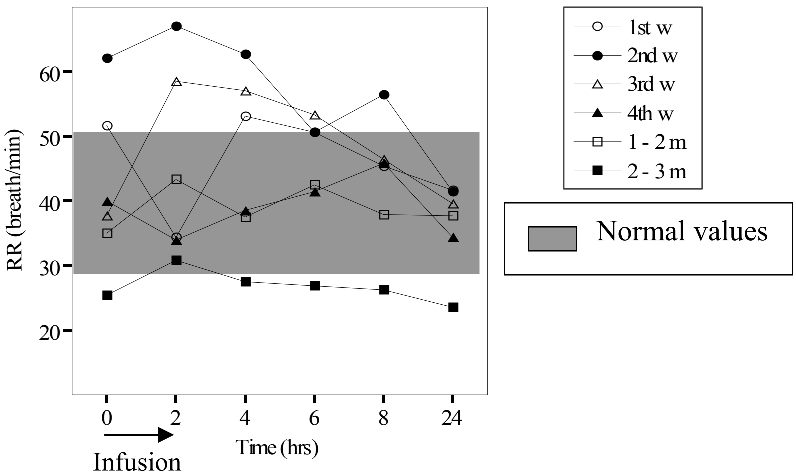
4. Results

4.1 The Calves

4.1.1 Clinical parameters

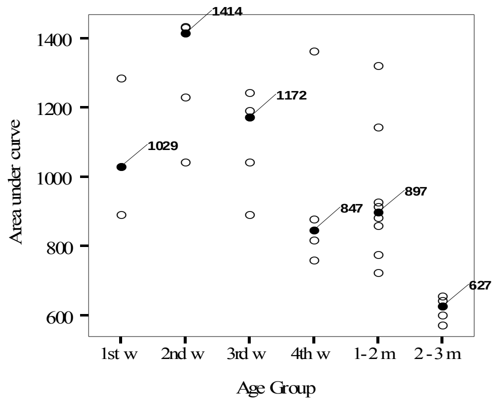
Respiratory rate (RR (breath/min): The results for the effect of intravenous of 5M NH_4Cl on RR is presented in Figs. 4.1a and 4.1b. The detailed results shown in Fig. 4.1a indicate that the initial mean values of RR decreased gradually with age and the younger calves in the 1st and 2nd week of life had higher mean values of RR than the other calves. By 2 hrs after the beginning of the infusion, RR increased in all calves except for the young calves in 1st and 4th week of life. The increase was significant (P<0.05) in the old calves (2-3 m). After 24 hrs, RR decreased gradually to values ranging from 27 to 50 breaths/min.

Fig. 4.1a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on RR (breaths/min) in clinically healthy calves (Mean values).



The general pattern of response shown in Fig 4.1b indicates that the response of the calves to the experimentally induced metabolic acidosis depends mainly on the age of the calves. This is indicated by the significant decrease in the calves' response with age (P<0.01-0.05). The young calves in the 2nd and 3rd week of life showed higher responses than the old calves of 2-3 m and of 1-2 m, respectively. Also the old calves of 2-3 m showed lower response compared with the other old ones (1-2 m).

Fig. 4.1b Changes in RR expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).



Age group	P <0.01					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
1st w	-					
2nd w		-				**
3rd w			-		**	
4th w				-		
1-2 m			**		-	**
2-3 m		**			**	-

Heart rate (HR (beats/min): Fig. 4.2a illustrates that the initial mean value of HR for the youngest calves in 1st week of life was higher (140 beats/min) than the older ones (mean values between 80-130 beats/min). Generally, HR decreased sharply (P<0.05) after 2 hrs in all age groups except in the old calves of 2-3 m. For the younger calves (1st and 2nd week) HR remained significantly lower (P<0.05) than the initial values after 6 hrs. From the 3rd week of life until 1-2 m there was a significant slight increase (P<0.01) in HR in response to the intravenous infusion. After 24 hrs, HR increased gradually towards normal to values ranging from 80 to150 beats/min.

Fig. 4.2a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on HR (beats/min) in clinically healthy calves (Mean values).

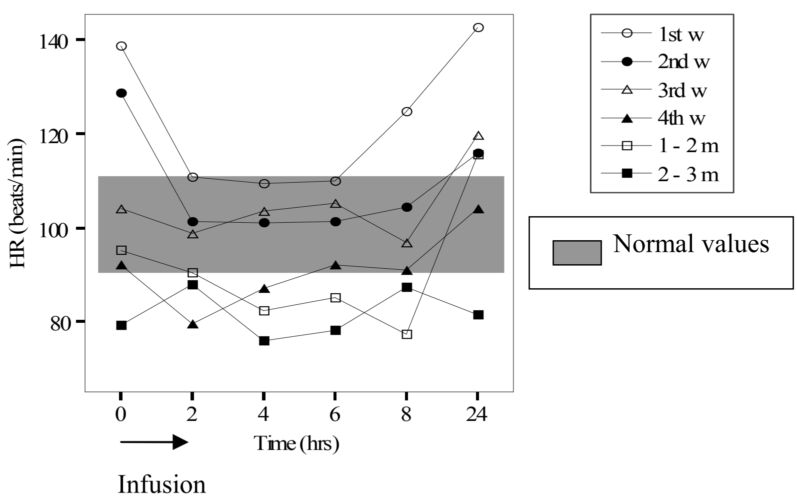
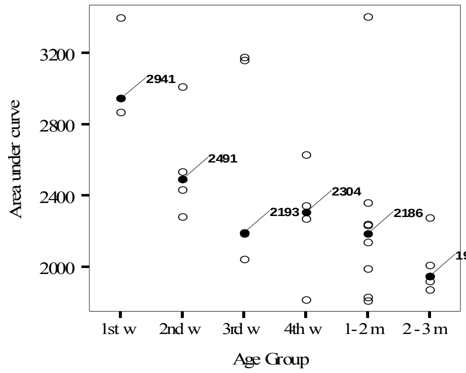


Fig. 4.2b shows that the general pattern of the calves' response did not change significantly with age.

Fig. 4.2b Changes in HR expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



4.1.2 Blood haematocrit (Hct)

Fig. 4.3a shows that the mean values of Hct fluctuated during the experimental period of 8 hrs in all age groups. In general, there was a slight decrease in Hct 4 hrs after the beginning of the infusion in all calves except in the old calves of 2-3 m. However, the decrease was not significant. After 4-6 hrs, the Hct showed a fluctuated pattern until 8 hrs, which was characterised by a maximal sharp decrease in Hct in all calves. After 24 hrs, the blood Hct increased again towards normal to values ranging from 0.25 to 0.27 l/l.

Fig. 4.3a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on Hct (l/l) in clinically healthy calves (Mean values).

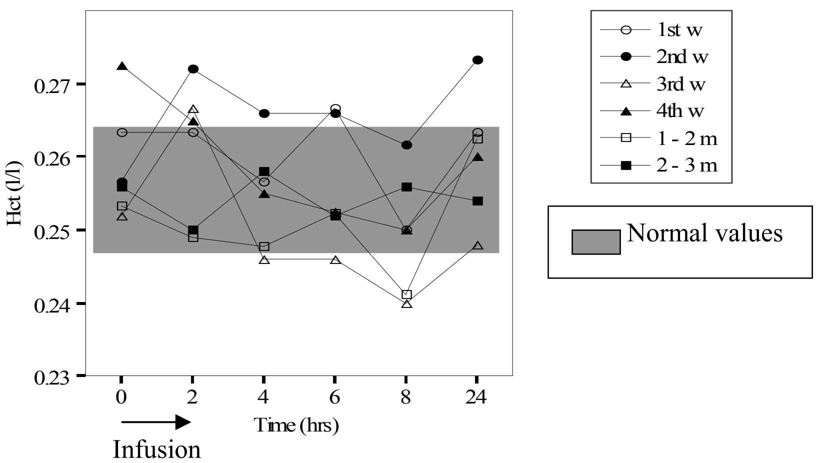
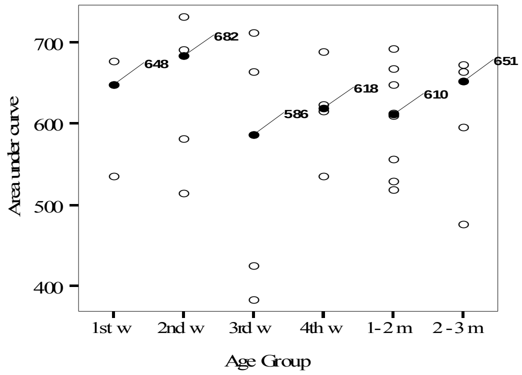


Fig. 4.3b indicates that the age had no significant effect on the calves' response to the experimentally induced metabolic acidosis.

Fig. 4.3b Changes in blood Hct expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



4.1.3 Serum parameters

Serum- [Na^+]: Fig. 4.4a shows that the initial mean values of serum- [Na^+] (138-143 mmol/l) were in the normal range for healthy calves (115-145 mmol/l, shaded area). Generally, serum- [Na^+] was not affected significantly by the intravenous infusion of 5M NH_4Cl during the experimental period of 8 hrs. However, for the old calves of 2-3 m there was a significant slight increase (P<0.05) in serum- [Na^+] after 6 hrs. After 8 hrs, the mean values of serum- [Na^+] decreased again towards normal in all age groups to values ranging from 139 to143 mmol/l.

Fig. 4.4a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Na^+] (mmol/l) in clinically healthy calves (Mean values).

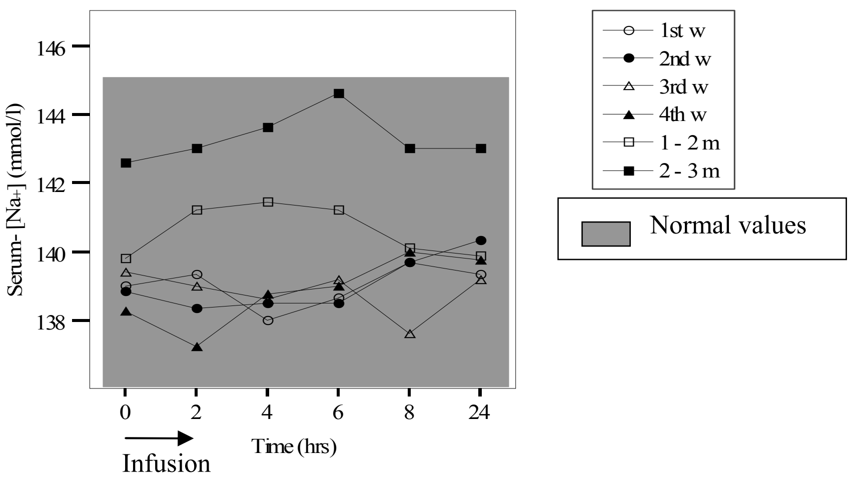
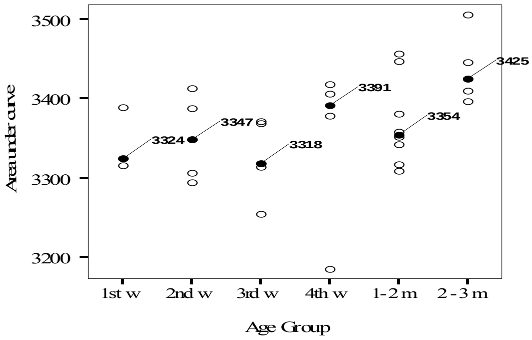


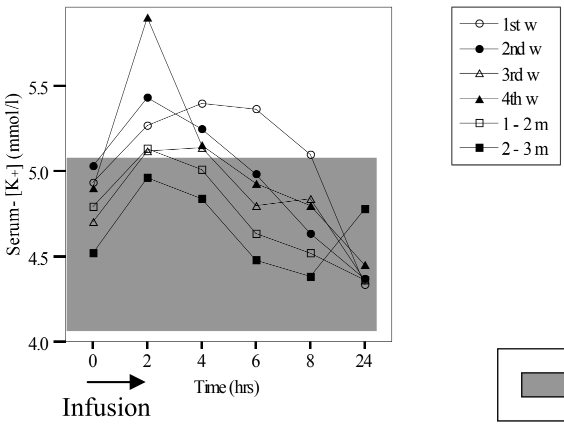
Fig. 4.4b indicates that the age had no significant effect on the calves' response to the experimentally induced metabolic acidosis.

