the opposite of their normal profile of reactivity. This polypeptide, when injected i.v. in a single dose potentiates constrictor responses to topically applied catecholamines. In contrast to these microcirculatory effects, PLV-2 inhibits norepinephrine-induced contractions in the isolated rabbit aortic strip.

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Blood Lactate and Pyruvate and Evidence for Hypocapnic Lacticacidosis in the Chicken.* (30153)

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In mammals there is an inverse relationship between plasma P_{CO_2} and level of blood lactate and pyruvate(1-3). A similar relationship for an avian species has not been established.

Materials and methods. Adult male white Leghorn chickens (2.5 kg to 3.1 kg) kept in outdoor pens were used in these experiments. Experiments were conducted between February and May so the animals were adapted to cold. The tracheas, left carotid arteries and right brachial veins were cannulated under local anesthesia (ethyl chloride). Incisions were closed and 20 mg/animal of heparin (sodium) was administered intravenously. After waiting approximately 15 minutes, a control sample of blood was drawn. Succinylcholine was injected i.v., initially in a dose of 40 mg/animal and before each additional ventilating regimen in a dose of 20 mg/animal. The animals were overventilated artificially by connecting the tracheal cannula of the animal to a respiratory pump which ran at a stroke volume of 38 ml and a rate of 50 breaths per minute (1.9 l/min). Gas mixtures of 21% O_2, and 0, 5 or 10% CO_2 with the remainder as N_2 were delivered to the animals on the over ventilation regimen. Presentation of gas mixtures was randomized to eliminate the possibility of sequence of presentation influencing the results. In some experiments only 0 and 5% CO_2 were used.

At the end of 30 minutes on a given gas mixture a 4 ml sample of arterial blood was drawn after first drawing ½ ml to clear the cannula. The portion of blood sample to be analyzed for lactate and pyruvate and glucose was drawn into a 2 ml syringe, transferred directly into a centrifuge tube containing 2 ml of chilled 10% trichloroacetic acid and mixed. Volume of blood was determined on the basis of weight increase assuming a specific density of 1.06 g/ml for chicken blood. The remainder of the sample was drawn into a heparinized syringe and stored in an ice bath until appropriate determinations could be made.

Lactate concentrations were determined by the method of Friedland and Dietrich(4).

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TABLE I. Average Concentration for Blood Lactate, Pyruvate, Glucose, Po_2, Pco_2, pH and Estimated Plasma Bicarbonate in Chickens After ½ Hour Hyperventilation with Various Gas Mixtures.

	No. animals	Lactate, mEq/l	Pyruvate, mEq/l	Glucose, mg %	Po_2, mm Hg	Pco_2, mm Hg	pH	Estimated plasma HCO_3^-, mM/l
Control	8	3.67 ± .23*	.16 ± .01	149 ± 10	88 ± 4	22 ± .8	7.50 ± .02	16.2 ± .8
Ventilated with								
0% CO_2	8	5.21 ± .29	.33 ± .02	169 ± 9	123 ± 8	<10†	7.67 ± .02	11.3 ± .5‡
5% CO_2	8	3.66 ± .24	.22 ± .02	173 ± 8	124 ± 4	27 ± 1.1	7.38 ± .02	15.5 ± 1.1
10% CO_2	5	4.21 ± .39	.21 ± .03	192 ± 18	124 ± 2	56 ± 5.0	7.17 ± .05	19.8 ± 1.1

* S.E. † Indicates plasma Pco_2 below sensitivity of system to detect. ‡ Estimated assuming $Pco_2 = 10$ mm Hg.

The method of Friedmann and Haugen(5) was used to estimate pyruvate concentrations. Blood glucose was determined enzymatically using Glucostat.† A Clark-type electrode was used to measure Po_2; a Severinghaus electrode measured Pco_2; and Metrohm micro pH electrode determined pH. Responses of the 3 electrode systems were recorded from a Beckman model 160 amplifier. It was not possible to record Pco_2 less than 10 mmHg with the equipment described. All gas and pH determinations were carried out with the electrode cuvettes in a water bath kept at the temperature of the animal when the sample was drawn. Plasma bicarbonate concentration was estimated by using the Henderson-Hasselbach equation, the measured values of pH and Pco_2 and assuming a pK′ of 6.1 and the solubility of CO_2 in plasma as 0.03 mM/l/mmHg Pco_2. Exact values for pK′ and solubility of CO_2 in chicken plasma are not available so that a correction for temperature 2°C greater than 38°C does not appear warranted. Mean and standard error of the mean were calculated on all data(6).

