time monitoring

Formaldehyde has been widely used as a disinfectant and preservative (known as formalin) in medical fields. The use of volatile substances including formaldehyde in buildings causes a particular health effect commonly referred to as Sick-House Syndrome. In 1999, the former Ministry of Health and Welfare proposed that the concentrations of indoor formaldehyde should be less than 80 ppb[1)]; a value consistent with that of the WHO indoor air quality guideline[2)]. Furthermore, in 2002, the Ministry of Health, Labour and Welfare issued guidelines for the reduction of formaldehyde concentrations in workplaces, requiring that employers should make efforts to maintain indoor concentrations of formaldehyde below 80 ppb for general workplaces and 250 ppb for specific workplaces where formaldehyde is handled[3)]. In 2001, the Ministry of Education, Culture, Sports, Science and Technology took action to deal with the problem of medical and dental students' exposure to formaldehyde in gross anatomy laboratories. The ministry's action prompted a number of surveys on the actual conditions pertaining to students' exposure to gaseous formaldehyde. Those results revealed that the concentrations of formaldehyde might exceed 1,000 ppb in ordinary gross anatomy dissection laboratories[4–7)].

It is necessary to reduce formaldehyde exposure when medical students and lecturers are exposed during gross anatomy dissection courses. However, it is costly to change exhaust fans to larger ones or to install additional exhaust systems. The purpose of this paper was to try to solve this problem of formaldehyde exposure with an effective, practical and low-cost countermeasure.

Objectives and Methods

Former ventilation system in the gross anatomy laboratory

The gross anatomy laboratory modified for this study is on the basement level of an eight-story building in the medical school. The laboratory space is 19.5 m × 24 m, and 3 m in height (1,400 m^3). There are 25 dissection tables. Four students are usually assigned to each table during the practice. The air in the laboratory is suctioned by a general ventilation system with three outlet openings leading to a main duct that transports the air to the rooftop of the building where it is discharged into the atmosphere. The ventilation rate had been designed as 14,800 m^3/h (=247 m^3/min) and the capacity of ventilation was 10.6 air changes per hour when the equipment was installed in 1989[7)].

Improvement of the air quality of the gross anatomy laboratory

We started to improve the ventilation system by changing the shape of the exhaust duct and the ventilation rate was increased to 340 m^3/min. Furthermore, we increased the ventilation rate of the laboratory up to 380 m^3/min in total by utilizing that of the preservation room next to the laboratory (40 m^3/min). We decided to adopt a local ventilation system using the existing ventilation assigned to the laboratory and develop local ventilation apparatus for each dissection table. It is planned that from March 2005, the local ventilation apparatus (plenum chamber, branch ducts, exhaust inlets, and flanges) of the dissection tables be connected to the general ventilation system through ducts in the ceiling when they are in use in the gross anatomy laboratory. In this way, the formaldehyde emitted during dissection can be immediately exhausted before it spreads in the laboratory.

Novel local ventilation apparatus

We designed a local ventilation apparatus (Grid type of hood: a downward suction) that can be attached to ordinary dissection tables and connected to the ventilation duct. The apparatus is made of stainless steel and was constructed by Kyushu Yoshiba Co. Ltd (Fukuoka, Japan). Six exhaust inlets (2 openings of 580 mm × 60 mm and 4 openings of 820 mm × 60 mm) were placed surrounding the upper face of the original dissection table (Fig. 1a–c). Five branch ducts from a plenum chamber that was installed under the dissection table and 1 branch duct from the main duct were connected to the 6 exhaust inlets (Fig. 1d). The air suction velocities were 0.46–0.60 m/s, evenly at any of the exhaust inlets. Total

Received March 8, 2005; Accepted June 13, 2005
Correspondence to: H. Yamato, Department of Industrial Health Engineering, Institute of Industrial Ecological Sciences, University of Occupational and Environmental Health, Japan, 1–1 Iseigaoka, Yahatanishi, Kitakyushu, Fukuoka 807-8555, Japan (e-mail: yamato@med.uoeh-u.ac.jp)