Fig. 4.4b Changes in serum- [Na^+] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum- [K^+]: Fig. 4.5a indicates that the initial mean values of serum- [K^+] (4.5-5.0 mmol/l) were in the normal range for healthy calves (3.5-5.0 mmol/l, shaded area). After 2 hrs, there was a sharp significant increase in serum- [K^+] in all age groups. After 4 hrs, the general pattern showed a semi linear decrease in serum- [K^+] towards normal to values ranging from 4.5 to 4.8 mmol/l (P<0.01-0.05). By 24 hrs after the beginning of the infusion, all the calves showed a significant decrease (P<0.01-0.05) in serum- [K^+] (4.4-4.8 mmol/l) below the initial values (4.5-5.0 mmol/l).

Fig. 4.5a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [K^+] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).



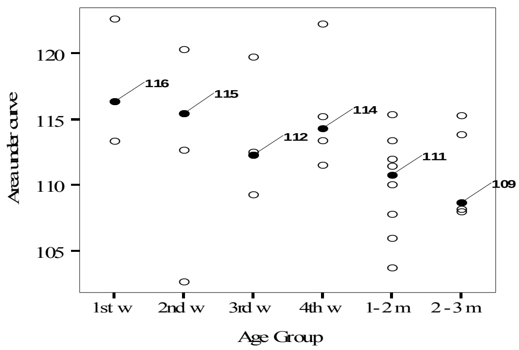
Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2	**	**	**	**	**	**
4		**	**	*		
6						
8						
24	**	**	**	*	**	*

Normal values

*P<0.05, **P<0.01

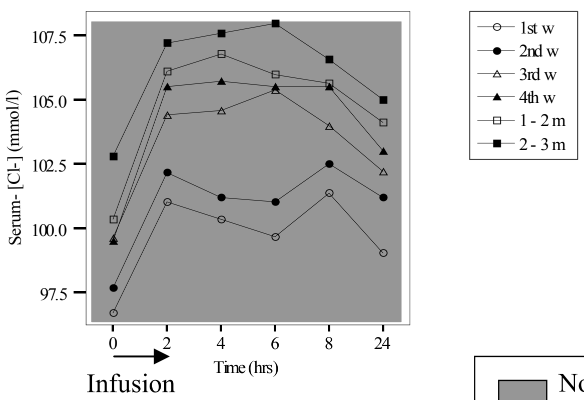
Fig. 4.5b illustrates that the young calves until the 4th week of life were more sensitive to the intravenous infusion compared with the older ones. However, the differences in the response of the calves were not statistically significant.

Fig. 4.5b Changes in serum- [K^+] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum- [Cl^-]: The initial mean values showed that there was a gradual increase in serum- [Cl^-] with age, i.e. 1st week=96.7 mmol/l, 2nd week=97.7 mmol/l, 3rd week=99.6 mmol/l, in the 4th week=99.5 mmol/l, 1-2 m=100 mmol/l and 2-3m=102.2 mmol/l (Fig. 4.6a). After 2 hrs, there was a sharp significant increase in serum- [Cl^-] compared with the initial values (P<0.001-0.05). After 4-8 hrs, the mean values of serum- [Cl^-] maintained at a significant steady higher level in all calves (P<0.001-0.05). After 24 hrs, the serum- [Cl^-] decreased again towards normal values. However, it remained at a significant slight higher level (P<0.01-0.05) (98-105 mmol/l) compared with the initial values in all age groups (96.7-102.5 mmol/l).

Fig. 4.6a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Cl^-] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).



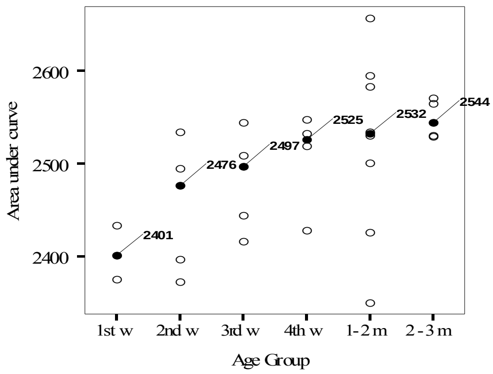
Normal values

Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2		*	***	***	***	***
4	**		***	**	***	***
6		*	**	***	***	**
8	*	*	**	***	***	***
24	*	*	*	***	**	*

*P<0.05, **P<0.01, ***P<0.001

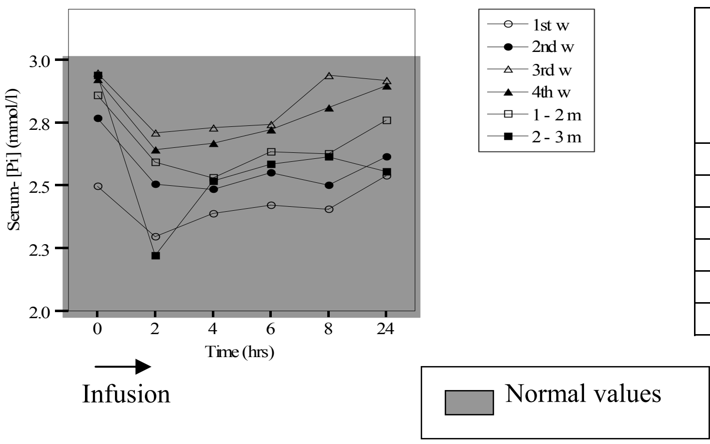
Fig. 4.6b shows that the change in serum- [Cl^-] in response to the experimentally induced metabolic acidosis is age-dependant. The oldest calves (2-3 m) showed the higher response ($P<0.05$) to the intravenous infusion than youngest calves (1st week).

Fig. 4.6b Changes in serum- [Cl^-] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum- [Pi]: Fig. 4.7a shows that the initial mean value of serum- [Pi] for the youngest calves in the 1st week of life was low (2.5 mmol/l) compared with the other age groups (mean values between 2.8-3.0 mmol/l). Generally, intravenous infusion of 5M NH_4Cl caused a sharp significant decrease in the mean values of serum- [Pi] 2 hrs after the beginning of the infusion in all age groups (P<0.001-0.05, Fig. 4.7a). After 4-8 hrs, the serum- [Pi] remained at a significantly lower steady level (2.4-2.8 mmol/l) compared with the initial values in all age groups (P<0.001-0.01). After 24 hrs, the serum- [Pi] increased again towards normal to values ranging from 2.5 to 2.9 mmol/l. However, the serum- [Pi] remained at a significant lower level compared with the initial values.

Fig. 4.7a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Pi] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

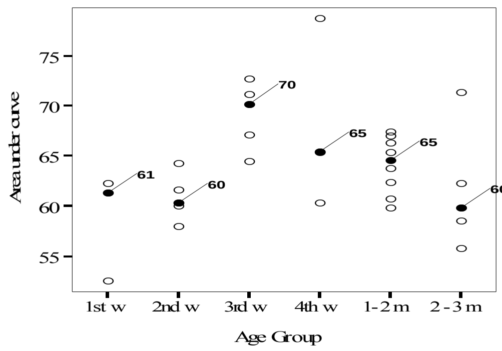


Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2		*	**	***	**	***
4		**	**		***	**
6		*			**	*
8		*			***	*
24		*			*	*

*P<0.05, **P<0.01, ***P<0.001

Fig. 4.7b indicates that the youngest calves in the 1st week showed the minimal response ($P<0.05$) to the intravenous infusion compared with the older ones (1-2 m). From the 2nd-4th week of life there was a gradual increase in the calves' response.

Fig. 4.7b Changes in serum- [Pi] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum- [Protein]: Fig. 4.8a shows the differences in the initial mean values of serum- [Protein] in relation to the age of the calves. The initial mean values showed that the highest serum- [Protein] value was observed in the old calves (64 g/l) followed by the mean values of 60-62 g/l for the youngest calves in the 1st and the 2nd week of life. The lowest mean value was observed in the calves of 1-2 m (54 g/l). The general pattern indicated that there was a slight decrease in the mean values of serum- [Protein] during the experimental period. However, this decrease was not significant.

Fig. 4.8a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Protein] (g/l) in clinically healthy calves (Mean values).

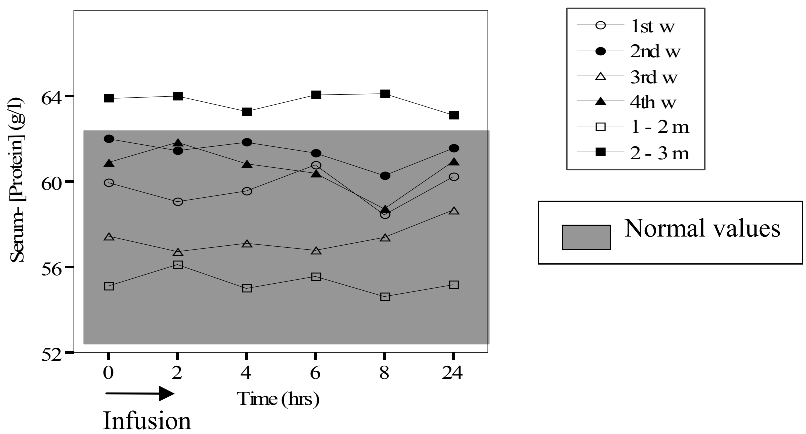
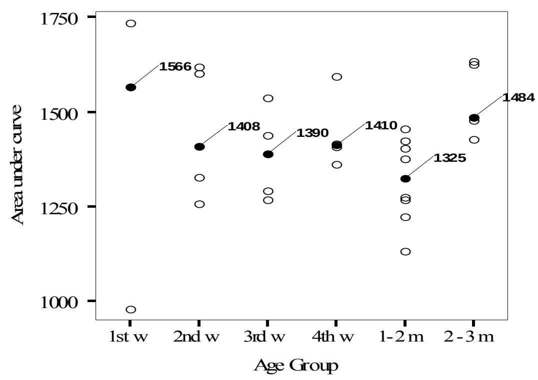


Fig. 4.8b indicates that the youngest calves (1st week) showed the maximal response to the intravenous infusion. From the 2nd week of life to 2-3 months the changes in serum- [Protein]

did not reflect an organised pattern of response. The age did not have significant effect on the calves' response to the experimentally induced metabolic acidosis.

Fig. 4.8b Changes in serum- [Protein] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum- [Albumin]: Fig. 4.9a shows a close relationship between the serum- [Albumin] and the age of the calves. The results also indicated that the youngest calves in the 1st week of life had lower serum- [Albumin] (21 g/l) compared with the other age groups (24-31 g/l). The general pattern of the calves' response indicated that there was a slight decrease in the mean values of serum- [Albumin] during the experimental period but this decrease was not significant.