Results. Average values for blood lactate and pyruvate concentrations obtained in 19 restrained, non-struggling, male chickens were 3.32 mEq/l (± 0.16) and 0.18 mEq/l (± .01), respectively. The average blood Po_2 was 90 mm Hg (± 2.8, n = 13); Pco_2 was 23 mm Hg (± 0.8, n = 14); and pH was 7.48 (± 0.02, n = 14).

The effect of hyperventilating chickens with gas mixtures of 0%, 5% and 10% CO_2 content and 21% O_2 on blood gases, pH, bicarbonate, lactate, pyruvate and glucose is shown in Table I. Po_2 averaged 124 mm Hg during the 3 periods of hyperventilation. Average Pco_2 increased with the increasing percentage of CO_2 in the gas mixtures and blood pH decreased with increasing Pco_2. The calculated bicarbonate concentration increased with respiratory acidosis (10% CO_2) and decreased with respiratory alkalosis (0% CO_2). There was no significant change in bicarbonate concentration during ventilation with 5% CO_2. Hyperventilating with 5 or 10% CO_2 also failed to influence lactate and pyruvate levels. The average difference when analyzed, using the individual chicken as its own control, was + 0.01 mEq/l for lactate (± 0.25) and + 0.04 mEq/l for pyruvate (± 0.02) (n = 8) with hyperventilation on 5% CO_2. On 10% CO_2 the differences from control levels were + 0.32 mEq/l, (± 0.42) for lactate and 0.03 mEq/l (± 0.02) for pyruvate (n = 5). When chickens were hyperventilated on gas mixtures containing 0% CO_2 average lactate and pyruvate concentrations were significantly greater than control levels (+ 1.75 mEq/l, ± 0.27 for lactate and 0.18 mEq/l, ± 0.02 for pyruvate, n = 8). Average blood glucose was 149 mg% (± 9.7). It increased during periods of hyperventilation irrespective of the gas composition.

Discussion. The present study demonstrates that hypocapnia combined with alkalosis can bring about a marked increase in blood lactate and pyruvate in the chicken. When compared with mammalian species the increased lactate occurred over already elevated lactate levels.

The value of 3.32 mEq/l in 19 chickens which is high in comparison to mammalian species may be considered normal for avian

† Worthington Biochemical Corp., Freehold, N. J.

species. In "resting" pigeons, blood lactate levels ranged from 2.56 mEq/l to 5.00 mEq/l (7). Blood lactate levels of 5.22 to 6.22 mEq/l have been reported in "non-laying" chickens(8). Specific information on the technique used in this citation is not available. Unless enzymatic action is rapidly halted pyruvate is converted to lactate during the period of time the blood is handled outside the body(9). In the present report a special effort was made to effect a rapid and thorough deproteinization. In addition the animal was not struggling before or during the time the sample was drawn so that the epinephrine titer should not alter the lactate concentration(10). Using the same procedures on 12 anesthetized cats average values for blood lactate were 1.11 mEq/l ($\pm$ 0.16).

Arterial blood Po_2 in the normal male chicken was sufficiently high to rule out the presence of arterial hypoxia as a cause of the elevated lactate concentration observed in control animals when compared to mammals. Blood Po_2, pH, pyruvate and glucose levels observed in the present study are within the range expected(11-14).

There are very few data on arterial blood Pco_2 in chickens. The value of 23 mm Hg obtained in the present study was from unanesthetized animals and the pressures were determined at the temperature of the animal. Alveolar Pco_2 has been reported to be approximately 40 mm Hg in anesthetized hens (15). Anesthesia could depress respiration and contribute to a higher arterial Pco_2. The gas mixtures used for artificial respiration were chosen to maintain blood Pco_2 close to the value under control conditions, or shift it below or above control levels. Because of the need for frequent and rapid changes, the respiratory pump was not gas tight on the intake side and arterial Pco_2 values were lower than the supply gas mixtures when the animals were artificially respired.

In mammals it is well established that blood levels of lactate and pyruvate are increased during periods of hypocapnia(1-3). The present report demonstrates that a representative species from a lower class of vertebrates can also display the same response. The physiological and biochemical significance of these observations is not clear. Certainly the manner in which glucose is handled, comparing mammalian and avian species, must be different because of the quantitative difference in normal blood glucose levels and the response to endocrine changes(16).

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