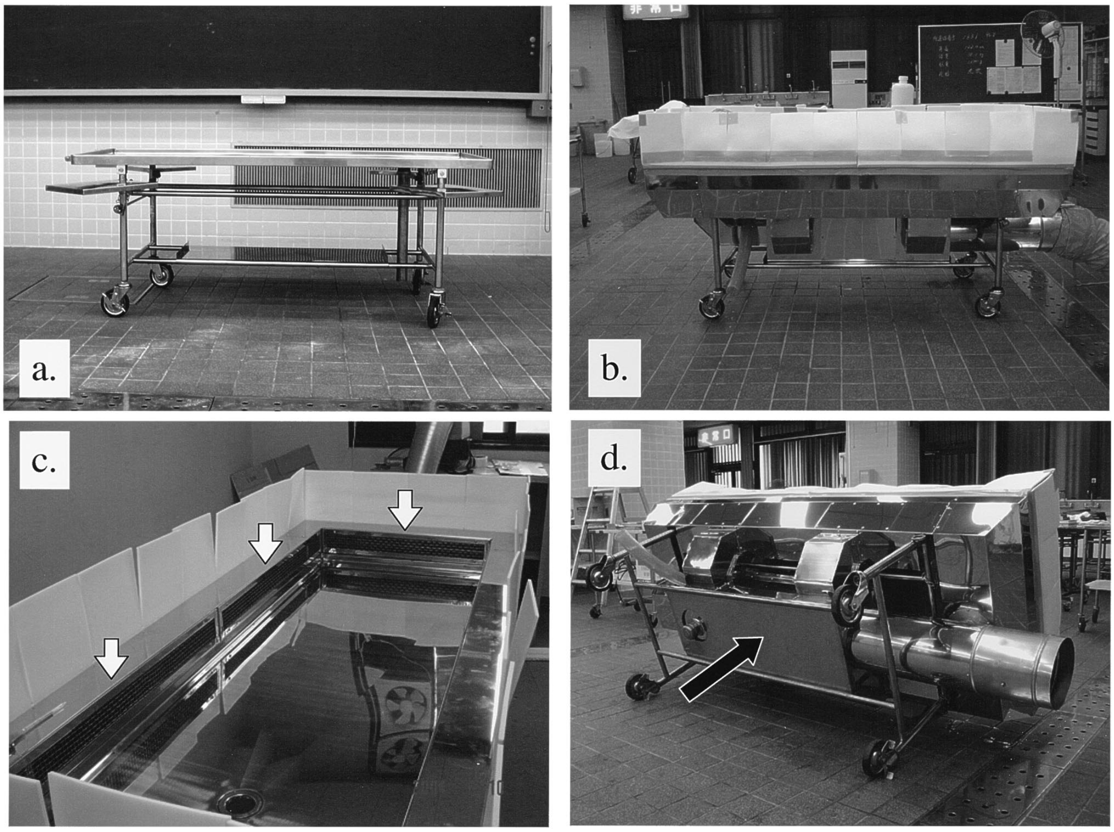

Fig. 1. Dissection tables. a. An ordinary dissection table in use for gross anatomy teaching. b. The newly developed local ventilation apparatus attached to a dissection table. c. Upper view of dissection table. White arrows show the exhaust inlets. There are 6 inlets on the upper surface of the dissection table. d. An underneath view of the improved dissection table. A plenum chamber (black arrow) and branch ducts are seen.

ventilation rate calculated by multiplying the areas of 6 inlets and each suction velocity was 8 m^3/min.

Enclosure hoods are well known to be more efficient than exterior hoods in local ventilation systems. In order to make the local ventilation apparatus an enclosure hood, we added bending soft vertical flanges around the upper plate of the dissection table (Fig. 2a). Urethane foam was used as the material of the flanges. They are hard enough to stand by themselves (Fig. 2b) and they easily bend down when students lower their arms in dissection practice (Fig. 2c). Thus, the local ventilation apparatus does not obstruct dissection while the flanges can keep the formaldehyde leakage to minimal levels.

