LASU Journal of Medical Sciences
Official Publication of the Faculty of Basic Medical Sciences and Faculty of Basic Clinical Sciences
Lagos State University College of Medicine, Ikeja
www.lasucom.edu.org.
E-mail: lasujms@lasucom.edu.ng

Research Article

Effect of Formaldehyde on Cardiovascular Hemodynamics among Adult Cohorts working as an Embalmer in South-West Nigeria

Akintoye Olabode O.[1], Popoola Sunday O.[2], Fabunmi Oyesanmi A.[1], Ajibare Ayodeji J.[1], Asuku Abraham O.[3]

[1]Department of Physiology, College of Medicine, Ekiti State University, Ado Ekiti, Nigeria. [2]Department of Anatomy, College of Medicine, Ekiti State University, Ado Ekiti, Nigeria. [3]Department of Medical Biotechnology, National Biotechnology Development Agency, Ogbomoso, Nigeria.

**Author for Correspondence:*
Asuku A. O.
Email: asufem2017@gmail.com, Telephone numbers: 08077427135

Keywords: Formaldehyde, Hemodynamics, Systolic blood pressure, Diastolic blood pressure, Radial pulse pressure, Postural changes

ABSTRACT

Objectives: All types of occupations are associated with various degrees of hazards, for those working in the mortuary department in the various hospitals setting, they are chronically exposed to formaldehyde. A lot of research has revealed that formaldehyde has a significant effect on humans, ranging from acute irritation to chronic life-threatening diseases, especially in the respiratory and nervous system. This study is aimed to determine evidence of cardiac injury that is caused by formaldehyde, using blood pressure changes as marker among male cohorts working as an embalmer at the mortuary department of a tertiary hospital in South-West, Nigeria.

Methods: Sixty-six volunteers (66) divided into Control and Formaldehyde groups were recruited for this study using a purposive sampling technique based. All the subjects were trained and properly briefed about the research and their informed written consent was obtained.

Results: Our result showed that the control group demonstrated significantly ($p<0.05$) higher systolic blood pressure (SBP), diastolic blood pressure (DBP), and Radial Pulse pressure in an upright position when compared to other postural changes, in contrast, there is no significant difference in SBP, DBP across various postural changes in the Formaldehyde group. However, the slope of DBP during postural changes in the control group showed an upward increase toward upright posture when compared with the Formaldehyde group although, the DBP values in the Formaldehyde group during different postural changes were significantly higher compared with the control group ($p<0.05$).

Conclusion: this study showed that formaldehyde fumes affect hemodynamic indices among mortuary workers.

INTRODUCTION

Formaldehyde is one of the oldest chemicals in human history because it is one of the earliest chemicals formed and utilized in cells. It is present in minute quantities physiologically in all body tissues.[1] Formaldehyde is mostly used in furniture, wood processing, carpets and textiles industries.[2] Also, it is used as binders for casting sand, stone wool, and glass wool mats in insulators, abrasive paper, dyes, agents for extraction and crop protection, animal feeds and medicines.[3] Moreover, formaldehyde is used in cosmetic industries as an antimicrobial agent in make up, shampoos, deodorants, hair preparations, soap, lotions, nail products, and mouth washes.[4] Despite the numerous uses and applications of formaldehyde in many industries and fields, acute exposure to it can however cause various health-related problems such as eyes, nose, throat, and skin irritations. Furthermore, chronic exposure can cause nasopharyngeal cancer and asthma.[5] Numerous people are exposed to formaldehyde during occupational activities because of its prevalent use and economic values. This involves both manufacturers of products containing certain levels of formaldehyde and those actively making use of such products.

