A STUDY OF ACID–BASE STATUS AND GASES IN BODY FLUIDS IN TWO SPECIES OF BOVINES

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ABSTRACT

A comparative study was undertaken on acid–base status and gases in arterial and venous blood and lumbar cerebrospinal fluid (CSF) in bovine species. The results revealed that arterial and venous blood pH, plasma bicarbonate, and base excess were significantly different between cow calves and buffalo calves. Bicarbonate content and pCO_2 of CSF did not vary between cow calves and buffalo calves, and were similar to those in man but lower than in dogs. It was concluded that acid–base components and gas parameters of CSF were more close to venous blood in pCO_2 and base excess but were similar to arterial blood in respect of pH and oxygen saturation. This signifies that information about acid–base parameters and gases in CSF can be obtained only by analysis of CSF samples and cannot be assessed from analysis of blood samples.

INTRODUCTION

BLOOD and cerebrospinal fluid (CSF) acid–base status and gases are important physiological parameters for diagnosis (in establishing pathophysiology of metabolic, gastrointestinal and cardiopulmonary disorders) and therapeutic purposes. The nature (respiratory or metabolic) and degree (moderate or severe) of acidosis and alkalosis determine their influence on cardiac rate, cardiac output, blood pressure and peripheral vascular resistance[1–3]. However, a perusal of the literature indicates that there is scanty information on these parameters in blood and CSF of animals. The present study reports the physiological status of acid–base parameters and gases in arterial and venous blood and CSF, and comparative evaluation of these parameters in cow calves and buffalo calves.

MATERIALS AND METHODS

Twelve healthy crossbred (Red-Dane × Sahiwal) and 12 buffalo calves of about one year of age were selected for the present study. The animals were kept on standard feeding and management practices[4]. Jugular vein and carotid artery exposed surgically were fitted with a siliconized catheter for collection of blood. The blood samples were drawn in heparinized air-tight disposable polypropylene radiometer syringes. Lumbar CSF was collected from comfortably controlled animals in calibrated glass capillary tubes and were immediately sealed with no air bubble or air column. The polypropylene syringes were provided with silicone sealing ring and cellulose fibre disk for impregnating sodium heparin (70 IU) compensated for Na^+, K^+ and Ca^{2+} binding. The samples were immediately analysed using a blood gas analyser (Radiometer ABL 30, Copenhagen, Denmark) for pH, partial pressure of CO_2 (pCO_2), pO_2, actual bicarbonate (HCO_3^-), total CO_2, actual base excess (ABE), standard base excess (SBE), standard bicarbonate (SBC), oxygen saturation (SAT), oxygen saturation (O_2 CT) and oxygen extraction ratio (OER). Arterial and venous carbonic acid (H_2CO_3) were calculated from pCO_2 and solubility coefficient of CO_2 in blood[5] using H_2CO_3 (mmol/l) = pCO_2 (mm Hg) × 0.03. OER was calculated using the formula[6] OER (%) = [(Arterial oxygen content (vol. %) − Venous oxygen content (vol. %)/Arterial oxygen content (vol. %)] × 100. The data were statistically analysed at 1 and 5% levels of significance by Student's *t* test.

RESULTS AND DISCUSSION

The mean arterial pH of cow calves (table 1) was lower than the reported value for Holstein-Friesian calves[7] but was very close to those reported for Ayrshire calves[8]. The difference in sampling techniques, method of analysis (rewarming of plasma or

Table 1 *Physiological values of acid–base variables and gases in arterial and venous blood and cerebrospinal fluid (mean ± SE) of cow calves and buffalo calves*