A life-size human body model was placed on the dissection bed surrounded by the urethane foam flanges. Three sheets of paper towel soaked with a 10% formalin solution were put onto the human body model as the emission source of formaldehyde. In this way, exposure to formaldehyde during the dissection course was simulated and the effectiveness of the local ventilation system was checked. The concentrations of formaldehyde were measured at two points while the local ventilation was operated: ① outside of the enclosure hood; the breathing zone of students (Fig. 2a), ② inside of the enclosure hood. After stopping the local ventilation, another measurement (③) was done in the breathing area of students, the same as the point ①. A portable formaldehyde detector (FORMTECTOR XP-308II, New Cosmos Electric Co. Ltd. Osaka, Japan) was used for real-time monitoring of formaldehyde. Output voltages were recorded to a data logger every 15 s and the logged outputs were then adjusted by HPLC results and converted into concentrations.

Results

Formaldehyde concentrations analyzed by HPLC and the results of real-time monitoring adjusted by HPLC are shown in Fig. 3. The average formaldehyde concentration outside of the hood (breathing zone of students sitting closest to the dissection table) was 50 ppb (①) and inside of the hood was 405 ppb (②) while the local ventilation system was operated. When the local ventilation was

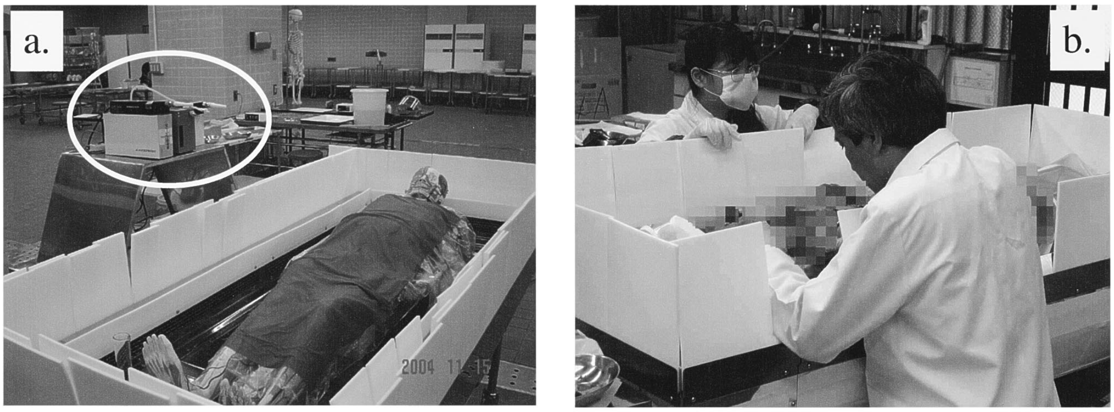

Fig. 2. Upper view of the newly improved dissection table. a. The upper plate of the table is surrounded with flanges made of urethane foam. Instruments for the measurement are set in the breathing area. b. Flanges are strong enough to stand by themselves. c. Flanges easily bend down when students lower their arms.