Formaldehyde is very effective for preservation of cadavers and is usually used in embalming solutions in anatomical dissection courses. Its use ensures efficient results in conservation and disinfection.[6] Embalmment with formaldehyde results in lowest to no microbiological activity for about 8 months and preservation of shape and size of vessels and organs.[7] Its use by embalmers is arguably the commonest and probably one of the longest standing applications. However, studies have shown an increase in the amount of formalin concentration and exposure especially in low resource settings with a poor ventilation system, ignorance, or non-adherence to set guidelines for protection against exposure by workers. Besides, it is very much possible to have leakage of formalin from cadavers due to the poor condition and or management of the cadavers. Dermal absorption of liquids containing formaldehyde and breathing in formaldehyde gas from the air are the primary means of exposure. Hence, those engaged in certain occupational activities (e.g.,fire fighters; manufacturers of plywood, and particle board; certain health care professionals; laboratory technicians; and mortuary employees) are much more exposed to formaldehyde compared to the general public.[8] Moreover, formaldehyde releases free radicals with both significant levels of reactivity and flammability and it decomposes releasing a toxic substance into the air of the working environment.[9-10]

A lot of studies have been done to show occupational health hazards attributable to chronic exposure to formaldehyde/ formalin. For example, besides, to being classified as a carcinogen, it has also been linked to nasal mucosa inflammatory and hyperplastic changes, congestion of the larynx, chronic inflammation of the pharynx, chronic rhinitis, loss of olfactory sensation. In the nervous system, it was demonstrated to be neurotoxic, and while chronic occupational exposure showed an almost 35% increase in risk for amyotrophic lateral sclerosis.[11]

The heart which is an indispensable organ for all blood flow in the body is ultimately responsible for cardiovascular hemodynamics. Ventricular contraction causes cardiac output which moves blood through the arteries and veins. The concentric contraction of cardiac myocytes brings about ventricular motion. Then, ventricular motion is turned into the cardiac output, which is the product of the heart rate and stroke volume. Cardiovascular hemodynamics has the most important influence on the blood flow and its actions in the blood vessels.[12]

Despite the highly significant role of cardiovascular hemodynamics in sustaining good health of workers exposed to formaldehyde, there seems to be a dearth of information on the effect of chronic exposure to formaldehyde and blood pressure changes that can be associated with it.

This study is aimed at examining the blood pressure changes with changes in posture among male cohorts working as embalmers in low resource setting of a tertiary hospital in South- West, Nigeria.

MATERIAL AND METHODS

Sixty-six (66) volunteers were recruited for this study using a purposive sampling technique based on the recommendation of Vo and Morg 2007, divided into two groups "control and formalin groups" of 33 adult volunteers each. The control group consists of healthy volunteers who were randomly selected in the community and the formalin group consists of embalmers working with secondary and tertiary government health institutions running mortuary services in Ekiti State, South-Western Nigeria.

Protocol: All subjects were met twice: Mondays for recruiting based on our inclusion criteria and Wednesday for the procedure. These individuals were older than 40 years, with similar sex distribution between the two groups. The proforma designed for this work was divided into four sections: socio-demographics, design of the mortuary (location, disposition, available apparatus, preparation room, changing room, post-embalming room, waiting room, and doorway), pre-employment health assessment, and present cardiovascular variables. All the subjects were trained and properly briefed about the research and their informed written consent was obtained. The distribution is shown in Table 1.

Inclusion criteria for selection of subjects;

The following were the inclusion criteria for subject recruitment into this study:

1. They must not be a known hypertensive patient or had cardiovascular derangement before employment
2. They must have been employed and working at the facility for at least two years.
3. For the control group (normal healthy adult): they must not be on any analgesic medications, not on hospital admission in the last one month, did not have surgery done in the last three months, not diabetic, not suffering from chronic pain syndrome (such as shingles, fibromyalgia, and diabetic neuropathic pain)
4. The willingness of all the patients and healthy volunteers to abide by the rule and protocol of the study, willingness to voluntarily partake in the study, and signing of the consent form.

Cardiovascular Variables: All subjects undergo the following non-invasive procedures: basic biodatas, anthropometric data, and cardiovascular variables. Radial Pulse Rate (beats/min) and Systolic and Diastolic blood pressures (mmHg) in lying, sitting, and standing positions sequentially using a digital sphygmomanometer (OMRON, Model number: M2Eco HEM-7120-AF). All procedures were done in the morning hours of 8:30am to 9:30am each day. Cardiovascular variables were done once in one hand for the three postures and same repeated on the other hand after subject is allowed to rest for 20 minutes. The mean of the values were recorded.