Fig. 4.9a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Albumin] (g/l) in clinically healthy calves (Mean values).

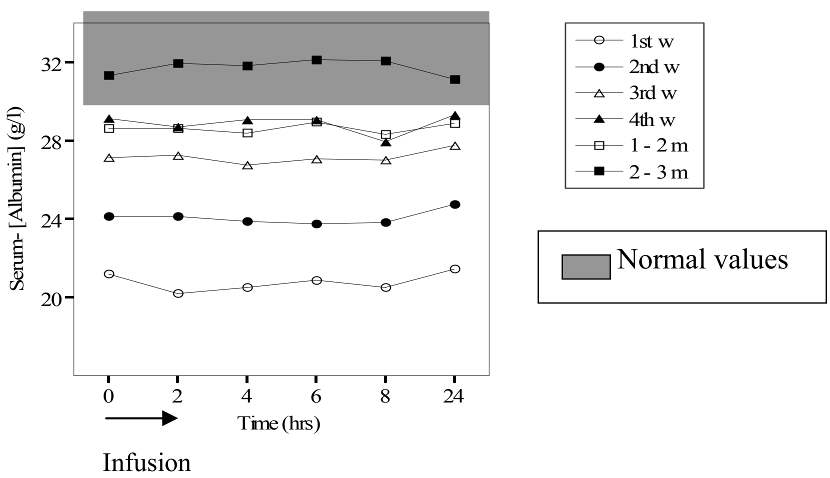
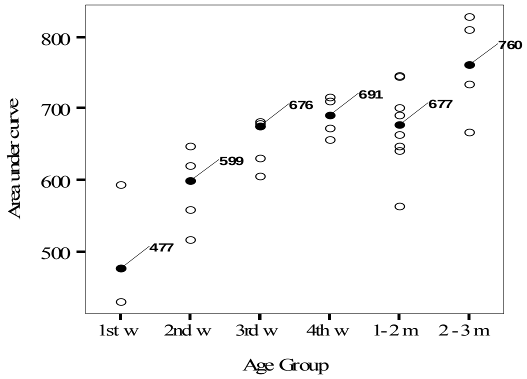


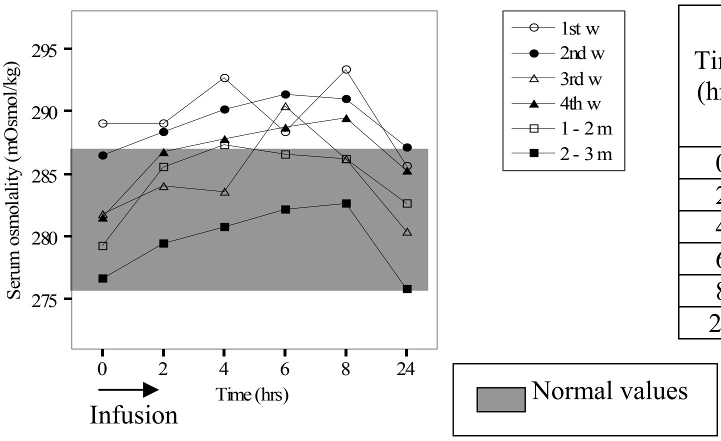
Fig. 4.9b shows a gradual increase in calves' response. However, the old calves of 2-3 m showed a higher response ($P<0.05$) compared with the younger calves in the 2nd week of life.

Fig. 4.9b Changes in serum- [Albumin] expressed as AUC in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



Serum osmolality: Fig. 4.10a shows the effect of intravenous infusion of 5M NH_4Cl on serum osmolality. The initial mean values indicated that there was a gradual decrease in serum osmolality in relation to the calves' age, i.e. 1st week=290 mOsmol/kg, 2nd week=288 mOsmol/kg, 3rd week=283 mOsmol/kg, 4th week=281 mOsmol/kg and 1-3 m= 276-277 mOsmol/kg. The detailed results show that by 2 hrs after the beginning of the infusion, there was a sharp increase in the serum osmolality until 8 hrs (P<0.001-0.05, 4.10a). After 24 hrs, the serum osmolality decreased again towards normal to values ranging from 290 to 275 mOsmol/kg. However, the serum osmolality for the young calves (4th week) remained at a significant higher level compared with the initial values after 24 hrs.

Fig. 4.10a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum osmolality (mOsmol/kg) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

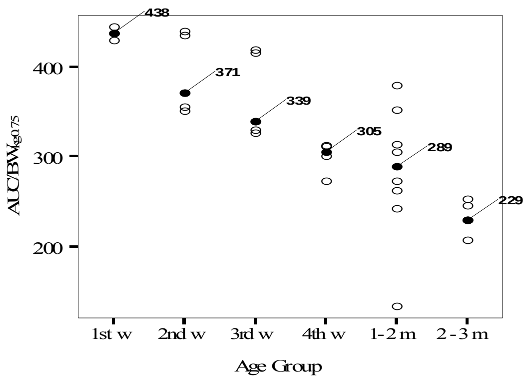


Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2			*	**	**	*
4				*	***	*
6		***	**	*	*	*
8	*	*	***	*	***	**
24				*		

*P<0.05, **P<0.01, ***P<0.001

Fig. 4.10b shows a gradual decrease in the values of AUC/BW $^{Kg0.75}$ with age (P<0.001-0.05). The youngest calves in the 1st week of life showed the higher response to the experimentally induced metabolic acidosis compared with the other age groups. The young calves in the 2nd, 3rd and 4th week of life also showed a higher response compared with the older calves.

Fig. 4.10b Changes in serum osmolality expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).



Age group	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
1st w	-			***	***	***
2nd w		-				**
3rd w			-		*	*
4th w	***			-		*
1-2 m	***		*		-	
2-3 m	***	**	*	*		-

*P<0.05, **P<0.01, ***P<0.001

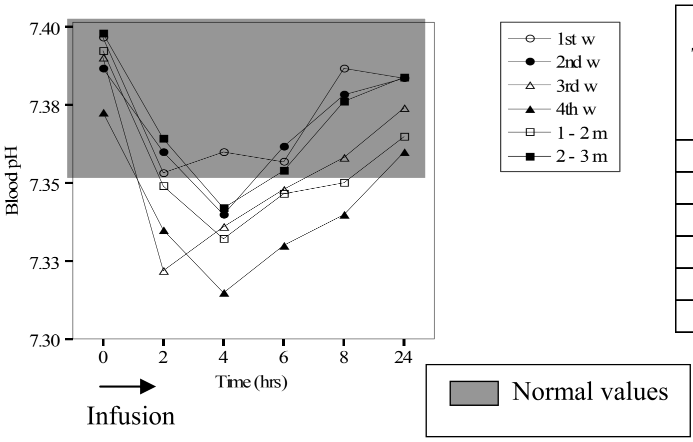
4.1.4 Acid-base parameters

Acid-base homeodynamics are known to play a major role in the calves' life from the first hours of life. Therefore, the age may have an influence on the susceptibility of the calves to the diseases related to acid-base disturbances. The response of acid-base parameters to the intravenous infusion of 5M NH_4Cl is presented first in relation to the time after the beginning of the intravenous infusion and second in relation to the changes in metabolic body weight ($BW_{kg}^{0.75}$).

4.1.4.1 Henderson- Hasselbalch variables

Blood pH: The effect of intravenous infusion of 5M NH_4Cl on venous blood pH is shown in Figs. 4.11a and 4.11b. Fig. 4.11a indicates that the initial mean values of pH (7.38-7.39) were in the normal range for healthy calves (7.35-7.40, shaded area). The general pattern of response showed that 2 hrs after the beginning of the infusion, there was a sharp decrease in the mean values of blood pH in all calves (P<0.001-0.05). The most pronounced significant decrease in blood pH was observed after 4 hrs (P<0.001-0.05). After 6-8 hrs, the blood pH remained significantly lower than the initial values (P<0.001-0.05). After 24 hrs, the blood pH increased gradually towards normal in all groups to values ranging from 7.36 to 7.39.

Fig. 4.11a Effect of intravenous infusion of ammonium chloride (5 M NH_4Cl) on venous blood pH in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

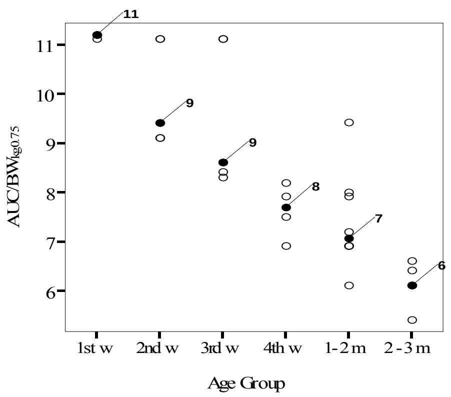


Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2	**	**	**	*	***	**
4		**	***	**	***	**
6		**	***	**	***	**
8		***	***		***	***
24						

*P<0.05, **P<0.01, ***P<0.001

Fig. 4.11b indicates that the general response of the calves to the intravenous infusion expressed as $AUC/BW_{kg}^{0.75}$ showed a gradual decrease in the calves' response with age (P<0.001-0.05).

Fig. 4.11b Changes in venous blood pH expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).



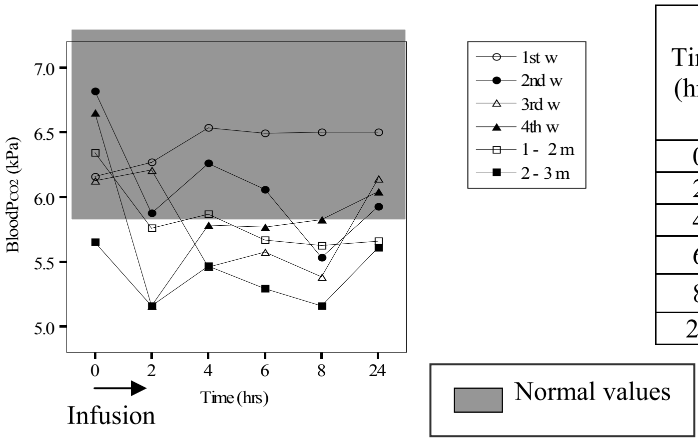
Age group	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
1st w	-			**	***	***
2nd w		-		*	**	**
3rd w			-			*
4th w	**	*		-		
1-2 m	***	**			-	
2-3 m	***	**	*			-

*P<0.05, **P<0.01, ***P<0.001

Blood P_{CO2}: Fig. 4.12a shows that the initial mean values of venous blood P_{CO2} (5.7-6.8 kPa) were in the normal range for healthy calves (5.8-7.2 kPa, shaded area). The mean values of P_{CO2} fluctuated during the experimental period of 8 hrs in all age groups. However, the youngest calves (1st week) showed a slight gradual increase in P_{CO2} after 4 hrs and remained appreciably unchanged until 24 hrs. Generally, after 2-4 hrs, there was a significant decrease in venous blood P_{CO2} in the younger calves in the 2nd week of life and in the calves 2-3 m.

After 8 hrs, the mean values of venous blood P_{CO2} showed the maximal significant decrease throughout the experimental period in all calves except in the young calves (1st and 4th week). After 24 hrs, the mean values of venous blood P_{CO2} increased again towards normal. However, P_{CO2} tended to remain at lower levels compared with the initial values (5.7-6.5 kPa).