	pH	pCO_2 (mmHg)	pO_2 (mmHg)	HCO_3^- (mmol/l)	TCO_2 (mmol/l)	H_2CO_3 (mmol/l)	ABE (mmol/l)	SBE (mmol/l)	SBC (mmol/l)	SAT (%)	O_2CT (vol %)	OER (%)
Cow calves												
Arterial blood	7.392 ±0.005	38.14 ±0.64	87.94 ±2.68	22.91 ±0.51	24.04 ±0.53	1.144 ±0.02	−1.1 ±0.63	−0.87 ±0.65	23.00 ±0.49	96.36 ±0.34	15.01 ±0.07	29.24 ±0.43
Venous blood	7.351 ±0.008	46.63 ±1.36	38.60 ±0.85	24.23 ±0.71	25.60 ±0.75	1.339 ±0.04	−1.37 ±0.49	−1.47 ±0.51	22.88 ±0.56	69.75 ±1.64	10.75 ±0.25	—
CSF	7.326 ±0.012	44.58 ±1.61	70.56 ±2.38	22.62 ±0.89	23.99 ±0.92	1.337 ±0.04	−2.09 ±0.86	−2.32 ±0.94	22.20 ±0.91	91.58 ±1.64	— —	—
Buffalo calves												
Arterial blood	7.446* ±0.009	38.68 ±1.32	87.81 ±2.61	25.88* ±0.66	27.06* ±0.69	1.158 ±0.03	1.03* ±0.62	0.75 ±0.71	26.08* ±0.61	96.78 ±0.47	14.46 ±0.24	26.20 ±1.08
Venous blood	7.412* ±0.008	41.90* ±1.22	39.51 ±1.30	27.06* ±0.68	28.34* ±0.68	1.229** ±0.03	1.61* ±0.63	1.88 ±0.67	25.75* ±0.72	66.54 ±2.16	10.76 ±0.42	—
CSF	7.335 ±0.009	43.21 ±1.72	54.65* ±2.67	23.26 ±0.81	24.62 ±0.85	1.296 ±0.04	−1.95 ±0.69	−2.26 ±0.82	22.82 ±0.73	84.49* ±1.03	—	—

Difference between cow calves and buffalo calves; *significant at 1%; **significant at 5%.

serum separated at room temperature to 38°C; filling of dead space of syringe with oil[7], causing more solubilization of CO_2, degree of equilibration of which is not known[9]; and use of calorimetric method), and difference in age[10,11] might be responsible for the differences from the reported values. Mean plasma bicarbonate was lower than derived plasma bicarbonate in Ayrshire cattle[10]. Measurement of plasma bicarbonate may lead to overstatement of acidosis and alkalosis[12]. In the present study mean arterial standard bicarbonate value was similar to the ones reported by Donawick and Baue[11]. Standard bicarbonate, which too accounts for change in pCO_2 and small differences caused by unsaturation of blood, does not accurately reflect quantitative changes in metabolic components[1]. Standard bicarbonate and base excess or base deficit, which are quantitative estimates of surplus base or acid, are better than any one alone. In the present study base excess was slightly different from the reports of Donawick and Baue[11]. This difference in actual bicarbonate and base excess may affect the use of Siggard–Anderson nomograms, which are based upon normal pH, pCO_2 and bicarbonate of human blood. There is some error inherent in the construction and use of all nomograms by virtue of the assumptions that must be made[1]. It is assumed that blood-buffering capacity is the same for all individuals and under all conditions. The constants of the Henderson–Hasselbach equation (pK of H_2CO_3 and solubility coefficient of CO_2) have been shown to be variable[13,14]. The *in vivo* buffer slope is also altered because of variation in blood to extracellular fluid volume ratio[15] and variations in H^+ or HCO_3^- distribution between extracellular fluid and intracellular fluid spaces[16]. Due to differences between buffering capacity of blood *in vitro* and *in vivo*, errors may be made when *in vitro* nomograms are applied to whole patient measurements[17] with actual haemoglobin concentration[18]. Variation of as much as 7 mEq/l in base deficient values in *in vitro* curves and *in vivo* measurements[19] which are identical for man and dog are very similar[20], but its reliability in bovines is not known. Total CO_2 content in arterial blood in the present study was also lower than the reported values[8,10]. Arterial pH, pCO_2, pO_2 and bicarbonate contents of buffalo calves agree with the findings of Singh *et al.*[21] Arterial and venous pH, HCO_3^-, TCO_2 and ABE were significantly ($P<0.01$) different between cow calves and buffalo calves.

The pH of CSF is mainly dependent on pCO_2 and bicarbonate content. The pH of CSF of cow calves and buffalo calves were close to the values reported by Singh *et al.*[21] pCO_2 and bicarbonate content of CSF did not vary between cow calves and buffalo calves and were similar to the levels in man[22] but were lower than those in dog[22–24]. The oxygen saturation of CSF of cow calves was higher ($P<0.01$) than that of buffalo calves. The higher saturation in cow calves may be due to higher CSF pO_2 and higher OER in cow calves. The large differences in pO_2 gradients between CSF compartments in the two bovine species are higher than in human lumbar CSF[25]. Venous blood may provide a better evaluation of the status of interstitial fluid of tissues than arterial blood[26,27]. CSF and brain interstitial fluids are considered to be of the same ionic strength[28]. But CSF was closer to venous blood in pCO_2, ABE and SBE, and similar to arterial blood in respect of pH, pO_2, TCO_2 and SAT. Therefore consistent and meaningful information about the acid–base status of CSF can be obtained by analysis of CSF and cannot be assessed from arterial or venous blood.