Statistical analysis

All data were expressed as the Mean ± SEM. Tests for homogeneity of the varied intervention carried out by using the Independent-Samples T-test from SPSS version 20 software with the level of significance set at $p < 0.05$.

All procedures were performed in the Nigeria Hospital according to the ethical guidelines of human subjects, which are, respect for persons, justice, and beneficence. All subjects signed an informed consent after the risks, clinical benefits, and purpose of the study were fully discussed with them all. Approval (Protocol number: EKSUTH/A67/2018/12/005) was obtained from the Research and Ethical Review Committee of the University Teaching Hospital, Nigeria.

RESULTS

Demographic features of subjects in the population study

Table 1 summarizes the descriptive data for both groups. All anthropometric data were similar statistically without significant differences.

Table 1: Demographic features.

	Control Grp	Formalin Grp	P Value
Age (yrs)	43.06±1.42	46±1.470.427	
Sex (% Male)	85	87	
Height (m)	1.73±0.012	1.76±0.011	0.378
Weight (kg)	67.45±1.49	66.48±1.43	0.099
BMI (kg/m^2)	22.22±0.43	21.79±0.40	0.259

Data expressed are means ± SD, n = 33

Clinical Hemodynamic Variables

In Table 2, the result from our study showed that the control group demonstrated significantly higher systolic blood pressure (SBP), diastolic blood pressure (DBP), and Radial Pulse pressure in an upright position when compared to other postural changes.

More so, in Table 3, the result from our study showed no significant difference in SBP, DBP across various postural changes in the Formaldehyde group. However, pulse pressure among this group in the upright position showed a highly significant difference when compared with the supine position. Besides, SBP values in the formaldehyde group during different postural changes are significantly higher when compared with the control group as shown in Figure 1. The slope of SBP during postural changes in the control group as demonstrated in Figure 1 showed a sharp decline towards an upright position when compared with the Formaldehyde group. However, the slope of DBP during postural changes in the control group as demonstrated in Figure 2 showed an upward increase toward upright posture when compared with the Formaldehyde group. Although, the DBP values in the Formaldehyde group during different postural changes are significantly higher when compared with the control group as shown in Figure 2.

Table 2: Cardiovascular response to postural changes in the control group

	SUPINE	SITTING	STANDING
Systolic BP (mmHg)	114.9±2.22	112.6±2.12	104.7±2.175$_{ab}$
Diastolic BP (mmHg)	69.15±1.59	72.0±1.658	76.3±1.656$_{a}$
PR (beats/min)	60.61±3.102	-	73.03±0.5.175 (*p<0.05)

Data expressed are means ± SEM, n = 33

Table 3: Cardiovascular response to postural changes in the formalin group

	SUPINE	SITTING	STANDING
Systolic BP (mmHg)	124.2±3.169	123.6±3.193	122.70±2.753
Diastolic BP (mmHg)	78.30±2.11	82.09±1.894	82.73±1.985
PR (beats/min)	60.97±4.88	-	77.18±7.312 (*p<0.05)

Data expressed are means ± SEM for SBP (Systolic blood pressure) and DBP (Diastolic blood pressure while that of PR (Pulse rate) are expressed in mean ± SD, n = 33

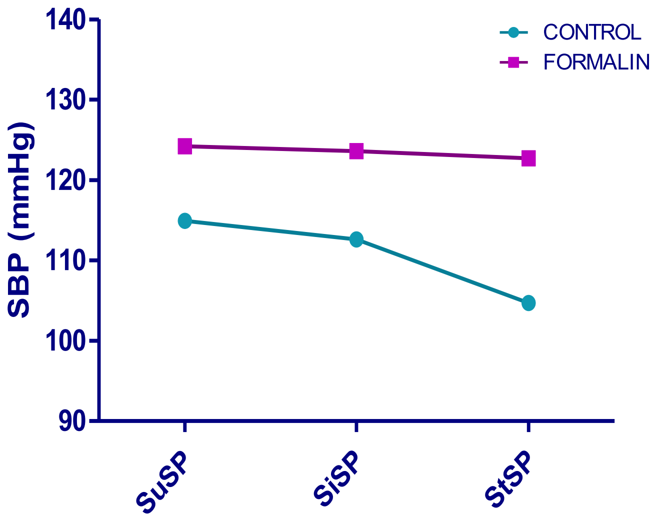

Figure 1: Systolic blood pressure changes to body postural changes in the control group compared to the formalin group

