

Level of Formaldehyde and Its Health Effects among Veterinary Students in the Gross Anatomy

Laboratory of Khon Kaen University

ระดับฟอร์มาลดีไฮด์และผลต่อสุขภาพของนักศึกษาสัตวแพทย์ในห้องปฏิบัติการ

วิชามหาวิทยาลัยเกษตรศาสตร์ของมหาวิทยาลัยขอนแก่น

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ABSTRACT

Toxicity of formaldehyde (FA) in cadaver embalming solution has become a major health concern of all involving parties. Questionnaires were performed with 84veterinary students of KKU currently taking small animal anatomy laboratory. 31 (36.7%) students expressed multiple post-exposure acute symptoms, including unpleasant smell, dry or sore nose, unusual thirst, itching or sore eyes, disturbance of sight, and general fatigue or dizziness. FA level in air measured directly from cadavers and body parts ( $3.88\pm 0.28$  ppm), 20 cm above the cadavers ( $1.29\pm 0.41$  to  $2.01\pm 4.3$  ppm) and five areas of the laboratory ( $0.78\pm 0.06$  to  $0.91\pm 0.23$  ppm) was apparently much higher than the permissible exposure limit which surely affected health of the students and teaching staffs. Thus, further studies to reduce FA exposure are crucial.

บทคัดย่อ

ความเป็นพิษของฟอร์มาลดีไฮด์ในน้ำยาดองตัวอย่างสัตว์ทดลองเพื่อการเรียนมหาวิทยาสตรเป็นข้อกังวลด้านสุขภาพของทุกคนที่เกี่ยวข้อง ผลการทำแบบสอบถามอาการที่เกิดจากการสัมผัสฟอร์มาลดีไฮด์ของนักศึกษาสัตวแพทย์ มคนที่ 84 ขอนแก่น จำนวน 31 กำลังเรียนวิชามหาวิทยาสตรสัตวเล็กพบว่า นักศึกษาจำนวน(36.7%) แสดงอาการเฉียบพลันในลักษณะต่างๆ อาทิ แสบจมูกและตา จมูกแห้งหรือเจ็บ กระจายน้ำมากกว่าปกติ คัดตา รบกวนการมองเห็น อ่อนเพลียและมึนงง ผลการตรวจวัดความเข้มข้นของฟอร์มาลดีไฮด์ทั้งจากสัตว์ทดลองและอวัยวะต่างๆ โดยตรง ( $3.88\pm 0.28$  พีพีเอ็ม) วัดที่ความสูงจากสัตว์ทดลอง .ชม 20( $1.29\pm 0.41$  ถึง  $2.01\pm 4.3$  พีพีเอ็ม) และวัดจากบริเวณต่างๆ ของห้องจำนวน บริเวณ 5( $0.78\pm 0.06$  ถึง  $0.91\pm 0.23$  พีพีเอ็ม พบว่ามีค่าสูงกว่าค่า (permissible exposure limit อย่างมาก ซึ่งย่อมส่งผลกระทบต่อสุขภาพของนักศึกษารวมทั้งอาจารย์และเจ้าหน้าที่ที่เกี่ยวข้อง การศึกษาเพื่อลดการสัมผัสกับฟอร์มาลดีไฮด์จึงมีความสำคัญอย่างยิ่ง

