Bone Cement Fumes Generated in Laminar Flow versus Conventionally-Ventilated Operating Rooms—Does the Mixing System Matter?

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INTRODUCTION:

Bone cement is commonly used in a variety of orthopaedic procedures and contains methyl methacrylate monomer (MMA). MMA is a colorless, clear, flammable liquid of intense odor. Its vapor concentration in the immediate breathing zone can vary significantly in the operative setting, and in higher concentrations, can become an occupational health hazard. Though MMA is non-carcinogenic and fume concentrations in dental and orthopaedic procedures typically remain below Occupational Safety and Health Administration (OSHA) permissible exposure limits of 100 ppm for an 8-hour period, these fumes are considered an occupational hazard particularly to persons who are pregnant. Therefore, MMA vapor reduction is desired. This study aimed to compare the MMA vapor levels emitted during mixing from 5 commercially available cement mixing systems within an OR with conventional ventilation (CV) and an OR with laminar airflow (LAF).

METHODS:

A prospective, in vitro study was conducted in a single hospital OR with LAF and an OR with CV. MMA vapor release during cement preparation of a Sawbone femoral canal was measured with a calibrated MiniRAE-3000. Five different vacuum cement mixing systems (Table 1) were utilized using the same cement type and were mixed according to the manufacturers' instructions. MMA vapor concentrations were measured in five phases of mixing. These time points were defined as: Phase 1, unpacking of the device; Phase 2, MMA ampule breakage; Phase 3, mixing; Phase 4, preparation of the cartridge; and Phase 5, cement extrusion and application. Each system was randomly utilized 10 times in both ORs. A one-way analysis of variance (ANOVA, $\alpha = 0.05$) was performed along with a post-hoc Tukey test to compare the 5 systems within each phase to each other. An independent t-test ($\alpha = 0.05$) was used to determine differences within individual mixing systems in both settings.

RESULTS:

When comparing the MMA concentration levels of each system across the 2 settings, emission levels remained significantly higher in the CV setting with few exceptions (**Tables 2 & 3**). When analyzing the summative MMA vapor emissions over time (**Figure 2, Tables 2 and 4a, b**), the most pronounced differences were observed in the CV setting (**Table 2, 4b**), notably in the middle phases of cement preparation. One notable consistency was that System #5 had the lowest overall emissions for each of the 5 phases in the CV setting.

DISCUSSION AND CONCLUSION:

These results indicate multiple differences in the levels of MMA fumes generated within a group of mixing systems, as well as differences across operative settings. This study demonstrated that an operative environment with LAF is conducive to clearing the fumes of MMA as well as limiting the amount of time that residual fumes linger after mixing. The enclosed system, system #5, outperformed all of the other mixing systems in the CV setting. In order to decrease the risk of harmful MMA exposure, especially in an OR lacking a LAF ventilation system, an enclosed mixing system can reliably keep fume levels to a minimum compared to other mixing systems. Utilizing this closed system, especially in a CV OR, may reduce MMA fume exposure potentially creating a more favorable working environment.