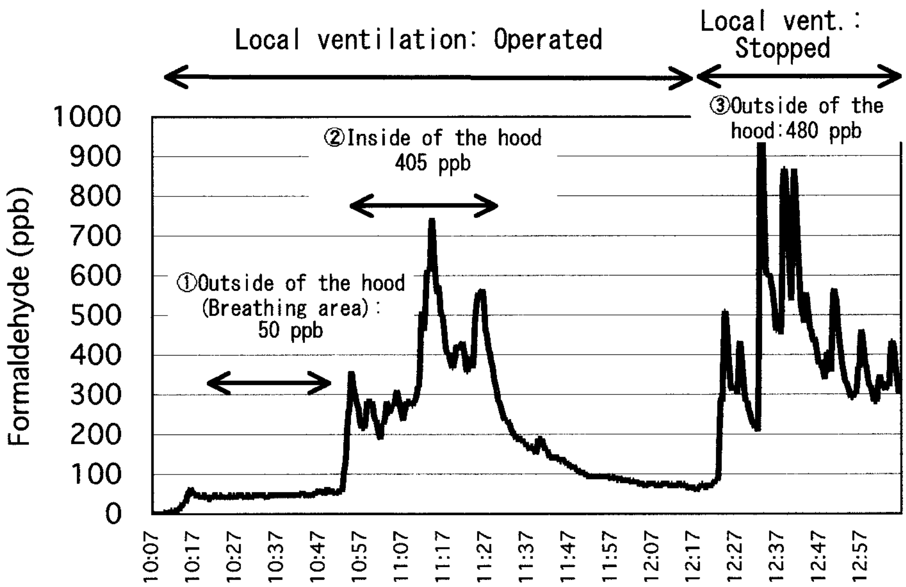

Fig. 3. Formaldehyde concentrations measured with HPLC and real-time monitoring.

disconnected, the formaldehyde concentration increased and its average became 480 ppb in the breathing zone (③). These results indicate that exposure to formaldehyde can be efficiently prevented by the local ventilation system designed by us.

Discussions

The most common measure to control the environment of a gross anatomy laboratory is to enhance its general ventilation. The capacity of ventilation is expressed as "number of air changes per hour" (the ventilation rate per hour is divided by the volume of a room). The capacity of ventilation is generally designed to have 2 air changes per hour for ordinary rooms, 10 air changes per hour for lavatories or specific rooms including gross anatomy laboratories. It may not be feasible to keep the formaldehyde concentration below 250 ppb by enhancing the general ventilation rate from cost and technical perspectives.

The advantages of our improvements, changing the existing general ventilation to local ventilation, are as follows: 1) students' level of formaldehyde exposure may be kept lower than the stipulated concentration of 250 ppb without interfering with their practice of dissection; 2) students' direct exposure to formaldehyde can be minimized since most of the formaldehyde emitted from cadavers is exhausted before spreading into the laboratory; 3) formaldehyde suctioned to the local ventilation system does not re-circulate to the laboratory; and 4) minimum influence on heating and cooling efficiency because the existing ventilation rate is used.

We are planning to install this local ventilation system to all the dissection tables. Adopting this local ventilation system may dramatically reduce the students' and lecturers' exposure to formaldehyde.

Acknowledgments: The authors wish to thank Ms. H. Otani and Ms.W. Inoue for their help in measuring formaldehyde concentrations with HPLC.

References

1) http://www1.mhlw.go.jp/houdou/0906/h0613-2.html#B1 (in Japanese)
2) WHO. Air Quality Guidelines for Europe, Second Edition. Chapter 5.8 Formaldehyde. http://www.euro.who.int/eprise/main/who/InformationSources/Publications/Catalogue/20010910_6
3) http://www.mhlw.go.jp/houdou/2002/03/h0315-4.html
4) M Mizuki and T Tsuda: Relationship between atopic factors and physical symptoms induced by gaseous formaldehyde exposure during an anatomy dissection course. Japanese Journal of Allergology 50, 21–28 (2001) (in Japanese, with English summary)
5) K Tanaka, K Nishiyama, H Yaginuma, A Sasaki, T Maeda, S Kaneko, T Onami and M Tanaka: Formaldehyde exposure levels and exposure control measures during an anatomy dissection course. Kaibogaku Zasshi 78, 43–51 (2003) (in Japanese, with English summary)
6) C Wei, K Harada, K Hara, A Itoh, N Kunugita, A Ohmori and A Ueda: Level of formaldehyde during an anatomy dissection course and its detrimental effects on medical students. San Ei Shi 46, 237–238 (2004) (in Japanese)
7) N Kunugita, T Nakashima, A Kikuta, T Kawamoto and K Arashidani: Exposure to formaldehyde during an anatomy dissecting course. J UOEH 26, 337–348 (2004) (in Japanese, with English summary)
8) S Kawamata and H Kodera: Reduction of formaldehyde concentration in the air and cadaveric tissues by ammonium carbonate. Anatomical Sci Int 79, 152–157 (2004)