**Key Words:** Formaldehyde, Dog cadaver, Health effects

**คำสำคัญ:** ฟอร์มาลดีไฮด์ ตัวอย่างสุนัขดอง ผลกระทบด้านสุขภาพ

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## Introduction

Gross anatomy is the backbone and fundamental topics in medical and veterinary education (Bay and Ling, 2007). Regards, most universities use cadaveric dissection to construct anatomical knowledge among students (Korf et al., 2008). Formaldehyde (FA) has been widely used as a principle component of embalming fluid for preparation of cadaver because of its effective and long-term preserving properties at a reasonable cost through inhibiting microbial growth and denaturing protein with rapid tissue penetration (Natekar and Desouza, 2007). Paradoxically, health risk among all involving parties becomes the major disadvantages of FA (Gahukar, 2014). Direct skin contact and inhalation of FA vapor can cause both acute and chronic health effects. The immediate symptoms include irritation of the throat, nose, eyes, and skin. Several studies have revealed that these acute effects always occur among anatomists, histologist, embalming technicians, medical and veterinary students (Agency for Toxic Substances and Disease Registry [ATSDR], 1999). However, the chronic exposure may cause the eruption of various cancers, such as nasopharyngeal cancer, ocular melanoma, lung cancer, brain cancer and leukaemia (Ya'acob et al., 2013). Thus, FA is classified as a human carcinogen by the United States Environmental Protection Agency (EPA) in 1999 and International Agency for Research on Cancer (IARC) in 2006. Accordingly, the Occupational Safety and Health and Administration (OSHA) established a permissible exposure limit (PEL) of FA at 0.75 ppm for time weighted average (TWA) and 2 ppm for short term exposure limit (STEL) (OSHA, 2004). In addition, the Ministry of Interior Affairs of Thailand stipulated

3 ppm for an 8-hour-TWA and 5 ppm for a 15-minute-STEL (Ministry of Internal Affairs, 2520).

Thus far, there are quite a few researches on the health effects of FA in gross anatomy laboratory in Thailand (Winkelmann and Guldner, 2004; Lakchayapakorn and Watchalayarn, 2010). Therefore, FA-related health effects of students and FA vaporized from dog cadavers at the anatomy teaching laboratory, Dept. of Vet Anatomy, Khon Kaen University, Thailand, is investigated.

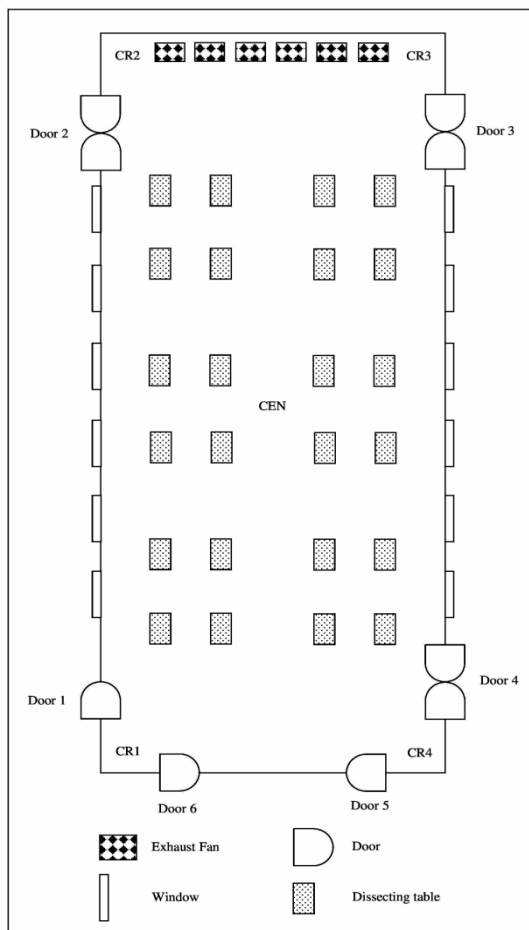
## Objectives of the study

The aim of this study was to seek information regarding formaldehyde-associated symptoms of students and staffs, and to measure the level of FA vapor from the dog specimens being used at the gross anatomy laboratory, Faculty of Veterinary Medicine, Khon Kaen University, Thailand.

## Methodology

### Site of the study

This study was conducted at the gross anatomy laboratory of the Dept. of Vet. Anatomy, Fac. of Vet. Med., Khon Kaen University (Figure 1). This non-air conditioned laboratory is approximately 23.8m x 10.4m x 4.1m in dimension with 4 doors and 25 louver windows on its left and right walls. Room air is ventilated by 12 ceiling fans and 6 wall exhausted fans. There are 24 dissecting tables evenly arrayed in 4x6 rows---21 for students and 3 for keeping equipment or self-study materials. The room temperature is usually about 25-28<sup>o</sup>C during the class.



**Figure 1** The layout of the gross anatomy laboratory. Measurements of FA in air were performed at the center (CEN), and the four corners (CR1-CR4) of the laboratory and 20 centimeters above each dissection table.