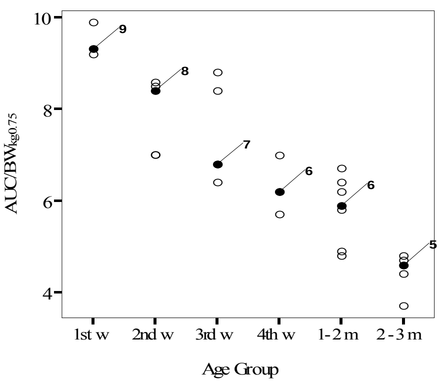
Fig. 4.12a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on venous blood P_{CO2} (kPa) in clinically healthy calves (Mean Values). (The empty cells in the table mean that the mean values were not significantly different).



Time (hrs)	P <0.05					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2		*	*	*	*	*
4		*	*	*	*	*
6						
8		*	*		*	*
24						

Fig. 4.12b indicates that the general pattern of the calves' response (expressed as $AUC/BW_{kg}^{0.75}$) was age-dependent. This is evidenced by the gradual increase in the value of $AUC/BW_{kg}^{0.75}$ from the 1st week of life to the age of 2-3 m ($P<0.001$-0.05).

Fig. 4.12b Changes in venous blood P_{CO2} expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).

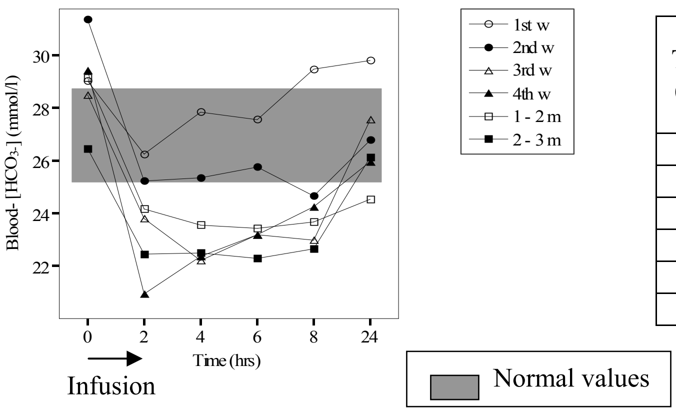


Age group	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
1st w	-	**		**	***	***
2nd w	**	-			**	
3rd w			-			*
4th w	**			-		*
1-2 m	***	**			-	*
2-3 m	***	**	*	*	*	-

*P<0.05, **P<0.01, ***P<0.001

Blood- [HCO_3^-]: Fig. 4.13a indicates that the changes in the blood- [HCO_3^-] were an important sign of the experimental metabolic acidosis induction. The initial mean values showed that the youngest calves in the 1st week of life had higher mean values of blood- [HCO_3^-] than the oldest calves of 2-3 m (29.8±2.5 mmol/l and 26.1±2.6 mmol/l, respectively). Critical evaluation suggested that there was a sharp significant decrease (P<0.001-0.05) in the blood- [HCO_3^-] after 2 hrs in all age groups except in the youngest calves (1st week). After 4-8 hrs, the blood- [HCO_3^-] remained significantly lower than the initial values (P<0.001-0.05). After 24 hrs, the blood- [HCO_3^-] increased again towards normal to values ranging from 29 to 23 mmol/l. However, in the old calves (1-2 m) the blood- [HCO_3^-] tended to remain at a significant lower level compared with the initial value.

Fig. 4.13a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on venous blood- [HCO_3^-] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

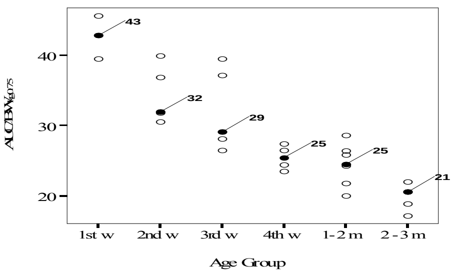


Time (hrs)	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2		*	**	*	***	***
4		**	***	*	***	*
6		*	***	*	***	***
8		**	***	***	***	*
24					*	

*P<0.05, **P<0.01, ***P<0.001

Fig. 4.13b also indicates that age had a significant influence on the calves' response as evidenced by a significant increase in $AUC/BW_{kg}^{0.75}$ values with the age (P<0.01-0.05).

Fig. 4.13b Changes in venous blood- [HCO_3^-] expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).

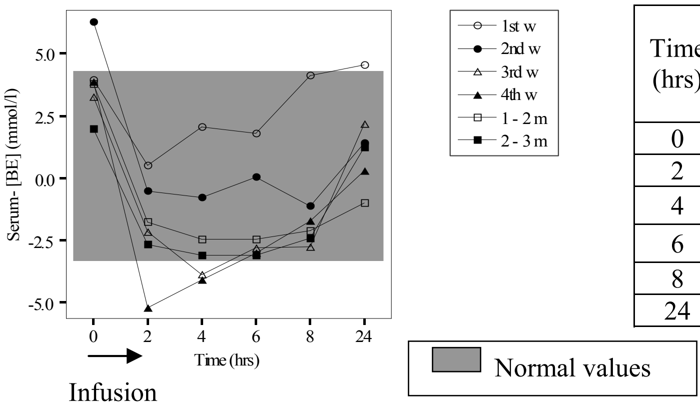


Age group	Level of significance					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
1st w	-			*	**	**
2nd w		-		*	**	*
3rd w			-			
4th w	*	*		-		*
1-2 m	**	**			-	
2-3 m	**	*		*		-

*P<0.05, **P<0.01

Blood- [BE]: The general pattern of the reaction showed that the youngest calves in the 1st week of life characterised by positive mean values of BE during the experimental period of 8 hrs (+6 - +4 mmol/l, Fig. 4.14a). However, the other calves groups (from the 2nd week of life to 2-3 m) showed negative BE values ranging from +1 to -4 mmol/l in response to the intravenous infusion. The youngest calves in the 1st week tended to maintain at a non-significant change in response to the infusion during the experimental period of 8 hrs and after 24 hrs. Generally, there was a sharp significant decrease in the mean values of blood- [BE] after 2 hrs compared with the initial values. After 4 hrs, the blood- [BE] did not reflect an organised pattern; therefore the changes in blood- [BE] did not show statistical significance in most calves. After 6 hrs, the blood- [BE] remained at an almost steady lower level than the initial values until 8 hrs. After 8 hrs, the blood- [BE] showed the maximal significant decrease compared with the initial values in all calves except in the youngest calves (1st week). After 24 hrs, the mean values of blood- [BE] increased again towards normal to values ranging from +4 to -2 mmol/l but remained lower compared with the initial values.

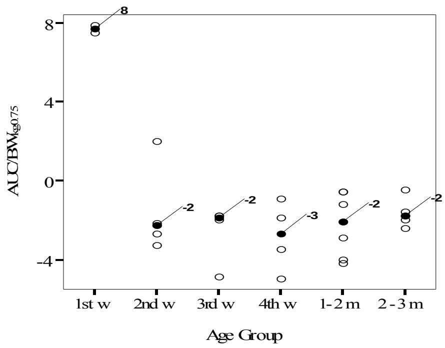
Fig. 4.14a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on blood- [BE] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).



Time (hrs)	P<0.05					
	1st w	2nd w	3rd w	4th w	1-2 m	2-3 m
0	-	-	-	-	-	-
2				*	*	
4				*	*	
6						*
8		*	*	*	*	*
24						

Fig. 4.14b indicates that the youngest calves in the 1st week of life showed a significant increase (P<0.001) in $AUC/BW_{kg}^{0.75}$ compared with the older calves and the increase was just significant (P<0.01) compared with the other young calves.

Fig. 4.14b Changes in venous blood- [BE] expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



The relationship between venous blood pH and Henderson-Hasselbalch variables: On the basis of Henderson-Hasselbalch theory, the changes in blood pH could be related to the changes in one or more of these variables: blood P_{CO2}, $[HCO_3^-]$ and [BE]. The detailed results presented in Fig. 4.15a show that the changes in blood pH in response to the changes in blood P_{CO2} were not clear during the first 3 weeks of life. This is confirmed by the low values of R^2 (0.001-0.02). From the 4^{th} week of life-3 months there was a slight decrease in blood pH in response to the decrease in blood P_{CO2} (R^2 = 0.08-0.11). However, these changes were not statistically significant.

Fig. 4.15a The relationship between venous blood pH and venous P_{CO2} in clinically healthy calves with experimentally induced metabolic acidosis.

(Linear regression equation: y = ax + b; R^2: Coefficient of determination)

The regression line applies only the investigated range of the findings.

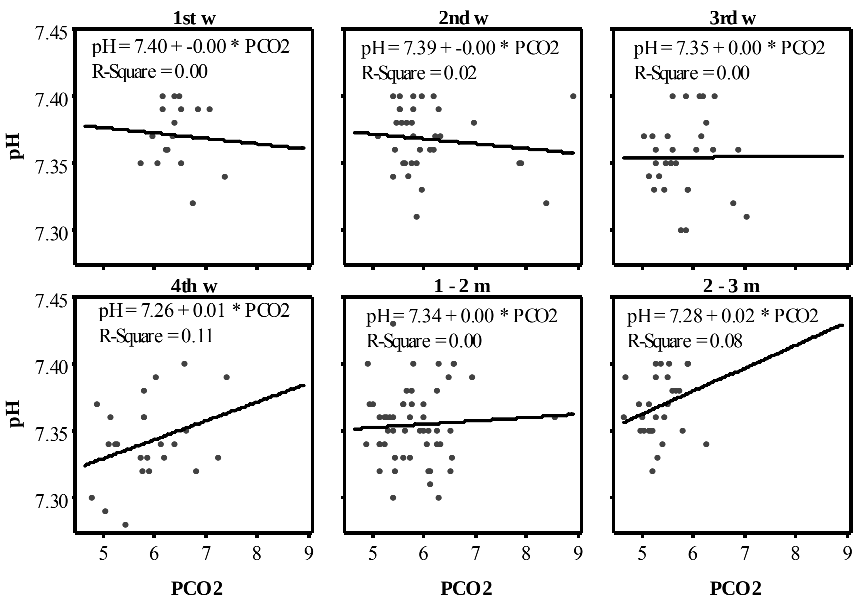


Fig. 4.15b shows that the changes in blood- [HCO_3^-] had a critical effect on blood pH (R^2 = 0.29-0.52). The decrease was significant (P<0.05) in the young calves (1st, 3rd and 4th week) and in the older calves (1-3 m).

Fig. 4.15b The relationship between venous blood pH and venous blood- [HCO_3^-] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.

