End-tidal partial pressure of carbon dioxide does not accurately reflect $P_{a\, CO_2}$ in rabbits treated with acetazolamide during anaesthesia

T.-S. LEE

SUMMARY
Acetazolamide, a carbonic anhydrase inhibitor, may cause significant disturbances in carbon dioxide transport and elimination. In this study, end-tidal carbon dioxide monitoring has been used to study the correlation between arterial carbon dioxide ($P_{a\, CO_2}$) and end-tidal carbon dioxide partial pressure ($P_{E\, CO_2}$) in rabbits treated with acetazolamide. A significant difference in ($P_{a\, CO_2} - P_{E\, CO_2}$) developed immediately after administration of acetazolamide and persisted for more than 2 h. It is concluded that $P_{E\, CO_2}$ did not reflect accurately $P_{a\, CO_2}$ and the ventilatory status of the rabbit which received acetazolamide within 2 h. (Br. J. Anaesth. 1994; 73: 225-226)

KEY WORDS

Previous studies on acetazolamide have observed disturbances in carbon dioxide transport and respiration and it is important to know whether or not monitoring of end-tidal carbon dioxide ($P_{E\, CO_2}$) is reliable in assessing the adequacy of ventilation when a patient receives acetazolamide.

Carbonic anhydrase is present in lung tissue where it directly catalyses the conversion of plasma and red blood cell $H_2CO_3$ to carbon dioxide as blood passes through the pulmonary capillaries, thus increasing the rate of dehydration and excretion of large amounts of carbon dioxide over small gradients [1, 2].

Clinically, acetazolamide is used in conditions such as glaucoma and metabolic alkalosis, particularly in overhydrated patients [3-5]. It delays the conversion of $H_2CO_3$ to carbon dioxide in blood and pulmonary capillary endothelium and hydration of carbon dioxide at the tissue level [6]. It may thus cause considerable disturbance to carbon dioxide transport in the tissue and elimination of carbon dioxide from the lungs and produce a significant difference between arterial and alveolar $P_{CO_2}$ [1, 2].

The time course of changes in carbon dioxide partial pressures after i.v. administration of acetazolamide has been described in dogs and cats [7-9].

The purpose of this study was to determine the reliability of $P_{E\, CO_2}$ monitoring in reflecting arterial $P_{CO_2}$ ($P_{a\, CO_2}$) in rabbits after i.v. administration of acetazolamide during anaesthesia and constant mechanical ventilation.

MATERIALS AND METHODS
The experiments were performed in seven New Zealand rabbits, weighing 3.2-3.6 kg, under halothane anaesthesia. After induction of anaesthesia, the trachea was intubated, pancuronium administered and the lungs ventilated mechanically with a Harvard animal ventilator to maintain an initial $P_{a\, CO_2}$ of 4.5-5.8 kPa. $F_{O_2}$ was maintained at 0.5 throughout the experiment. A cannula was placed in the femoral artery for direct arterial pressure monitoring and blood sampling and a central vein catheterized via the femoral vein.

$P_{E\, CO_2}$ was measured at the proximal end of the tube with an Engstrom Eliza carbon dioxide analyser. After baseline measurements were obtained at steady state, acetazolamide 20 mg kg$^{-1}$ was administered i.v. At 1, 5, 15, 30, 60, 90, 120, 150 and 180 min after injection, the following measurements were made: heart rate, arterial pressure, arterial blood gas tensions and pH, mixed expired carbon dioxide and $P_{E\, CO_2}$. The results were expressed as mean (SEM) and analysed by the paired $t$ test. $P < 0.05$ was regarded as significant.

RESULTS
Before administration of acetazolamide, the control values of $P_{a\, CO_2}$ and $P_{E\, CO_2}$ were close, the difference between them being less than 0.5 kPa. Immediately after i.v. acetazolamide, $P_{E\, CO_2}$ decreased significantly and rapidly to its lowest point at 5 min, from 4.9 to 3.1 kPa, and returned gradually to its initial value in 1 h (fig. 1).

$P_{a\, CO_2}$ increased significantly immediately after administration of acetazolamide from 5.1 kPa to a peak of 7.8 kPa at 30-60 min. At the end of the 3-h observation period, it gradually declined towards, but was still significantly higher than, the baseline

TAI-SHION LEE, M.D., Department of Anesthesiology, Box 10, Harbor-UCLA Medical Center, 1000 W Carson Street, Torrance, CA 90509-2910, USA. Accepted for Publication: January 25, 1994.
When carbonic anhydrase is inhibited, elimination of carbon dioxide through the lung is only a fraction of the normal carbon dioxide output and emanates largely from carbamino and dissolved carbon dioxide [9]. Normally, pulmonary carbon dioxide output is derived mainly from bicarbonate. After carbonic anhydrase, 45% emanates from dissolved carbon dioxide, 38% from carbamino and only 17% from bicarbonate [8]. Alveolar \( P_{CO_2} \) decreases and mixed venous \( P_{CO_2} \) increases progressively. Therefore, elimination of carbon dioxide is considerably disturbed resulting in a significant increase in \( P_{CO_2} \) and decrease in \( P_{\ell CO_2} \). There is significant tissue retention of carbon dioxide and disequilibration of carbon dioxide concentrations between mixed venous, and arterial blood and alveolar gas [1, 4]. With constant ventilation, \( (P_{ACO_2} - P_{\ell CO_2}) \) increases. In the absence of cellular anhydrase activity, there is a build-up of carbon dioxide stores in the tissues [10]. The degree of carbon dioxide retention may be as high as 5.8% of total carbon dioxide production, but the true extent may not be reflected appropriately in arterial or venous blood [4, 5]. In spontaneously breathing anesthetized dogs, alveolar \( P_{CO_2} \) is decreased and mixed venous \( P_{CO_2} \) is increased after inhibition of carbonic anhydrase [8]. Because of the

increase in tissue and plasma carbon dioxide, ventilation increased markedly after acetazolamide to almost double at 30 min [8], which may be partially responsible for the initial decrease in alveolar \( P_{CO_2} \) [8]. The transfer of dissolved carbon dioxide in blood in the lung is increased by the increased gradient for carbon dioxide from mixed venous blood to alveolar air during this period [4, 8]. The rapid reduction in \( P_{\ell CO_2} \) to its lowest point at 5 min is consistent with a previous report of a marked decrease in carbon dioxide output to 60% of control during that period [8]. \( (P_{ACO_2} - P_{\ell CO_2}) \) was increased for 2 h after administration of acetazolamide in our study, also in agreement with the results of previous studies [7, 8].

Because of species differences, it may not be possible to extrapolate from this rabbit study to the clinical situation. Nevertheless, as patients may receive acetazolamide for treatment of metabolic alkalosis or glaucoma during surgery in an emergency, the anaesthetist should be aware of the possible unreliability of \( P_{ACO_2} \) to reflect \( P_{\ell CO_2} \) and ventilation in these situations.

**REFERENCES**