**Schedule of cadaver dissection**

85 second year students (4-5 students per table and one dog cadaver) were assigned to attend the three-hour session (from 1.00-4.00 PM) of small animal anatomy laboratory, twice a week (Monday and Wednesday) for 15 weeks (starting the second week of August 2014 to the third week of November 2014). A total of 21 dogs cadavers of both sexes were embalmed with 10% formalin solution. The regional dissection was performed at the lower neck/shoulder,

thorax, abdomen, pelvis, forelimb, hind limb, head and upper neck, and brain and spinal cord. After finishing the Wednesday lab session, the cadavers were kept in the formalin well in the other building. They were taken out and washed well with tap water before being placed on the dissecting table on Monday.

**Questionnaire**

The questionnaire used in this study was modified from that of the Office of Environmental Health Hazard Assessment (OEHHA, 1999), and Swedish Performance Evaluation System (SPES) questionnaire. This questionnaire was translated to Thai language. In this study, various symptoms caused by the toxicity of the embalming fluid among the veterinary students were evaluated. The questions concerned individual characteristics (e.g., age, gender). All 13 subjective symptoms included general feelings, effects on eyes, nostrils and skin, etc. Quantitative symptoms were asked on a four categories---not at all, barely recognizable, strong/prominent/irritating, and intolerable (see Table 1). All the symptoms were explained to the students beforehand for the accurate response.

**Measurement of FA in air and cadavers**

HAL-HFX105 handled FA meter (Hal Technology LLC, California, United States) was used for this all FA measurement in this study. The measurements were conducted while anatomy laboratory classes were running. FA in air was measured at five sites---the centre and 4 corners of the laboratory (Figure 1). FA in cadavers (after skin of each area was removed) was measured in the immediate vicinity of the cadaver (at the level 20 cm above the cadavers). The measurements were performed triplicately following the dissecting

assignments of the course---over the lower neck/shoulder (week 1), forelimb (week 2), thoracic cavity (week 4), abdominal cavity (week 8), hind limb (week 10), upper neck/head (week 12) and cranial cavity/brain/spinal cord (week 14). Temperature and humidity in this laboratory room during the experiment were also recorded.

#### Statistical Analysis

The statistical significance of group differences among was analyzed by one-way ANOVA. The two-sided T-test at the statistically significant level of 0.05 and with the 95% confidence intervals are used. SPSS program (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY:IBM Corp, USA) was used for all analyses.

### Results

#### Acute symptoms among students

Thirty-one male and 53 female veterinary students (out of 85 who were taking the class) completed and returned the questionnaire. The mean age of all students was 19.62 years (ranging between 18 to 24 years).

Results of various acute symptoms among veterinary students after exposure to FA were shown in Table 1. The most prominent symptom was the intolerably unpleasant smell (54.7%). Regards, students answering to have strong, prominent and irritating symptoms of respiratory distress, insomnia, and skin irritations were found to be lower than 10%. However, the intolerable symptom extending above 10% were unpleasant smell (54.7%), dry or sore nose (13.1%), unusual thirst (17.8%), itching or sore eyes (30.9%), disturbance of sight (14.4%), and general fatigue or dizziness (28.6%). The questionnaire

revealed that about 31 (36.7%) students expressing strong/prominent/irritating (17.77, 21.14%) and intolerable symptoms (13.08, 15.58%) were clearly affected by the FA vapor.

#### Concentration of FA in air

The mean concentrations of FA of all areas being measured in the 1<sup>st</sup>, 4<sup>th</sup>, 8<sup>th</sup>, and 14<sup>th</sup> week of the class were  $0.78 \pm 0.06$ ,  $0.91 \pm 0.23$ ,  $0.86 \pm 0.17$ , and  $0.83 \pm 0.09$  ppm, respectively (Table 2). It was quite apparently that the concentrations in the center of the lab were always higher than that in the other areas at any measurement time, especially in the 4<sup>th</sup> (1.35 ppm) and 8<sup>th</sup> week (1.18 ppm) when thorax and abdomen were opened.