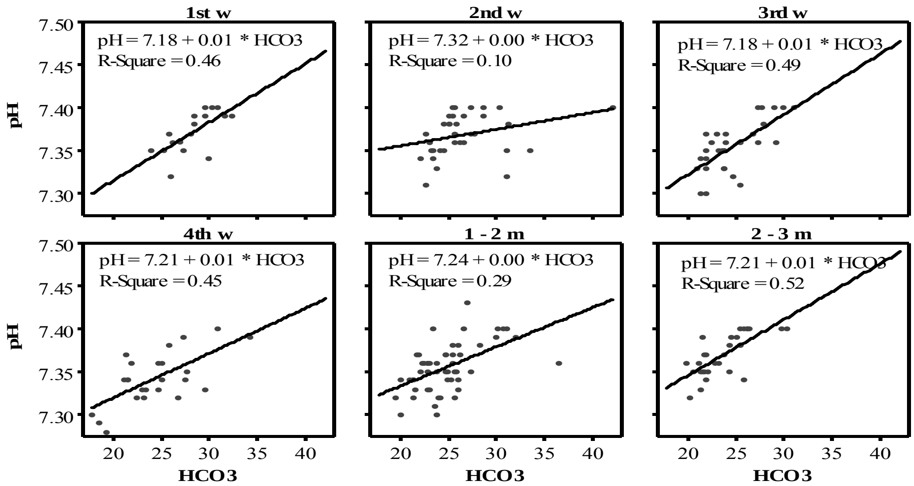
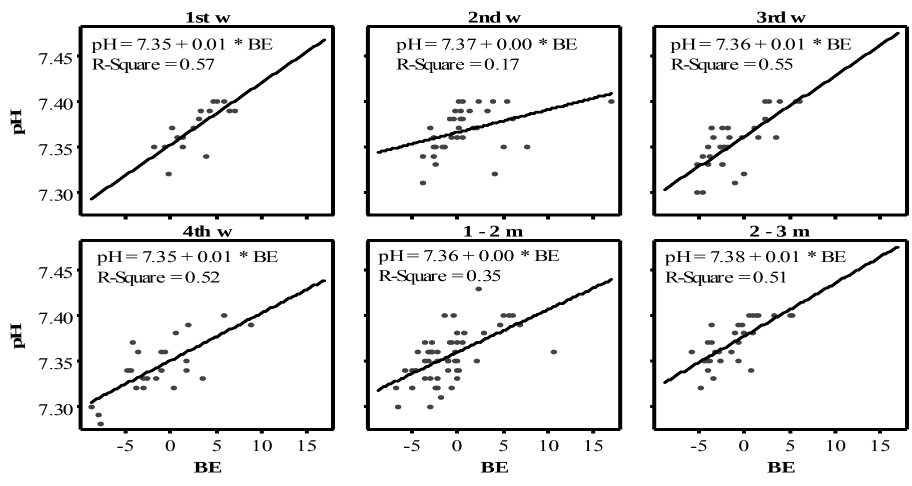


Fig. 4.15c indicates that the changes in blood pH were correlated to the changes in serum- [BE] (R^2 = 0.17-0.57, P<0.05) in all calves.

Fig. 4.15c The relationship between venous blood pH and blood- [BE] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.



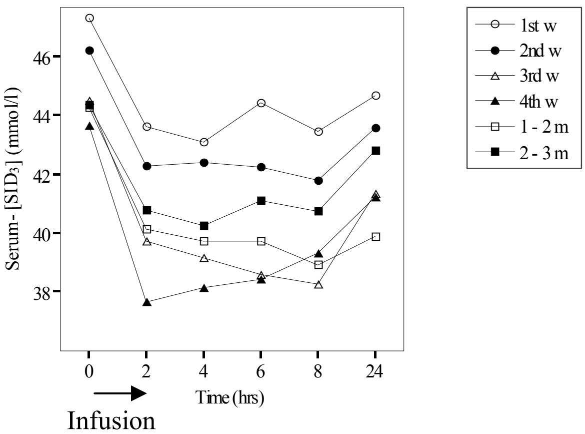
4.1.4.2 Stewart's variables

On the basis of the Stewart theory, Stewart proposed that the blood pH can not change unless one or more of the three independent variables change (P_{CO2}, SID_3 and A_{tot}).

Blood P_{CO2}: The changes in blood P_{CO2} in response to the intravenous infusion has been shown previously in the detailed results presented in Figs. 4.12a and 4.12b.

Serum- [SID_3]: Fig. 4.16a illustrates that intravenous infusion of 5M NH_4Cl induced a rapid decrease in serum- [SID_3] in all groups from the initial mean values (47.3-43.7 mmol/l) to 44.7-39.7 mmol/l after 8 hrs. By 2 hrs after the beginning of the intravenous infusion, there was a sharp decrease in the mean values of serum- [SID_3] in all age groups ($P<0.001-0.05$) except in the youngest calves (1^{st} week). After 4 hrs, all the calves showed the maximal significant decrease ($P<0.001-0.05$) in serum- [SID_3] and remained lower after 8 hrs. After 24 hrs, serum- [SID_3] remained significantly lower than the initial values in the young calves in the 2^{nd} and 3^{rd} week and in the old calves of 1-2 m.

Fig. 4.16a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) serum- [SID_3] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

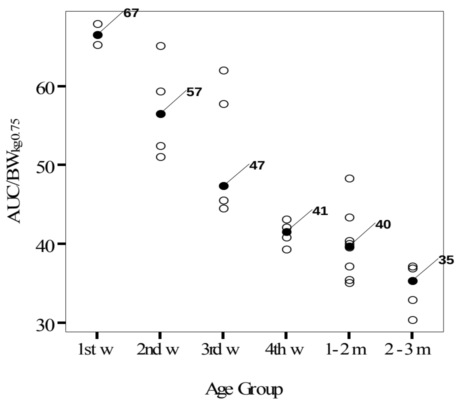


Time (hrs)	Level of significance					
	1^{st} w	2^{nd} w	3^{rd} w	4^{th} w	1-2 m	2-3 m
0	-	-	-	-	-	-
2	*	*	***	**	***	**
4		*	***	**	**	**
6		***	***	**	***	
8		*	***	**	***	
24		**	**		**	

*P<0.05, **P<0.01, ***P<0.001

Generally, there was a gradual decrease in the values of $AUC/BW_{kg}^{0.75}$ with the age of the calves (Fig. 4.16b). Therefore, the calves' response tended to decrease with age from the 1^{st} week of life until 2-3 months ($P<0.001-0.05$).

Fig. 4.16b Changes in serum- [SID_3] expressed as AUC/$BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values). (The empty cells in the table mean that the median values were not significantly different).

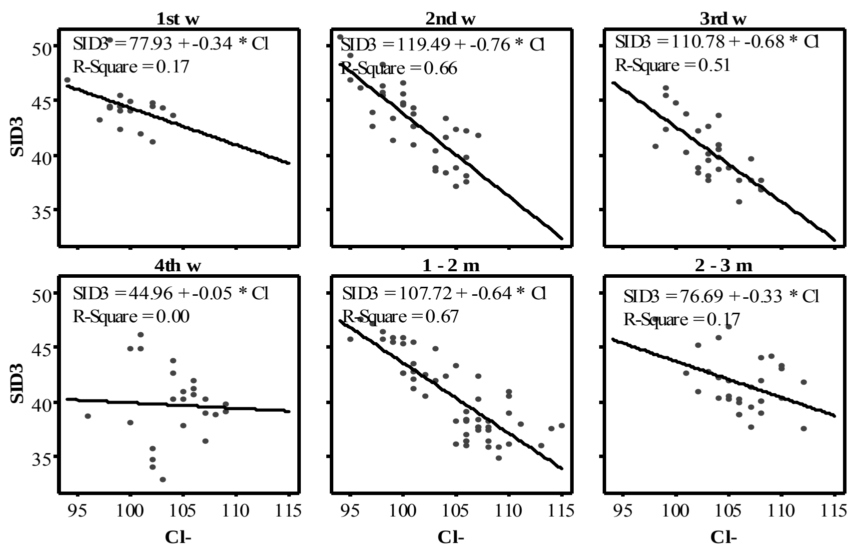


Age group	Level of significance					
	1^{st} w	2^{nd} w	3^{rd} w	4^{th} w	1-2 m	2-3 m
1^{st} w	-			***	***	***
2^{nd} w		-		*	**	*
3^{rd} w			-			
4^{th} w	***	*		-		
1-2 m	***	**			-	
2-3 m	***	*				-

*P<0.05, **P<0.01, ***P<0.001

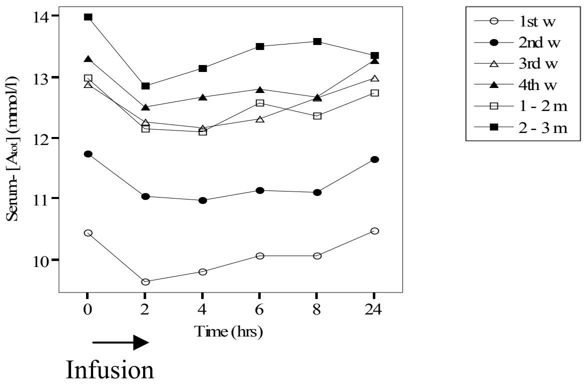
On the basis of the equation (1): $SID_3 = [Na^+] + [K^+] - [Cl^-]$, the changes in serum- [SID_3] depends on the changes in one or more of the three strong ions: Na^+, K^+ and Cl^-. The results indicated that the changes in serum- [Na^+] and serum- [K^+] (Appendix A_1 and A_2) did not cause a noticeable significant decrease in serum- [SID_3] in all calves (R^2 = 0.01-0.1 and 0.002-0.06, respectively). However, it clear that from Fig. 4.16c the decrease in serum- [SID_3] depended mainly on the changes in serum- [Cl^-] (R^2 = 0.51-0.67, P<0.01).

Fig. 4.16c The relationship between serum- [SID_3] (mmol/l) and serum- [Cl^-] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis.
(Linear regression equation: y = ax + b; R^2: Coefficient of determination)
The regression line applies only the investigated range of the findings.



Serum- [A_{tot}]: Fig. 4.17a indicates that the younger calves (1^{st} and 2^{nd} week) had low mean values of serum- [A_{tot}]. Generally, there was a sharp decrease in serum- [A_{tot}] by 2 hrs after the beginning of the infusion (P<0.001-0.05) except in the youngest calves (1^{st} week). After 4-8 hrs, the serum- [A_{tot}] remained significantly lower (P<0.001-0.05) than the initial values. After 24 hrs, the serum- [A_{tot}] increased again towards normal but remained at a significant lower level in the old calves (1-2 m).

Fig. 4.17a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [A_{tot}] (mmol/l) in clinically healthy calves (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

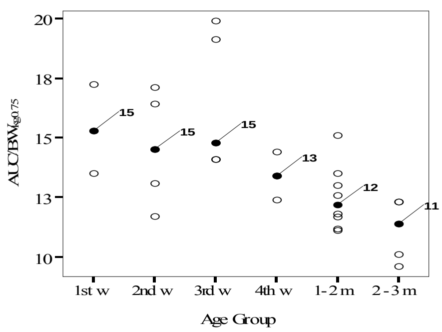


Time (hrs)	Level of significance					
	1^{st} w	2^{nd} w	3^{rd} w	4^{th} w	1-2 m	2-3 m
0	-	-	-	-	-	-
2		*	**	**	**	**
4		**	**		***	**
6		*	*		*	
8		*			***	
24					*	

*P<0.05, **P<0.01, ***P<0.001

The evaluation of the changes in the serum- [A_{tot}] expressed as $AUC/BW_{kg}^{0.75}$ suggested that from the1^{st}-3^{rd} week of life the calves showed the same pattern of response (Fig. 4.17b). Then there was a gradual decrease in the calves' response until 3 months. However, this pattern of response was not significant in relation to the age of the calves.

Fig. 4.17b Changes in serum- [A_{tot}] expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy calves with experimentally induced metabolic acidosis (Median values).



According to the equation (2): [A_{tot}] (mmol/l) = [Albumin (g/l) (0.123 × pH – 0.631)] + [Pi (mmol/l) (0.309 × pH – 0.469)], it clear that from Fig. 4.17c the changes in serum- [A_{tot}] depended mainly on the changes in serum- [Albumin] in all calves (R^2 = 0.31-0.87, P<0.01).

Fig. 4.17c The relationship between serum- [A_{tot}] (mmol/l) and serum- [Albumin] (g/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination) The regression line applies only the investigated range of the findings.

