Xenon washout from the rabbit femur during short hyperbaric exposures

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Davis TRC. Xenon washout from the rabbit femur during short hyperbaric exposures. Undersea Biomed Res 1992; 19(5):355–359. — Xenon washout from the femora of 5 anesthetized rabbits was recorded during short hyperbaric exposures (3 atm abs). Equipment tests showed that the scintillation counter was heat sensitive. The recorded count rate from a constant source of $^{133}$Xenon decreased during compression (temperature rose 5°C) and increased during decompression (temperature fell 5°C). When the scintillation counter was thermally insulated, the rate of xenon washout from the femur remained unchanged in all rabbits during these hyperbaric exposures. The conclusion is that the rate of xenon washout from the femur is not affected by changes in ambient pressure. As most scintillation counters are heat sensitive, it is possible that the previous report of such changes was erroneous and caused by heat sensitivity of the recording equipment.

xenon washout
bone
compression
decompression

It has been reported that the rate of bone blood flow changes during the compression and decompression phases of short hyperbaric exposures (1–3). Experiments that monitored intraosseous pressure (1) and xenon washout (2, 3) concluded that bone blood flow increases during compression and decreases during decompression. However, a subsequent study concluded that intraosseous pressure remains unchanged during short hyperbaric exposures (4).

This study was performed to confirm previous reports (2, 3) that the rate of xenon washout from bone changes during the compression and decompression phases of short hyperbaric exposures.

METHOD AND MATERIALS

Young adult male New Zealand rabbits (2.5–5 kg) were premedicated (i.m. hypnorm 0.3 ml/kg; hypnorm = fentanyl citrate 0.315 mg/ml and fluanisone 10 mg/ml) and
anesthetized (i.v. midazolam 2 mg/kg). Anesthesia was maintained by i.v. infusion of hypnorm (2 ml · kg⁻¹ · h⁻¹). Each rabbit was placed in the compression chamber (ambient gas mixture = air). The hind limb under investigation was placed in a clamp to prevent movement during xenon washout recordings. A sharp metal trochar and cannula (22 gauge) was passed percutaneously through the lateral cortex of the distal metaphysis of the femur. The cannula’s position in the medulla was confirmed by a back flow of fatty blood; 0.1 ml of ¹³³Xenon solution (3 mCi/ml: Amersham International, UK) was injected into the cannula and flushed through with saline (0.1 ml). The trochar was reinserted. A thermally insulated, sodium iodide crystal scintillation counter (Field Scintillation Counter, no 618A, Ecko Electronics Ltd, England) was placed directly over the distal femur. This was connected to a count recorder (NE Scaler Ratemaster, Nuclear Enterprises Ltd, Reading, England) and pen recorder (Type X Pen Recorder, Telsec Instruments, Oxford, England) which were calibrated to record counts in the main ¹³³Xenon wavelength.

¹³³Xenon washout from the femur was observed at 1 atm abs for 3 min. The ambient air pressure in the compression chamber was then increased, over 2 min, to 3 atm abs. After 15 min at this pressure, the chamber was decompressed, over 2 min, back to atmospheric pressure. ¹³³Xenon washout was monitored throughout these hyperbaric exposures and for 5 min after decompression.

Data analysis

For each ¹³³Xenon washout curve, a best fit exponential curve of the form \( \log_{10} \text{cps} = A + BC^t \) (cps = ¹³³Xe counts/s; \( t \) = time; \( A \), \( B \), and \( C \) = constants) was generated using Genstat 5 software (Lawes Agricultural Trust, Rothamsted Experimental Station, England). The percentage of the data variation that could be accounted for by this exponential curve was calculated.

RESULTS

Equipment test

The equipment was tested by recording the count rate of a constant ¹³³Xenon source (4 mBq) during three hyperbaric exposures (3 atm abs). Figure 1 shows the changes that were observed in the count rate during these simulated dives. Compression decreased and decompression increased the count rate. The ambient temperature in the compression chamber rose by 5°C during compression and fell by 5°C during decompression. To investigate whether these temperature changes were the cause of the changes in the count rate, the scintillation counter was heated by a domestic fan heater. This produced a marked reduction in the recorded count rate from the constant ¹³³Xenon source.

The scintillation counter was thermally insulated with foam. Although the equipment remained slightly heat sensitive, this was insufficient to affect the results of this experiment.

Animal studies

¹³³Xenon washout from the femur was recorded during 15 simulated dives in 5 rabbits. Figures 2–4 show examples of the ¹³³Xenon washout curves. For each washout
XENON WASHOUT

Fig. 1. Recorded count rate from a constant source of $^{133}$Xenon during 3 simulated dives to 3 atm abs. Traces recorded during the upper 2 dives were interrupted during the bottom phase which lasted 40–60 min, respectively. $ls$ = leave surface; $ab$ = arrive bottom; $lb$ = leave bottom; $as$ = arrive surface.

Fig. 2. $^{133}$Xenon washout from the distal femur during the compression phase of a simulated dive to 3 atm abs. $CPS =$ counts per second; $LS =$ leave surface; $AB =$ arrive bottom. Best fit exponential curve ($\log_{10}$cps = 3.763 + 3.041 x 0.998$^t$) accounts for 99.8% of the data variation.
Fig. 3. $^{133}$Xenon washout from the distal femur during the decompression phase of a short, simulated dive to 3 atm abs. $CPS =$ counts per second; $LB =$ leave bottom; $AS =$ arrive surface. Best fit exponential curve ($\log_{10}cps = 2.539 + 3.343 \times 0.999^x$) accounts for 99.8% of the data variation.

curve at least 99.5% of the data variation could be accounted for by the computer-generated exponential curves. In all instances the unaccounted variation (less than 0.5%) occurred throughout the washout curve and was not clustered within a particular phase of the hyperbaric exposure.

DISCUSSION

This study has failed to confirm the previous reports (2, 3) that the rate of $^{133}$xenon washout from bone changes during compression and decompression. It is possible that the failure of the present study to demonstrate changes resulted from differences in the experimental designs of the two studies. Older animals, whose marrow would have contained less hematopoietic tissue and more fat, were used in the previous experiment. However, it is not stated whether the equipment used in the previous study was tested for temperature or pressure sensitivity. It is possible that these workers observed an artifact caused by temperature sensitivity of their scintillation counter. Most sodium iodide scintillation counters are temperature sensitive (5, 6).

Previous reports (2, 3) of changes in $^{133}$xenon washout supported the findings of another study that demonstrated changes in intraosseous pressure during the compression and decompression phases of short hyperbaric exposures (1). However, a subsequent study (4) failed to demonstrate changes in intraosseous pressure during simulated dives. Furthermore, equipment tests suggested that the results of the
Fig. 4. \(^{133}\)Xenon washout from the distal femur during a short, simulated dive to 3 atm abs. CPS = counts per second; LS = leave surface; AB = arrive bottom; LB = leave bottom; AS = arrive surface. Best fit exponential curve (log(cps) = -3.612 + 4.756 \times 0.997) accounts for 99.9% of the data variation.

previous experiment (1) may have resulted from temperature sensitivity of the pressure transducer.

In conclusion, this study failed to demonstrate that the rate of \(^{133}\)Xenon washout from bone marrow varied during the compression and decompression phases of short hyperbaric exposures. It is suggested that the previous reports of such changes (2, 3) may have resulted from temperature sensitivity of the scintillation counter.

The data analysis was performed by Mr. P. Riley, Statistician, Cripps Computing Centre, Nottingham University, Nottingham, England.—Manuscript received December 1991; accepted May 1992.

REFERENCES