The FA levels measured at 20 cm above the cadavers were 1.54 ppm in the 1<sup>st</sup> week, 2.01 ppm in the 4<sup>th</sup> week, 1.95 ppm in the 8<sup>th</sup> week, and 1.29 ppm in the 14<sup>th</sup> week, respectively (Table 2). These levels were double to that in any other measured points in the gross anatomy laboratory.

#### Concentration of FA in cadavers

The FA concentrations were noticeably varied among the cadavers of which were  $2.07 \pm 0.60$  ppm in the cranial cavity,  $2.27 \pm 0.39$  ppm in the lower neck/shoulder,  $5.02 \pm 0.59$  ppm in the thoracic cavity,  $4.89 \pm 0.73$  ppm in the abdominal cavity,  $4.39 \pm 0.69$  ppm in the forelimb, and  $4.59 \pm 0.82$  ppm in the hind limb (Table 3). There was no association between body weight of cadavers and FA concentrations. The highest level of FA was measured at the thoracic cavity on the 4<sup>th</sup> week of dissection whereas the lowest levels were measured in the lower neck/shoulder in the 1<sup>st</sup> week and the cranial cavity in the 14<sup>th</sup> week of the class (Figure 2).

**Table 1** The acute symptoms of the veterinary students after exposed to formaldehyde

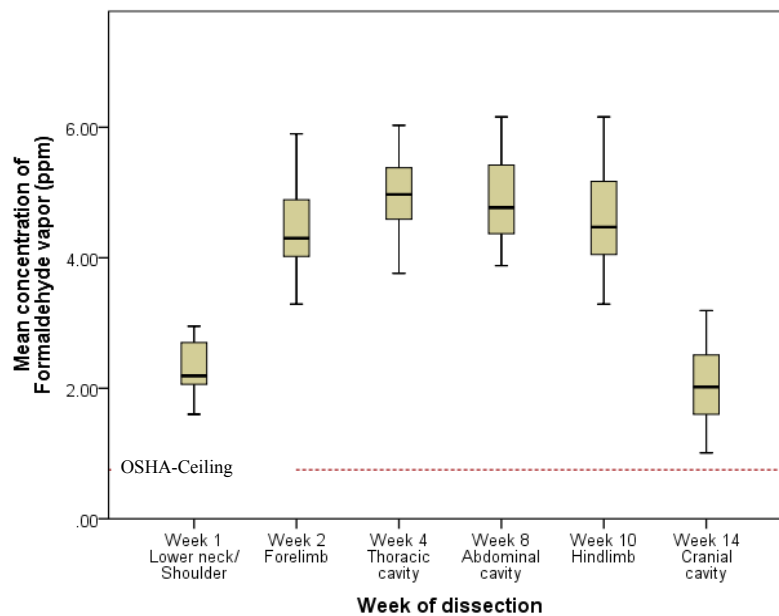
Symptoms	Extend of Symptoms, n (%)			
	Not at All	Barely Recognizable	Strong, Prominent and Irritating	Intolerable
Unpleasant smell	1 (1.2)	5 (6.0)	32 (38.1)	46 (54.7)
Dry or sore nose	18 (21.4)	20 (23.8)	35 (41.7)	11 (13.1)
Running or congested nose	26 (31.0)	28 (33.3)	22 (26.2)	8 (9.5)
Unusual thirst	21 (25.0)	26 (31.0)	22 (26.2)	15 (17.8)
Redness eyes	35 (41.7)	26 (31.0)	17 (20.2)	6 (7.1)
Itching or sore eyes	14 (16.7)	23 (27.4)	21 (25.0)	26 (30.9)
Disturbance of sight	27 (32.1)	28 (33.3)	17 (20.2)	12 (14.4)
Nausea	46 (54.8)	16 (19.0)	16 (19.0)	6 (7.2)
Headache	29 (34.5)	32 (38.1)	17 (20.2)	6 (7.2)
Respiratory distress	59 (70.2)	12 (14.3)	7 (8.3)	6 (7.2)
General fatigue or dizziness	21 (25.0)	23 (27.4)	16 (19.0)	24 (28.6)
Insomnia	72 (85.8)	6 (7.1)	6 (7.1)	0 (0.0)
Itchy or irritated skin on hand	58 (69.0)	19 (22.6)	3 (3.6)	4 (4.8)
Mean count ± SD	32.85±20.4	20.31±8.48	17.77±9.25	13.08±12.45
Mean percentage ± SD	39.11±24.29	24.18±10.1	21.14±11.02	15.58±14.79

