The danger of heating mercury in dental surgeries

T M Letcher*, P Cleaton-Jones**, M Albers* and J Schnieder*

*Department of Chemistry, University of the Witwatersrand, Johannesburg, South Africa
**Dental Research Unit of the South African Medical Research Council, and the University of the Witwatersrand, Johannesburg, South Africa

Keywords: Health hazards; mercury, pollution, toxicity

SUMMARY

Merfield et al (1976) recently mentioned the possible hazard of inadvertent mercury heating in a dental surgery. The present study investigated this effect by heating mercury in a controlled box. The resulting mercury vapour concentration was determined using the colorimetric method of Jørgensen (1974). Mercury vapour concentration was markedly increased by increases in temperature. Special care must be taken to avoid mercury spillage near central heating units, heaters and sterilizers.

OPSOMMING

Merfield et al (1976) het onlangs melding gemaak van die moontlike gevaar wat die onopsetlike verhitting van kwik in 'n tandheelkundeoperasiekamer inhou. In die huidige studie is hierdie effek ondersoek deur kwik in 'n gekontrolleerde kissie te verhit. Die kwikdampkonsentraat wat so geskep is, is deur middel van die kolorimetriese metode van Jørgensen (1974) vasgestel. Kwikdampkonsentraat is opvallend verhoog deur temperatuur. Spesiale sorg moet beoefen word om te verhoed dat kwik naby sentrale verwarmingseenhede, verwarmers en sterilisators verspil word.

Perhaps the most serious cause of high level mercury vapour contamination in dental surgeries is inadvertent heating of liquid mercury. This was most likely the cause of the serious mercury intoxication reported recently by Merfield *et al* (1976).

The vapour pressure of mercury increases rapidly with increase in temperature. Table I lists the equilibrium vapour pressures and the saturated mercury vapour concentrations in air for decadic intervals of temperature between 0 °C and 100 °C, computed by assuming mercury vapour to be an ideal gas. The mercury vapour concentration in a room at 25 °C, containing exposed mercury surfaces can, in theory, reach the equilibrium or saturated level of 16,5 mg Hg m^{-3}. Fortunately, this level is not usually attained because even moderate ventilation reduces the mercury concentration to insignificant levels by air replacement. If, however, the mercury is heated, the rate of evaporation and the resulting air contamination increases tremendously. To illustrate this, a control space was sealed off from ventilation effects, liquid mercury allowed to evaporate at various temperatures and the mercury contamination of the space determined.

Table I. Equilibrium vapour pressure (P) and concentrations (c) of mercury in air at various temperatures (t)

t/°c	P/torr	c/mg m^{-3}
0	185×10^{-6}	2.2
10	0.49×10^{-3}	5.6
20	0.20×10^{-3}	13.2
30	2.78×10^{-3}	29.5
40	6.08×10^{-3}	62.5
50	12.67×10^{-3}	126.0
60	25.28×10^{-3}	241.0
70	48.25×10^{-3}	453.0
80	88.80×10^{-3}	809.0
90	158.2×10^{-3}	1402.0
100	272.9×10^{-3}	2327.0

MATERIALS AND METHODS

A fume hood was sealed off with plastic sheets and used as the experimental box. It was fitted with two fans to ensure good air circulation within the box. The mercury, in a 10 cm diameter beaker was controlled at various temperatures using a heating mantle, contact thermometer and electronic relay. The mercury surface was 6 cm below the rim of the beaker. The mercury contamination was detected using five palladium chloride impregnated discs and analysed by comparing the greyness of the exposed discs to eight "standard" discs which had previously been exposed to mercury saturated air for periods from 7,5 minutes to 120 minutes (Jørgensen, 1974). The positions of the discs, fans and mercury are given in Table II.

The procedure used for each experimental run was as follows: the mercury was heated to the operating temperature, the fans were then set in motion and after 10 min the discs were exposed to the mercury vapour. As soon as the discs became sufficiently dark to compare with one of the standards, these discs were replaced by fresh discs without switching off the fans or

heater, and the process repeated twice. To avoid contact with the mercury vapour, most manipulations were done by means of draw strings. At the end of the experiment a draw string was made to rip through the plastic sheeting while simultaneously the extractor fans were switched on thereby replacing the contaminated air.

RESULTS

The results in Table III summarize the three runs (of five discs each). The mercury vapour concentration was found to be uniform throughout the box indicating good air circulation. The three consecutive runs did show a slight increase of mercury vapour concentration with time. In the case of the 40 °C and 70 °C runs the vapour within the box was super-saturated.

DISCUSSION

The experiment was carried out in a sealed fume hood because it was considered too dangerous to perform the study in a room of dental surgery proportions.

To put the above levels of contamination in perspective it should be noted that the commonly accepted Threshold Limit Value in the United States of America is 0,05 mg m^{-3} (Eames, 1976). The levels encountered in these experiments are very much higher than one would experience in a surgery. Nevertheless these experiments do show that very high levels of mercury contamination can be encountered in air at room temperature in the vicinity of even moderately heated mercury. Heat sources such as autoclaves, motors, air conditioning units, and central heating bars can very easily generate temperatures far in excess of 70 °C and must therefore be looked upon with care when dealing with mercury, especially in poorly ventilated surgeries.

We consider that the mercury intoxication experienced in the well documented case of Merfield *et al* (1976) was primarily due to the spilt mercury being heated by the autoclave.

Table II. The positions of the beaker, fans, thermometer and discs in the box as measured from the lower front right corner. The coordinates, x, y and z refer to the length, breadth and height

	x/m	y/m	z/m
Box size	2,0	0,8	1,2
Mercury beaker	0,25	0,4	0,1
Fan A	0,1	0,4	0,15
Fan B	1,90	0,4	0,25
Thermometer + disc 1	0,25	0,4	0,3
Thermometer + disc 2	0,5	0,2	0,4
Thermometer + disc 3	0,8	0,6	1,0
Thermometer + disc 4	1,2	0,2	0,4
Thermometer + disc 5	1,7	0,6	0,4

Table III. Mercury vapour concentrations in the experimental box at various mercury temperatures

Mercury temperature °C	Air temperature °C	Mercury concentration/mg m^{-3} Mean ± standard deviation Run 1	Run 2	Run 3
22 ± 1	24 ± 2	2,4 ± 0,5	4,2 ± 0,8	4,8 ± 0,8
40 ± 2	22 ± 1	32,0 ± 6,7	35,0 ± 5,0	40,0 ± 6,1
70 ± 2	22 ± 1	94,0 ± 16,7	108,0 ± 17,9	120,0 ± 15,8

ACKNOWLEDGEMENTS

T.M. Letcher wishes to thank the C.S.I.R. (South Africa) for financial assistance.

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