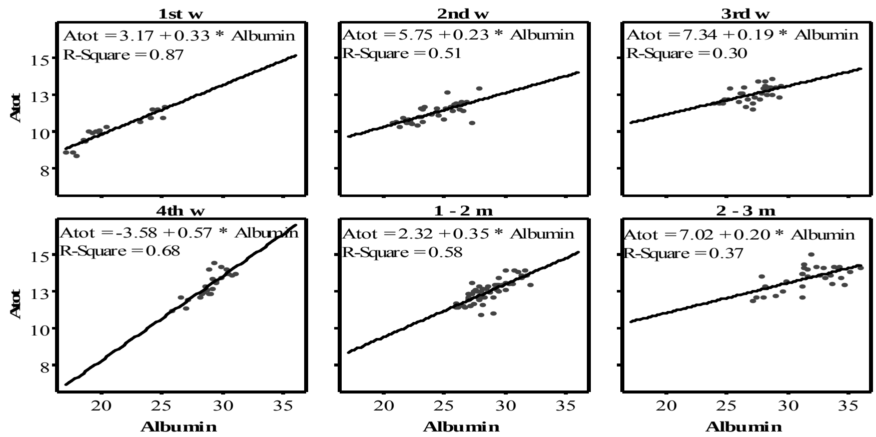
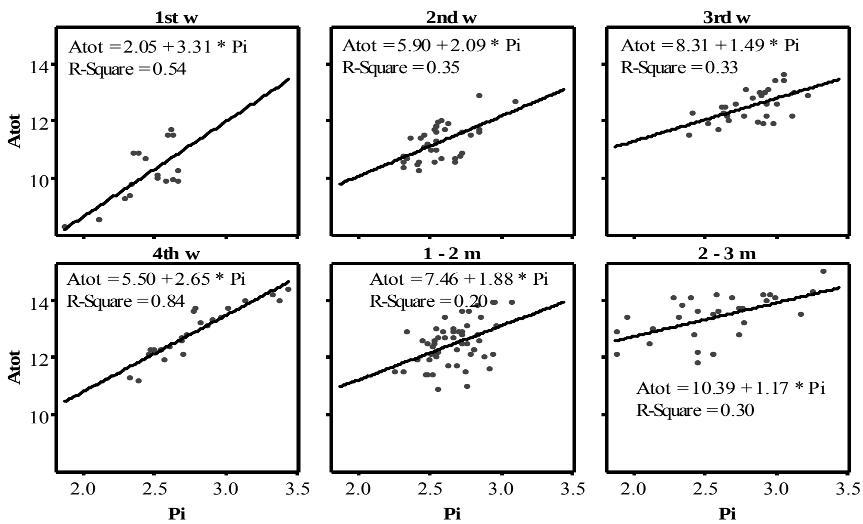


Fig. 4.17d indicates that the significant decrease in serum- [Pi] (R^2 = 0.2-0.84, P<0.01) had strong influence on serum- [A_{tot}] in addition to the changes in serum- [Albumin].

Fig. 4.17d The relationship between serum- [A_{tot}] (mmol/l) and serum- [Pi] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination) The regression line applies only the investigated range of the findings.



The relationship between venous blood pH and Stewart's variables: Fig. 4.18a shows that the primary signs of the experimentally induced metabolic acidosis were the noticeable decrease in serum- [SID_3]. From the 2nd week of life to 2-3 m the decrease in the serum- [SID_3] caused a strong significant decrease in blood pH (R^2 = 0.31-0.80, P<0.01).

Fig. 4.18a The relationship between venous blood pH and serum- [SID_3] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination) The regression line applies only the investigated range of the findings.

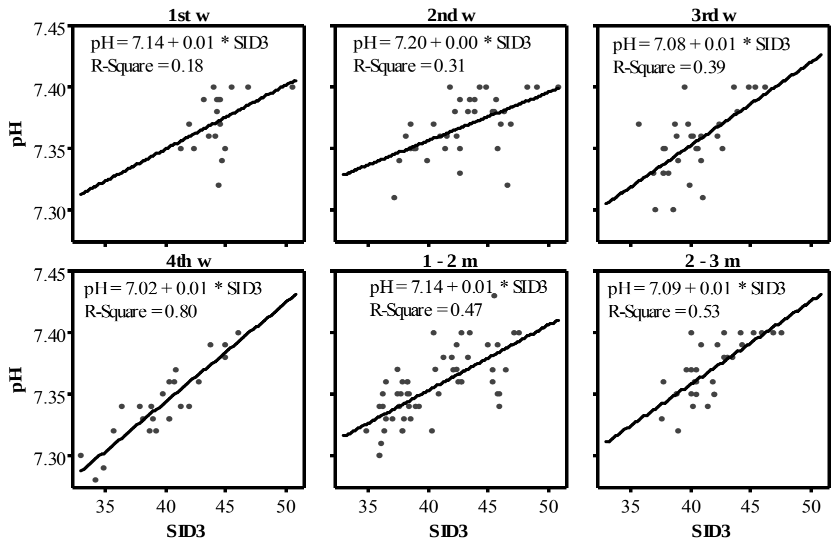
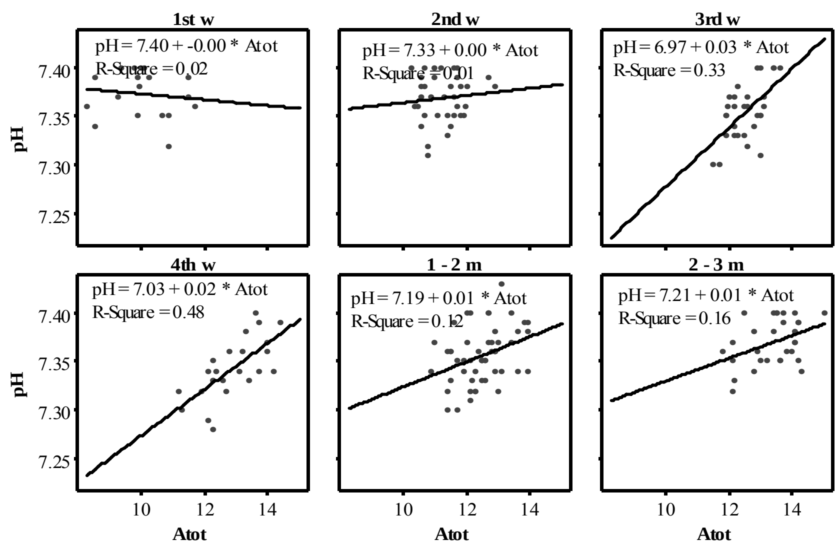


Fig. 4.18b indicates that the changes in serum- [A_{tot}] associated with marked changes in blood pH in all calves (R^2 = 0.12-0.48, P<0.05) except in the younger calves (1st and 2nd week).

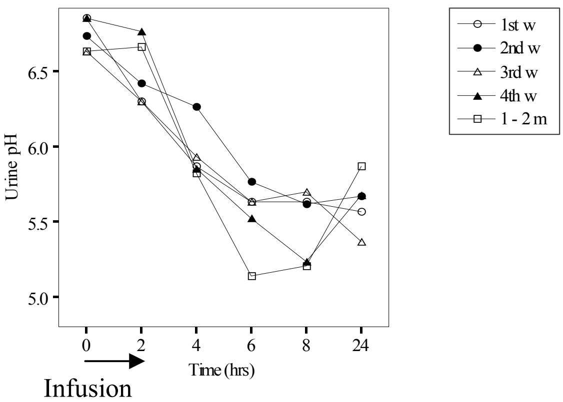
Fig. 4.18b The relationship between venous blood pH and serum- [A_{tot}] (mmol/l) in clinically healthy calves with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination) The regression line applies only the investigated range of the findings.



4.1.5 Urine parameters

Urine pH: Fig. 4.19 shows the results of the effect of intravenous of 5M NH_4Cl on urine pH. The urine pH was very responsive to the changes in acid-base status of the blood and decreased gradually during the intravenous infusion in all age groups. The significant decrease in urine pH was observed after 2 hrs. After 4 hrs, the urine pH maintained at a significant gradual decrease compared with the initial values. After 6 hrs, the old calves showed the higher significant decrease in the urine pH compared with the other age groups and maintained at a significant gradual decrease after 8 hrs. After 8 hrs, the younger calves (1^{st} and 2^{nd} week) showed the first significant decrease in urine pH during the experimental period. By 24 hrs after the beginning of the infusion, the urine pH tended to maintain at a lower level in all age groups (5.4-5.9) compared with the initial pH (6.6-6.9). However, this decrease was not statistically significant.

Fig. 4.19 Changes in urine pH in clinically healthy calves with experimentally induced metabolic acidosis (Mean values). (The empty cells in the table mean that the mean values were not significantly different).

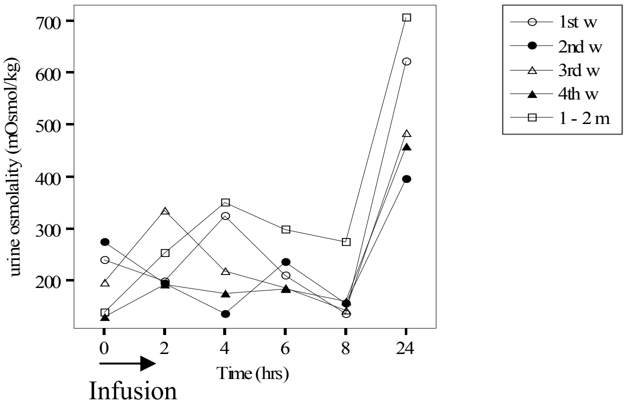


Time (hrs)	Level of significance				
	1^{st} w	2^{nd} w	3^{rd} w	4^{th} w	1-2 m
0	-	-	-	-	-
2		*			
4			**		***
6		*	*		***
8	*	*			***
24					

*P<0.05, **P<0.01, ***P<0.001

Urine osmolality: Fig. 4.20 shows that the mean values of urine osmolality fluctuated during the experimental period of 8 hrs. Generally, it is clear that the changes in urine osmolality in the young calves during the first 4 weeks of life did not reflect statistical significance during the experimental period. However, the old calves of 1-2 m showed a significant gradual increase in urine osmolality after 2 hrs (P<0.05), 4 hrs (P<0.01), 6 hrs (P<0.05) and 8 hrs (P<0.01). By 24 hrs after the beginning of the intravenous infusion, the urine osmolality showed the maximal increase during the experimental period in all age groups. The significant increase (P<0.001) was observed in the old calves of 1-2 m.

Fig. 4.20 Changes in urine osmolality (mOsmol/kg) in clinically healthy calves with experimentally induced metabolic acidosis (Mean values).



Fractional excretion of electrolytes (FE): The results for the effect of intravenous infusion of 5M NH_4Cl on the fractional excretion of electrolytes are shown in Figs. 4.21a, 4.21b, 4.21c and 4.21d. Fig. 4.21a shows that the initial mean values of FE $_{Na+}$ during the first 4 weeks of life were between 0.4-0.6 %. However, the old calves showed the higher mean values of FE $_{Na+}$ (0.9 %). In response to the experimentally induced metabolic acidosis the FE $_{Na+}$ was variable in relation to the age of the calves. The young calves showed no significant change during the experimental period of 8 hrs and after 24 hrs. During the 2nd week of life, there was a sharp increase in FE $_{Na+}$ after 2 hrs. In the 4th week of life and in the old calves, there was a slight increase in the FE $_{Na+}$. The young calves in the 1st and in the 3rd week did not appear any change in FE $_{Na+}$ in response to the intravenous infusion. By 4 hrs after the beginning of the infusion, the FE $_{Na+}$ decreased to values lay close to the initial values and remained at that level after 24 hrs. The significant decrease ($P<0.05$) in the FE $_{Na+}$ below the initial values was observed in the old calves (1-2 m).