Key: SBP (systolic blood pressure); SuSP (SBP in supine position); SiSP (SBP in sitting position); StSP (SBP in standing position)

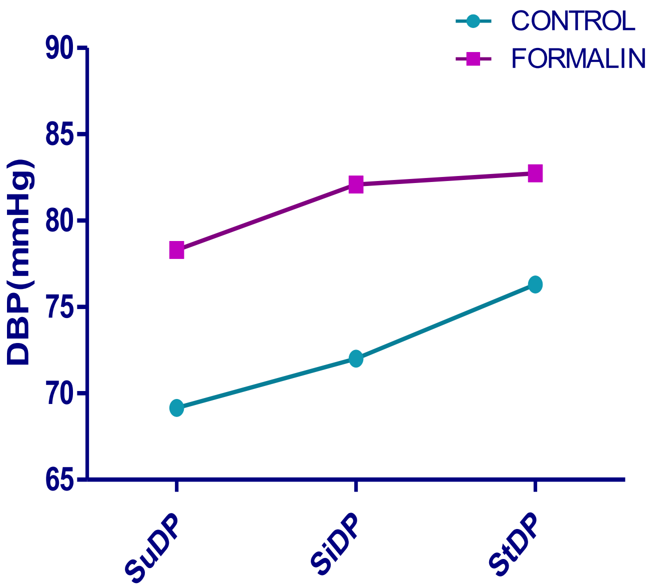

Figure 2: Diastolic blood pressure changes to body postural changes in the control group compared to the formalin group

Key: DBP (diastolic blood pressure); SuDP (DBP in supine position); SiDP (DBP in sitting position); StDP (DPB in standing position).

DISCUSSION

In this present study, most of all the cardiovascular parameters tested were significantly altered. When moving from a recumbent position to upright posture it usually results in a small but measurable decrease in systolic blood pressure (SBP) due primarily to a spread of blood volume into the lower abdomen, buttocks, and legs under the influence of gravity and this was demonstrated in our study among the control group. However, our result showed no significant difference during postural changes among the formaldehyde group as shown in Table 2 although the values of the cardiovascular hemodynamics were significantly higher when compared with control as shown in Figures 1 and 2. The reason for this might be attributed to the duration of exposure among other factors. In most people, this decrease in blood pressure is very slight and temporary, as a whole host of response mechanisms are immediately put together to regulate blood pressure. The most prominent amongst these responses is the baroreflex configuration.[13] There are receptors in the carotid artery located in the neck, and major vessels and structures in the thorax. These receptors swiftly detect any decrease in arterial pressure and central thoracic volume and then trigger a coordinated increase in the activity of the sympathetic nervous system, decrease in the activity of the parasympathetic nervous system, and modulation of cascades of hormones. It has also been shown that the sensory signals that contribute to the sympathetic response during postural changes associated with head-up – tilt are initiated in the cardiac chambers, aortic and carotid structures, and vestibular receptor.[14] Moreover, the detection of alterations in venous return, which exert control over specific sympathetic nerve activity, takes place in afferent neurons residing in the cardiac chambers and pulmonary structures.[15]

In retrospect, several animal studies have reported that formalin has a role to play on cardiovascular hemodynamics. Formalin was shown to affect cardiac dysfunction possibly mediated by impaired calcium handling in excitation-contraction coupling mediated through the sarcoplasmic reticulum which could decrease cardiac contractility and reduced SBP.[16] More so, formaldehyde was also shown in a previous animal study to have a direct negative chronotropic response on the heart which seems to be caused mainly by the inhibition of sympathetic nervous activity through the central nervous system.[17]

In conclusion, this study showed that formaldehyde fumes affect hemodynamic indices among healthy adults. It also paves the way for further studies on chronic effects of formaldehyde especially understanding the adaptive compensatory changes taking place in the cardiovascular system and whether gender difference plays a role.