**Table 2** Concentrations of formaldehyde vapor being measured in 5 areas of the gross anatomy laboratory and 20 cm above the cadavers. The measurements were performed while students were regionally dissecting the cadavers on weeks 1 (lower neck and shoulder), 4 (thoracic cavity), 8 (abdominal cavity) and 14 (cranial cavity) of the class.

Areas	Concentrations of formaldehyde (min-max) (ppm)			
	1 <sup>st</sup> week	4 <sup>th</sup> week	8 <sup>th</sup> Week	14 <sup>th</sup> week
Corner 1	0.73 (0.71-0.75)	0.79 (0.77-0.81)	0.75 (0.75-0.76)	0.78 (0.70-0.83)
Corner 2	0.80 (0.79-0.82)	0.84 (0.83-0.85)	0.82 (0.80-0.83)	0.83 (0.80-0.87)
Corner 3	0.73 (0.70-0.77)	0.74 (0.70-0.77)	0.72 (0.70-0.75)	0.74 (0.69-0.78)
Corner 4	0.80 (0.79-0.82)	0.85 (0.80-0.89)	0.84 (0.82-0.87)	0.79 (0.76-0.83)
Center	0.86 (0.84-0.89)	1.35 (1.30-1.45)	1.18 (1.13-1.23)	0.98 (0.92-1.04)
Mean (air)±SD	0.78±0.06	0.91±0.23	0.86±0.17	0.83±0.09
Mean (above cadavers)±SD	1.54±0.28	2.01±0.43	1.95±0.60	1.29±0.41

**Table 3** Concentrations of formaldehyde being measured above each area of the 21 cadavers

Case No.	Body weight (kg)	Concentration in each area of the cadavers (ppm) (n=21)						Mean ±SD
		Cranial cavity	neck/ Shoulder	Thoracic cavity	Abdominal cavity	Forelimb	Hindlimb	
1	9.40	3.01	2.08	4.59	4.05	4.05	5.73	3.92±1.26
2	9.70	2.51	2.75	5.82	3.88	4.23	4.15	3.89±1.19
3	10.90	2.02	2.70	5.32	6.12	4.47	4.05	4.11±1.55
4	15.20	1.40	2.27	5.19	5.73	4.30	4.47	3.89±1.70
5	8.40	1.60	2.36	4.30	4.89	4.89	3.62	3.61±1.37
6	7.60	2.02	2.06	5.10	6.16	5.14	6.16	4.44±1.92
7	6.80	2.34	2.27	4.93	5.42	3.29	3.62	3.65±1.31
8	10.90	1.13	1.60	5.15	5.14	3.29	4.30	3.44±1.75
9	28.10	1.70	2.13	4.89	4.47	4.99	5.90	4.01±1.70
10	12.20	2.34	2.08	3.76	4.05	4.82	5.73	3.80±1.41
11	11.40	2.02	2.23	5.38	4.37	4.72	4.63	3.89±1.41
12	10.40	1.59	2.11	4.42	4.77	4.26	4.05	3.53±1.34
13	11.20	1.77	2.86	4.35	5.04	3.62	3.88	3.59±1.15
14	12.00	2.54	2.95	5.65	4.72	4.47	3.29	3.94±1.20
15	16.20	2.61	2.74	4.95	3.89	4.15	4.20	3.76±0.91
16	20.00	2.12	2.86	4.74	4.15	5.15	5.25	4.05±1.29
17	13.80	3.19	2.19	6.03	5.27	5.90	5.17	4.62±1.57
18	18.20	2.19	1.80	4.97	6.01	3.88	3.92	3.80±1.60
19	8.40	1.43	1.97	5.90	4.58	3.46	4.72	3.68±1.72
20	16.20	1.01	1.77	5.60	5.52	4.02	4.51	3.91±2.15
21	11.90	2.88	1.90	4.32	4.61	5.15	5.02	3.98±1.30
Mean±SD	12.80±4.94	2.07±0.60	2.27±0.39	5.02±0.59	4.89±0.73	4.39±0.69	4.59±0.82	3.88±0.28



**Figure 2** Concentrations of formaldehyde vapor in dog cadavers. All levels were much higher than the permissible exposure level for the time weighted average (0.75 ppm) established by the Occupational Safety and Health and Administration (OSHA).