Fig. 4.21a Changes in the fractional excretion of sodium (FE $_{Na+}$) in clinically healthy calves with experimentally induced metabolic acidosis (Mean values).

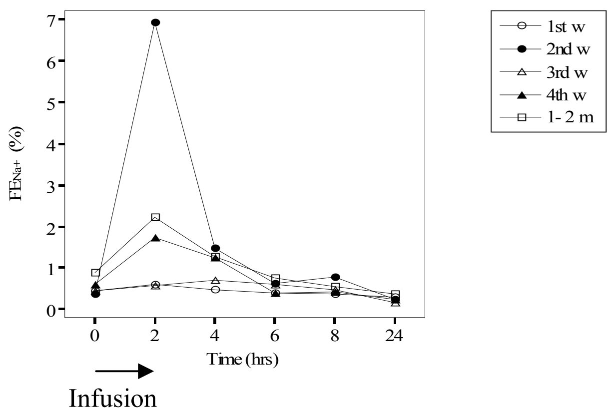


Fig. 4.21b indicates that the initial mean values of FE $_{K+}$ were between 20-30 %. The general pattern of the renal response showed that the youngest calves (1^{st} week) showed the minimal response to the intravenous infusion during the experimental period and had lower mean values of FE $_{K+}$ compared with the other age groups. After 2 hrs, the FE $_{K+}$ did not change significantly in the youngest calves (1^{st} week) and remained at a value lay close to the initial values. After 4-6 hrs, the younger calves (2^{nd} and 3^{rd} week) showed a significant decrease (P<0.01) in FE $_{K+}$ compared with the initial values. After 8 hrs, the young calves (4^{th} week) showed a significant increase (P<0.05) compared with the initial values. After 24 hrs, the FE $_{K+}$ decreased gradually to values less than the initial values in all calves and the significant decrease (P<0.01) was observed in the old calves.

Fig. 4.21b Changes in the fractional excretion of potassium (FE $_{K+}$) in clinically healthy calves with experimentally induced metabolic acidosis (Mean values).

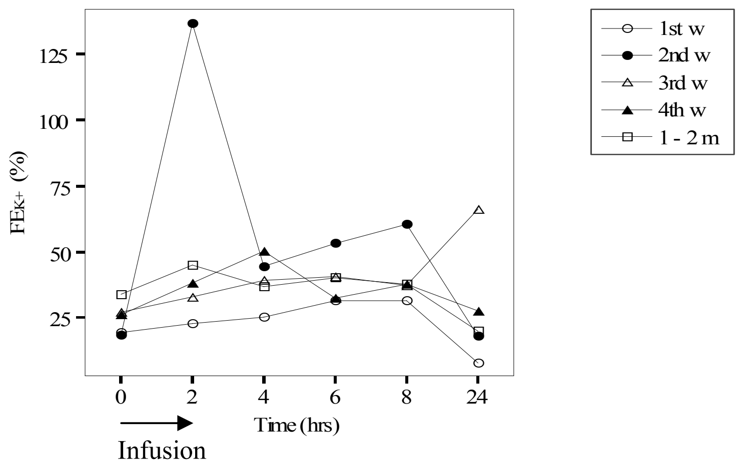


Fig. 4.21c shows that the initial mean values of FE $_{Cl-}$ were between 0.06-4 %. The general pattern of the renal response indicated that the youngest calves (1^{st} week) show the minimal response to the intravenous infusion during the experimental period. Generally, there was a sharp increase in the mean values of the FE $_{Cl-}$ after 2 hrs in the young calves in the 2^{nd} week of life; however, the other age groups showed a slight increase in the FE $_{Cl-}$ after 4 hrs. The decrease was significant (P<0.05) in the young calves in the 1^{st} and 2^{nd} week and in the old calves. After 8 hrs, the FE $_{Cl-}$ remained at a steady higher level in all calves. After 24 hrs, the FE $_{Cl-}$ decreased towards the initial values in all calves. However, it remained significantly lower (P<0.05) than the initial values in the old calves.

Fig. 4.21c Changes in the fractional excretion of chloride (FE $_{Cl-}$) in clinically healthy calves with experimentally induced metabolic acidosis (Mean values).

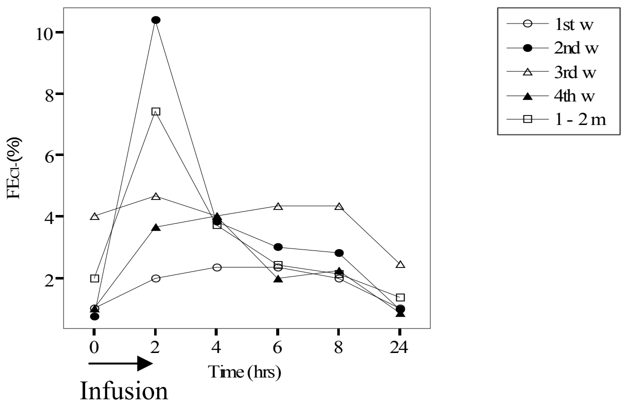
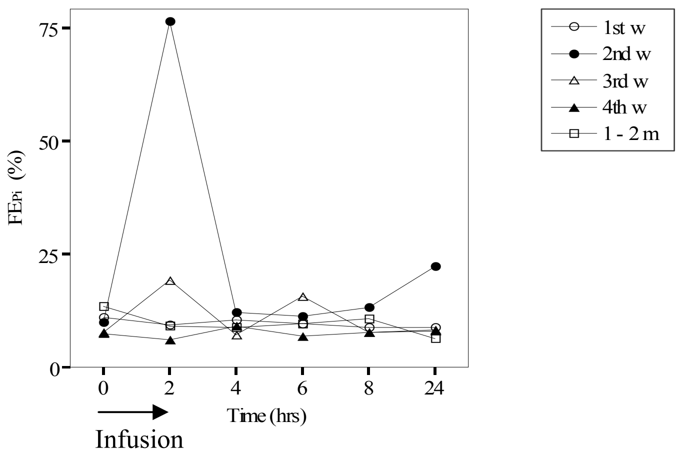


Fig. 4.21d indicates that the initial mean values of FE $_{Pi}$ were between 8-10 %. The general pattern of the renal response showed that the mean values of FE $_{Pi}$ did not change significantly in response to the intravenous infusion and remained at a steady level lay close to the initial values during the experimental period of 8 hrs and after 24 hrs.

Fig. 4.21d Changes in the fractional excretion of inorganic phosphate (FE $_{Pi}$) in clinically healthy calves with experimentally induced metabolic acidosis (Mean values).



4.2 The young camels

4.2.1 The control data

Because there is no published data regarding the normal values of acid-base parameters in camels a total number of 38 blood samples were collected from clinically healthy young and adult camels (Table 8) to provide the normal values of these parameters. The normal values for blood and serum parameters and acid-base parameters are presented in Tables 10a and 10b, respectively. The results showed that there was no significant difference between the age groups in serum- [Na^+], serum- [Cl^-], and serum osmolality. However, there was a significant difference between age groups in blood Hct, serum- [K^+], serum- [Pi], serum- [Protein] and serum- [Albumin].

Table 10a Blood and serum parameters in camels (*Camelus dromedarius*) (mean±SD).

Sex	Blood and serum parameters							
	Hct (l/l)	(mmol/l)				(g/l)		Osmolality (mOsmol/kg)
		Na^+	K^+	Cl^-	Pi	Total protein	Albumin	
Adult males (5-8 yrs)	0.28^a ±4.6	150.5^a ±2.7	4.8^a ±0.4	110.8^a ±3.1	2.37^a ±0.3	57.7^a ±4.3	34.7^a ±3	308.3^a ±5.7
Lactated female camels (5-8 yrs)	0.21^b ±2	149.8^a ±6.6	4.1^b ±0.3	110.4^a ±6.5	1.86^b ±0.4	63.7^b ±6.6	31.9^b ±4.6	301.1^a ±15.6
Young camels (males and female) (3-5 m)	0.25^a ±3.6	150.6^a ±4	5.98^c ±1	110.1^a ±3.2	3.1^c ±0.5	54.8^a ±4	31.9^b ±1.7	308.7^a ±5.9

Means within the same column bearing different superscripts are significantly different at $P<0.05$.

Table 10b shows that the age of the camels had no significant effect on blood pH and serum- [SID_3]. However, lactated female camels showed lower values of serum- [A_{tot}] compared with the adult males and the young camels.

Table 10b Blood and serum acid-base parameters in camels (*Camelus dromedarius*) (mean±SD).

Sex	Blood pH	(mmol/l)	
		Serum- [SID_3]	Serum- [A_{tot}]
Adult males (5-8 yrs)	7.42 [a] ±0.01	44.5 [a] ±2.2	14.1 [a] ±0.9
Lactated female camels (5-8 yrs)	7.42 [a] ±0.01	43.4 [a] ±2.4	12.4 [b] ±1.4
Young camels (males and female) (3-5 m)	7.42 [a] ±0.01	46.6 [a] ±3.7	14.7 [a] ±1.2

Means within the same column bearing different superscripts are significantly different at P<0.05.

4.2.2 Clinical parameters of the experimental young camels

Respiratory rate (RR (breaths/min): Fig. 4.22a indicates that the initial mean values of RR for the young camels were between 9-13 breaths/min. Generally, the mean values of RR increased significantly (P<0.01) by 2 hrs after the beginning of the infusion in all young camels except in the young camels 3-4 m. After 4-8 hrs, all young camels showed a steady significant increase (P<0.001) in RR. After 24 and 48 hrs, the mean values of RR decreased gradually to values lay close to the initial values (9-12 breaths/min).

Fig. 4.22a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on RR (breath/min) in clinically healthy young camels (Mean values).