ACKNOWLEDGEMENTS

We duly acknowledge the Management of Ekiti State University Teaching Hospital, Ekiti for their immense support and assistance during the course of this research.

CONFLICTS OF INTEREST

The authors declare no conflicts of interests in the publication of this research work.

REFERENCES

1. Swenberg JA, Moeller BC, Lu K, Rager JE, Fry RC, Starr TB. Formaldehyde carcinogenicity research: 30 years and counting for mode of action, epidemiology, and cancer risk assessment. Toxicol Pathol. 2013;41(2):181–189.
2. Hermann MB, Degen GH, Hengstler JG. The carcinogenicity debate on formaldehyde: How to derive safe exposure limits? Arch Toxicol. 2010; 84(6): 421–422.
3. Gerberich HR, Seaman GC, Kroschwitz JI, Howe-Grant M, Eds., Kirk–Othmer Encyclopedia of Chemical Technology, 5th ed., Vol. 11. New York: John Wiley and Sons; 2004: 929–951.
4. Reuss G, Disteldorf W, Gamer AO, Hilt A. Formaldehyde. In: Ullmann's Encyclopedia of Industrial Chemistry, 6th rev. ed., Vol. 15. Weinheim: Wiley-VCH VerlagGmbH; 2003:1–34.
5. Casset A, Marchand C, Purohit A, le-Calve S, Uring-Lambert B, Donnay C. Inhaled formaldehyde exposure: Effect on bronchial response to mite allergen in sensitized asthma patients. Allergy. 2006; 61: 1344–1350.
6. Brenner E. Human body preservation – old and new techniques. J Anat 2014: 224:316–344. https://doi.org/10.1111/joa.12160
7. Balta JY, Twomey M, Moloney F. The antimicrobial capacity of embalming solutions: a comparative study. J Appl Microbiol 2018:126:764–770. https://doi.org/10.1111/jam.14191
8. Ki-Hyun K, Shamin AJ & Jong-Tae L. Exposure to Formaldehyde and Its Potential Human Health Hazard, Journal of Environmental Science and Health, Part C, 2011:29:4, 277-299.
9. Ferreira JR, Rezende LC, Barbosa ADS, De Carvalho P, De Lima NE, Carvalho AA. Economic, human, and environmental health benefits of replacing formaldehyde in the preservation of corpses. Ecotoxicol Environ Saf. 2017;145:490–495.
10. Perna RB, Bordini EJ, Deinzer-Lifrak M. A case of claimed persistent neuropsychological sequelae of chronic formaldehyde exposure clinical, psychometric, and functional findings. Arch Clin Neuropsychol. 2001;16(1):33–44.
11. Weisskopf MG, Morozova N, O'Reilly EJ . Prospective study of chemical exposures and amyotrophic lateral sclerosis. J Neurol Neurosurg Psychiatry. 2009;80(5):558–561.
12. Joshua DP, Ian M, Stephen B, Amgad NM. Physiology, Cardiovascular Hemodynamics, National Library of Medicine, National Institutes of Health. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020
13. Izzo JL, Taylor AA. The sympathetic nervous system and baroreflexes in hypertension and hypotension. Vol. 1, Current Hypertension Reports. Current Medicine Group LLC; 1999. p. 254–263.
14. Shoemaker JK, Hogeman CS, Khan M, Kimmerly DS, Sinoway LI. Gender affects the sympathetic and hemodynamic response to postural stress. Am J

Physiol - Heart Circ Physiol. 2001;281(550-555).
15. Luzier AB, Nawarskas JJ, Añonuevo J, Wilson MF, Kazierad DJ. The effects of gender on adrenergic receptor responsiveness. J Clin Pharmacol. 1998;38(7):618–624.
16. Takeshita D, Nakajima-Takenaka C, Shimizu J. Effects of formaldehyde on the cardiovascular system *in situ* rat hearts. Basic Clin Pharmacol Toxicol. 2009 Oct;105(4):271–280.
17. Tani T, Horiguchi Y. Effects of Formaldehyde on Cardiac Function. Jpn J Pharmacol. 1990;52(4): 563–572.