**Discussion and conclusions**

This study revealed considerably irritation of FA which produced acute symptoms among veterinary students who exposed FA during anatomy laboratory, including unpleasant smell, itching or sore eyes, general fatigue or dizziness, dry or sore nose, unusual thirst, and disturbance of sight. This would trigger a certain respiratory symptoms and probably decrease their olfactory sensation. Such findings are consistent with other reports (Naing et al., 2006; Ya’acob et al., 2013).

Occupational exposures to FA estimated in this study reveals that students are exposed to high FA levels. The FA concentration in the gross anatomy laboratory ranged from 0.78-0.91 ppm during dissection practice. The FA concentration was lowest in the 1<sup>th</sup> and 14<sup>th</sup> weeks when regions of the lower neck/shoulder and cranial cavity were being dissected, and peak values were in the 4<sup>th</sup> and 8<sup>th</sup> week when

dissection of the thoracic and abdominal cavity were being performed (Table 1). Thus, it is a matter of fact that higher amount of FA was released when deeper or body cavities were being dissected. This is consistent with the study of Ohimichi et al. (2006), which reported the average indoor concentrations of FA in a gross anatomy during the three 3-week sessions (out of 20 sessions) to be 0.45, 0.38, and 0.68 ppm, respectively. Costa et al. (2008) also reported that the mean level of FA exposure in pathology anatomy laboratory was 0.44±0.08 ppm (ranging from 0.04-1.58 ppm). Moreover, FA concentration in the indoor air reported by Lakchayapakorn and Watchlayarn (2010) ranged only from 0.401 to 0.581 ppm. These levels were much lower than those in our study, especially in the 4<sup>th</sup> and 8<sup>th</sup> week of dissection when dissection of body cavities was being performed.

In the present study, the FA level above the dog cadavers ranged from 1.29 to 2.01 ppm. These values were much higher than that measured in the five areas of the laboratory. Shiraishi (2006) reported a mean concentration in the immediately vicinity of the six cadavers, ranging from 0.20-2.18 ppm. Kawamata et al. (2004) reported a range of 1.2-3.0 ppm in the air 10 cm above the cadaver. However, the airborne FA level in the immediately vicinity cadavers reported by Gahukar et al. (2014), ranging from 0.26-0.7 ppm (0.32-0.86 mg/m<sup>3</sup>), was lower than that of the present study. This would be relative with the FA concentration in the embalming solution, soaking solution and areas of dissected cadavers at the time of measurements.

The mean concentration of FA vapor in dog cadavers, ranging from 2.07-5.02 ppm, immensely exceeded the permissible exposure level for time weighted average (0.75 ppm) established by the Occupational Safety and Health and Administration (OSHA) (Figure 2). A long-term exposure to FA would be considered as high occupational health risk. Overall, the FA levels in the anatomy laboratory, and in the cadaver throughout the class period exceeded the permissible exposure level for FA in the guidelines set by the Health, Labour and Welfare Ministry in specified workplaces (0.25 ppm), and higher than the World Health Organization (WHO) guideline (0.3 ppm) (WHO, 2000). All of the FA observations were higher than OSHA PEL value (0.75 ppm for time weighted average) and OSHA value (2 ppm for short term exposure limit). The results demonstrated that the indoor air and cadaver quality in the gross anatomy laboratory concerning FA

concentration were mostly exceeding the approved safety limits for humans.

In summary, the veterinary students exposed to FA vapor higher than the permissible exposure limit. The most clinical symptoms are unpleasant smell, itching or sore eyes, general fatigue or dizziness, dry or sore nose, unusual thirst, and disturbance of sight. Future studies on the current topic should focus on the attempt to reduce FA concentration in the lab and exposure of FA of all involving parties.

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