Title: WASHIN AND WASHOUT OF THREE VOLATILE ANESTHETICS CONCURRENTLY ADMINISTERED DURING CARDIOPULMONARY BYPASS

Authors: N. A. Nussmeier, M.D., N. H. Cohen, M.D., G. J. Moskowitz, B.A., D. M. Fisher, M.D., and E. I. Eger II, M.D.

Affiliation: Department of Anesthesia, University of California, San Francisco, California 94143-0648

Introduction. Washin and washout of isoflurane (I) administered via the oxygenator during cardiopulmonary bypass (CPB) were defined recently.[1,2] Enflurane (E) and halothane (H) are also commonly used during CPB. Based on their differing blood/gas partition coefficients, differences among I, E, and H in their rates of washin and washout might be magnified by hypothermia during CPB. We administered I, E, and H concurrently during CPB to address this issue.

Methods. Institutional approval and informed consent were obtained from 4 patients undergoing cardiac surgery. Prior to CPB, no volatile anesthetic was administered. CPB circuits included Bentley 10-B bubble oxygenators primed with 2000 ml of lactated Ringer's solution; mean Hct during CPB was 24.4 ± 1.8%. After establishing hypothermic CPB at a stable oxygenator temperature (25.2 ± 0.6 °C), a mixture of 0.3 MAC each of I, E and H in oxygen was administered via the oxygenator. Immediately before the addition of anesthetics, and at 1, 2, 4, 8, 16, and 32 min during addition of anesthetics, simultaneous gas and blood samples were obtained from the following locations: a) inlet gas tubing; b) exhaust gas outlet; c) arterial line tubing of the CPB circuit (arterialized blood); and d) venous return port (venous blood). Immediately prior to rewarming, a final set of samples was obtained. The anesthetic concentrations in these samples were the highest (peak) concentrations produced during washin. Anesthetic administration was discontinued as rewarming started. Samples were obtained at 1, 2, 4, 8, 16 and 32 minutes during washout. The study ended before pulmonary ventilation recommenced.

Anesthetic concentrations in all samples were determined by gas chromatography and converted to partial pressures using the blood/gas partition coefficients determined in each study (corrected for the temperature of each sample). Mean blood/gas partition coefficients were 1.43 ± 0.18 for I, 2.14 ± 0.25 for E, and 2.59 ± 0.29 for H. Repeated-measures analysis of variance was used to determine differences among anesthetics in rates of washin and washout.

Results. Figure 1 displays the rise in I, E, and H partial pressures in arterial blood (P_{art}) toward inlet gas partial pressures (P_{in}) during washin. Washin of I was significantly faster than either E or H at all time periods; washin of E was faster than H after 1 min. At 16 min of washin, P_{art} for I was 40% equilibrated with P_{in}, P_{art} for E was 34% equilibrated, and P_{art} for H was 26% equilibrated. At 32 min, equilibration was 48% for I, 43% for E, and 32% for H. Figure 2 displays the decline in P_{art} from the peak partial pressures obtained just before discontinuing anesthetic ($P_{art(0)}$) during washout. Rates of washout of I, E and H did not differ significantly. At 8 min of washout, P_{art} of each agent had declined to < 30%, at 16 min to < 25%, and at 30 min to < 13% of its peak.

Discussion. The speed of washin of the three agents differed, as predicted from their blood/gas partition coefficients: I > E > H. Washin of all agents was slower during hypothermic CPB than during administration via the lungs of normothermic patients, probably because of the greater tissue capacity for these agents produced by hypothermia (with blood/gas partition coefficients similar to those measured in normothermic non-hemodiluted patients). There were no significant differences among the three agents in their rates of washout. We have no explanation for this finding. The rate of washout of each agent was faster that its rate of washin, and was similar to washout during pulmonary administration in normothermic patients. The normal decay rates during washout may be the result of declining blood/gas partition coefficients (due to rewarming) and the counterbalancing presence of relatively high tissue stores of anesthetic (due to washin during hypothermia). In summary, washin of I is faster than E or H, and E is faster than H during hypothermic CPB; during washout, these differences disappear.

Figure 1. Washin of Three Anesthetics

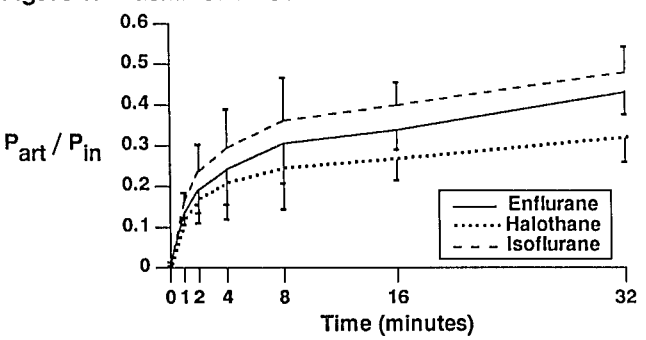
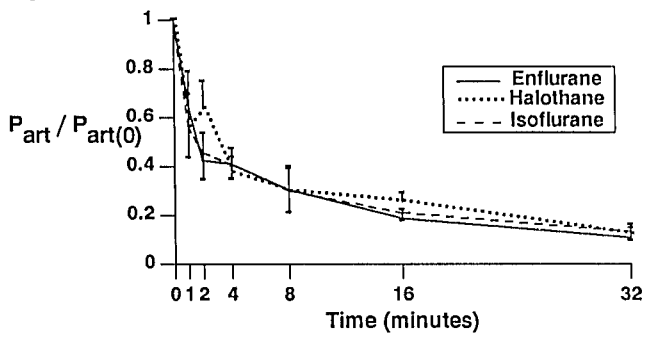


Figure 2. Washout of Three Anesthetics



References.

1. Nussmeier NA, *et al.*: Washin and washout of isoflurane during cardiopulmonary bypass. Anesth Analg 67:S159, 1988
2. Loomis CW, *et al.*: Arterial isoflurane concentration and EEG burst suppression during cardiopulmonary bypass. Clin Pharmacol Ther 40:304-313, 1986