Arterial and mixed venous xenon blood concentrations in pigs during wash-in of inhalational anaesthesia†

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There are no data available on the kinetics of blood concentrations of xenon during the wash-in phase of an inhalation anaesthesia aiming at 1 MAC end-expiratory concentration. Therefore, we anaesthetized eight pigs with continuous propofol and fentanyl and measured arterial, mixed venous and end-expiratory xenon concentrations by gas chromatography–mass spectrometry 1, 2, 3, 4, 5, 7, 10, 15, 20, 30, 60 and 120 min after starting the anaesthetic gas mixture [67% xenon/33% oxygen; 3 litre min⁻¹ during the first 10 min, thereafter minimal flow with 0.48 (SD 0.03) litre min⁻¹]. End-expiratory xenon concentrations plateaued (defined as <5% change from the preceding value) at 64 (6) vol% after 7 min, and arterial and mixed venous xenon concentrations after 5 and 15 min respectively. The highest arterio-venous concentration difference occurred after 3 min. Using the Fick principle, we calculated a mean xenon uptake of 3708 (829) and 9977 (3607) ml after 30 and 120 min respectively.

Keywords: anaesthetic techniques, inhalation; anaesthetics, gases, xenon; pharmacokinetics, xenon; pig

Accepted for publication: March 26, 2001

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Br J Anaesth 2001; 87: 497–8

Methods and results

As part of another protocol approved by the institutional animal care committee (Regierungspräsidium, Tübingen, Germany) and performed in accordance with the legal regulations for the use of laboratory animals, which investigated the effects of different anaesthesia techniques during experimental bowel obstruction, eight pigs aged 12–16 weeks and weighing 37.5–46 (SD 3.2) kg were premedicated with azaperon 4 mg kg⁻¹ i.m. and atropine 2.5 mg i.m. Anaesthesia was induced with i.v. ketamine 2 mg kg⁻¹ and pentobarbitone 8–10 mg kg⁻¹. The trachea was intubated and ventilation was performed with 30% oxygen in nitrogen using a standard semi-closed ventilator (Cicero; Draegerwerk, Lübeck, Germany). Ventilatory settings throughout the experiment were tidal volume (Vₜ) 10–14 ml kg⁻¹ (adjusted to achieve a $P_{aCO_2}$ of 37–43 mm Hg), ventilator frequency (f) 12 min⁻¹, and a positive end-expiratory pressure of 5 cm H₂O. Muscle paralysis was obtained with alcuronium dichloride (0.25 mg kg⁻¹) followed by an infusion (14 mg h⁻¹). Anaesthesia was maintained with a continuous i.v. infusion of propofol (5–10 mg kg⁻¹ h⁻¹) and fentanyl (5–10 μg kg⁻¹ min⁻¹). Depth of anaesthesia was assessed by continuous EEG monitoring (Neurotrac; Interspec, Cronshocken, PA, USA); the 95% spectral edge frequency was always below 15 Hz during the experiment. Ringer’s solution (7 ml kg⁻¹ h⁻¹) was administered continuously as a maintenance fluid. A thermodilution pulmonary artery catheter was placed via
the right internal jugular vein, and both femoral arteries were exposed to insert a catheter for blood sampling and continuous recording of arterial pressure. A 3 Fr thermistor-tipped fibre-optic catheter was used for measurement of cardiac output by thermal dye double indicator (indocyanine green) dilution and for the determination of intrathoracic blood volume (FT-Pulsicath PV 2023, Cold Z021; Pulsion, München, Germany). A minimum of 2 h was allowed for recovery after the surgical procedure. For the measurement of minute volume, a rotating vane flowmeter was used as an independent volumeter because of the inaccuracy of the built-in volumeter of the anaesthesia machine resulting from the higher density of xenon.

Thereafter, the inspired gas mixture was changed from 2 litre min⁻¹ of air and 1 litre min⁻¹ of oxygen to 2 litre min⁻¹ of xenon and 1 litre min⁻¹ of oxygen for 10 min, as described previously, in order to achieve an end-expiratory xenon concentration close to 1 MAC (minimum alveolar concentration) without causing hypoxaemia as a result of the expected nitrogen wash-out. For economy, the fresh gas flow was then reduced to 0.175 (SD 0.03) litre min⁻¹ of xenon and 0.306 (0.02) litre min⁻¹ of oxygen for the rest of the study period. End-expiratory gas, arterial and mixed-venous blood were sampled 1, 2, 3, 4, 5, 7, 10, 15, 20, 30, 60 and 120 min after starting xenon inhalation and the respective xenon concentrations were measured by gas chromatography–mass spectrometry. Whole-blood xenon calibration curves for each animal were constructed on the calibration curves for each animal were constructed on the

Arterial and mixed venous blood xenon concentration reached a plateau at 5 min (70 (9) vol%) after 7 min. The xenon concentrations in the arterial and mixed venous blood reached a plateau at 64 (6) vol% (defined as <5% change from the preceding value) after 7 min. There were no significant changes in heart rate, arterial and central venous blood pressure, intrathoracic blood volume and cardiac output during the study period.

Comment

In a pig model, we measured the xenon concentration in blood during the wash-in phase of inhalational anaesthesia. Arterial and mixed venous blood xenon concentration increased rapidly, with a time lag of 10 min, indicating the prompt establishment of equilibrium in the vascular compartment and, hence, the main target of anaesthesia, the brain. When compared with a previous study, the time needed to reach an arterial equilibrium was relatively long, probably because of the lower initial fresh gas flows used in the present investigation. Gas accumulation in the gut and adipose tissue may cause the mixed venous xenon concentration to slowly rise until the end of the experiment.7 The calculated mean xenon uptake of approximately 4 litres after 30 min and 10 litres after 120 min of inhalational anaesthesia with xenon at end-expiratory gas concentrations close to 1 MAC in 45-kg animals confirms the prediction reported by Luttropp and co-workers for an average adult during the first 2 h of xenon administration using a minimal flow technique.8

Acknowledgements

We thank Mrs R. Engelhardt and Mr W. Siegler for skilful technical assistance.

References