CONCLUSION

Venous blood analysis for acid–base variables and gas tension may be used only for limited therapeutic purposes. For proper diagnostic purposes, and for establishing pathophysiology of metabolic, gastrointestinal and pulmonary disorders, analysis of both arterial and venous blood is essential.

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1. Haskin, S. C., *J. Am. Vet. Med. Assoc.*, 1977, **170**, 423.
2. Cullen, D. J. and Eiger, E. I., *Anaesthesiology*, 1974, **41**, 345.
3. Stoyka, W. W., *Can. Anaesth. Soc. J.*, 1972, **19**, 119.
4. Setia, M. S., Singh, R., Rattan, P. J. S. and Tiwana, M. S., *Z. Tierphysiol. Tierernaehr. Futtermittelkd.*, 1987, **58**, 163.
5. Siggaard–Anderson, O., In: *Chemical Diagnosis of Disease*, (eds) S. S. Brown, F. L. Mitchell and D. S. Young, Elsevier, Netherland, 1979.
6. Sobti, V. K., Singh, S. S., Sabitri, S. and Rama Kumar, V., *Acta Vet.*, 1984, **34**, 15.
7. McSherry, B. J. and Grinyer, I., *Am. J. Vet. Res.*, 1954, **15**, 509.

8. Hales, J. R. S. and Findlay, J. D., *Respir. Physiol.*, 1968, **4**, 333.
9. Saveringhaus, J. W., *Handbook of Physiology of Respiration II*, American Physiological Society, Washington, 1965.
10. Fischer, E. W., *Br. Vet. J.*, 1959, **115**, 244.
11. Donawick, W. J. and Baue, A. E., *Am. J. Vet. Res.*, 1968, **29**, 561.
12. Rose, R. J. and Ilkiw, J. E., *Res. Vet. Sci.*, 1980, **28**, 393.
13. Linder, R. J. and Norman, J., *J. Physiol. Cambridge*, 1971, **215**, 491.
14. Howorth, P. J. N., *Lancet*, 1974, **1**, 253.
15. Dell, R. N., *Chest*, 1972, **61**, 35.
16. Mellemgaard, K. and Astrup, P., *Scand. J. Clin. Lab. Invest*, 1960, **12**, 187.
17. Siggaard Anderson, O., *Ann. N. Y. Acad. Sci.*, 1966, **153**, 41.
18. Collier, C. R., Hackney, J. D. and Mohler, J. G., *Chest*, 1972, **61**, 65.
19. Haskin, S. C., *J. Am. Vet. Med. Assoc.*, 1977, **170**, 429.
20. Brackett, N. C., Wingo, C. F., Muren, O. and Solano, J. T., *N. Eng. J. Med.*, 1969, **280**, 124.
21. Singh, J., Mirakhur, K. K., Prasad, B. and Kohli, R. N., *Zbl. Vet. Med.*, 1981, **28**, 131.
22. Ponser, T. B. and Plum, F., *New Eng. J. Med.*, 1967, **227**, 605.
23. Pavlin, E. G. and Hornbern, T. F., *Am. J. Physiol.*, 1975, **228**, 1134.
24. Bledsoe, S. W., Eng. D. Y. and Hornbein, T. F., *J. Appl. Physiol.*, (*Respirat Environ Exercise Physiol.*), 1981, **51**, 369.
25. Rossanda, M. and Spanzeila, E. P., *Br. J. Anaesth*, 1976, **48**, 753.
26. Furue, A., Brawley, R. K., Struve, E. and Gott, V. L., *Surgery*, 1973, **74**, 214.
27. Maxwell, T. M., Lim, R. C., Rudes, R. and Hunt, T. K., *Am. J. Surg.*, 1973, **126**, 249.
28. Fencle, B., Miller, T. B. and Pappenheimer, T. R., *Am. J. Physiol.*, 1966, **210**, 265.