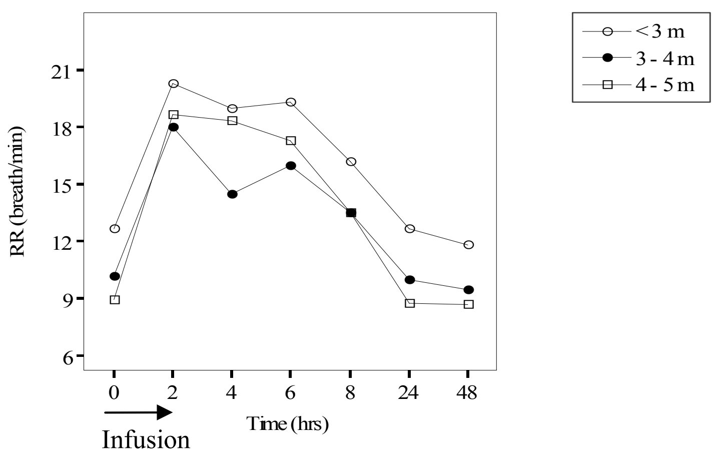
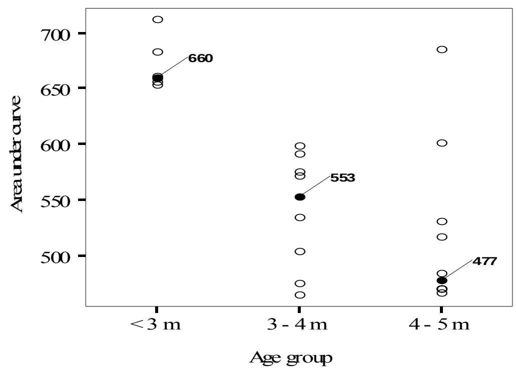


Fig 4.22b indicates that the response of the young camels to the experimentally induced metabolic acidosis was also age-dependent as indicated by the gradual significant decrease (P<0.05) in the camels' response with age. Therefore, younger camels of <3 m showed the

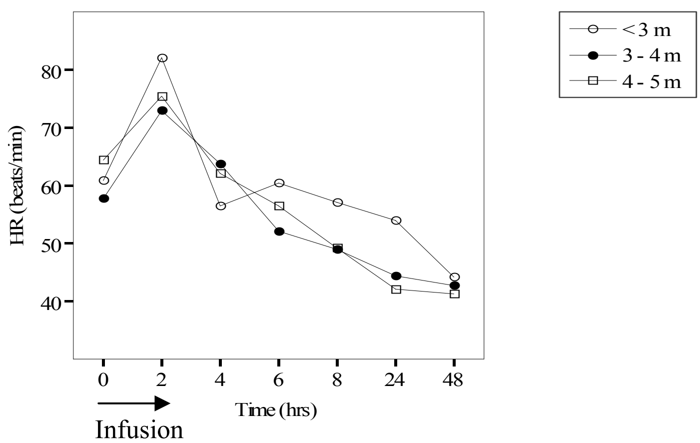
significant higher response (P<0.05) to the experimentally induced metabolic acidosis than the older ones.

Fig. 4.22b Changes in RR expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



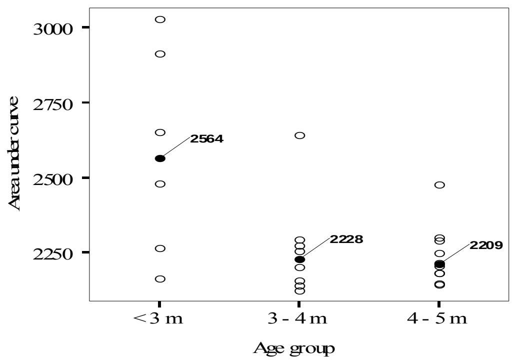
Heart rate (HR (beats/min): Fig. 4.23a indicates that the initial mean values of HR for the young camels were between 58-65 beats/min. Generally, the mean values of HR increased sharply (P<0.05) after 2 hrs in all young camels. The pronounced significant decrease (P<0.05) in HR was observed in the old camels of 4-5 m after 24 hrs. After 48 hrs, all young camels showed a significant decrease (41-44 beats/min, P<0.05) the mean values of HR below the initial values.

Fig. 4.23a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on HR (beats/min) in clinically healthy young camels (Mean values).



The results obtained in Fig. 4.23b show that the age had no significant effect on the response of the young camels to the experimentally induced metabolic acidosis.

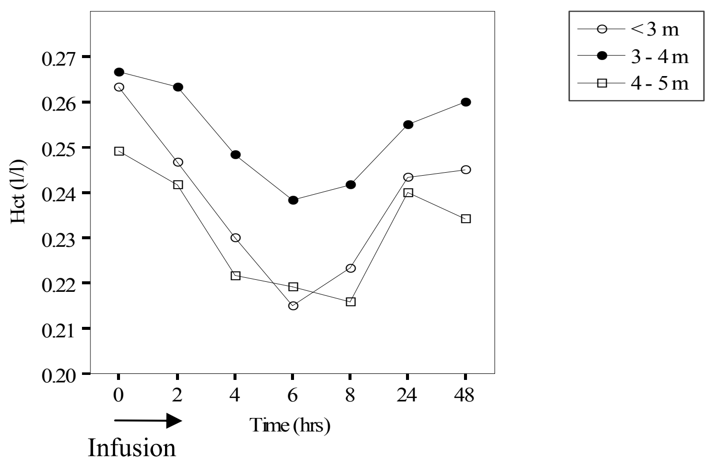
Fig. 4.23b Changes in HR expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



4.2.3 Blood haematocrit (Hct) of the experimental young camels

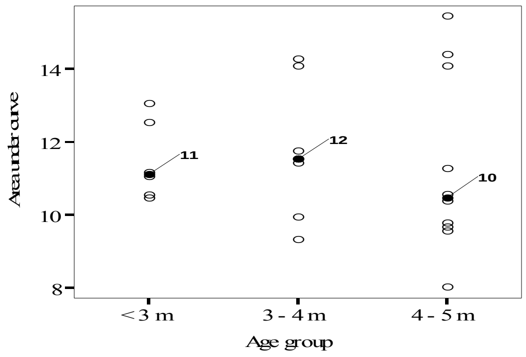
Fig. 4.24a shows that there was a gradual significant decrease ($P<0.01$) in Hct after 4-6 hrs in the younger camels of <3 m and in the old camels of 4-5 m. The pronounced significant decrease ($P<0.001$) in Hct was observed after 6 hrs and remained at a significant gradual decrease ($P<0.05$) after 8 hrs. After 24 and 48 hrs, the mean values of Hct increased again towards normal in all young camels. However, in the old camels (4-5 m) the blood Hct remained at a significant lower level ($P<0.05$) than the initial values after 48 hrs.

Fig. 4.24a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on blood haematocrit (Hct (l/l) in clinically healthy young camels (Mean values).



The results shown in Fig. 4.26b indicate that the age had no significant effect on the camels' response to the intravenous infusion.

Fig. 4.24b Changes in blood Hct expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



4.2.4 Serum parameters of the experimental young camels

Serum- [Na^+]: Fig. 4.25a shows that the initial mean values of serum- [Na^+] (145-148 mmol/l) were in the normal range for healthy camels (143-154 mmol/l) and less than those for the young camels in the control data (150.6±3.6 mmol/l, Table 10a). Generally, there was a sharp decrease in serum- [Na^+] by 2 hrs after the beginning of the intravenous infusion in all young camels. The significant decrease ($P<0.01$) in serum- [Na^+] was observed in the young camels of 3-4 m. After 6-24 hrs, there was a gradual increase serum- [Na^+]. After 48 hrs, the serum- [Na^+] showed the maximal decrease below the initial values in all young camels. However, the decrease was not statistically significant.

Fig. 4.25a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Na^+] (mmol/l) in clinically healthy young camels (Mean values).

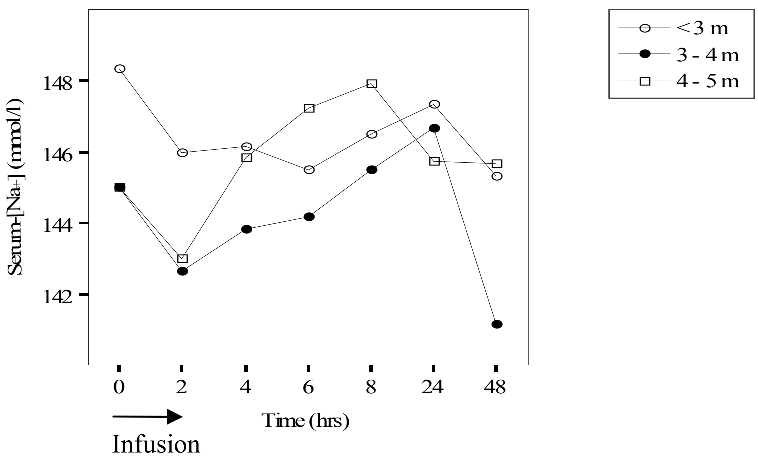
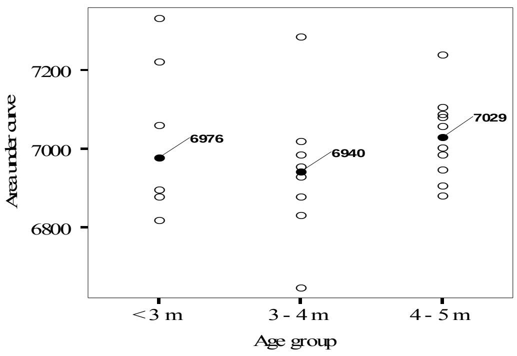


Fig. 4.25b shows that the age had no significant effect on the camels' response to the experimentally induced metabolic acidosis.

Fig. 4.25b Changes in serum- [Na^+] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Serum- [K^+]: The results presented in Fig. 4.26a indicate that the initial mean values of serum- [K^+] (4.6-4.8 mmol/l) were in the normal range for healthy camels (3.6-6.0 mmol/l) and less than those for the young camels in the control data (5.98±1 mmol/l, Table 10a). The general pattern of the camels' response showed that there was a gradual sharp decrease in the mean values of serum- [K^+] after 2-4 hrs in all young camels. The pronounced significant decrease ($P<0.01$) in serum- [K^+] was observed after 8 hrs in the old camels of 4-5 m. Then the serum- [K^+] increased again towards the initial values after 24 and 48 hrs. However, the increase remained at a significant lower level ($P<0.05$) than the initial values after 48 hrs in the old camels of 4-5 m.

Fig. 4.26a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) serum- [K^+] (mmol/l) in clinically healthy young camels (Mean values).

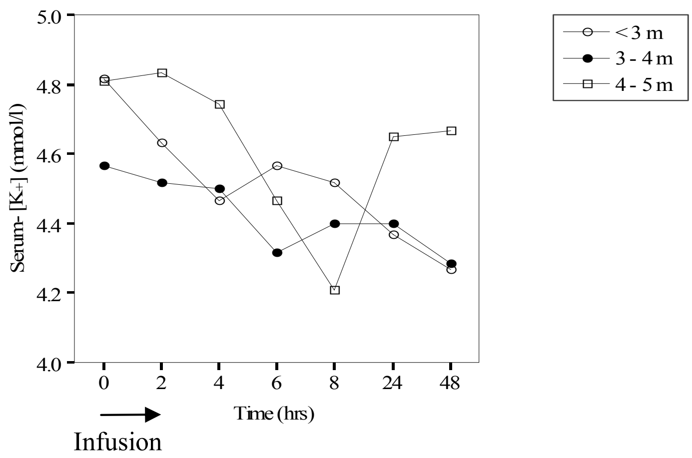
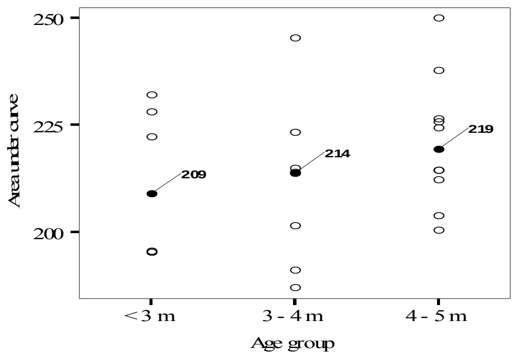


Fig. 4.28b illustrates that there was a gradual increase in the camels' response. However, this pattern of response to metabolic acidosis was not statistically significant.

Fig. 4.26b Changes in serum- [K^+] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Serum- [Cl^-]: The initial mean values (106-110 mmol/l) shown in Fig. 4.27a were in the normal range for healthy camels (101-123 mmol/l) and similar to those for the young camels in the control data (110.1±3.2 mmol/l, Table 10a). There was a gradual increase ($P<0.01$) in serum- [Cl^-] after 2 hrs. After 8 hrs, there was a significant increase ($P<0.001$) in serum- [Cl^-] and remained at a significant higher level ($P<0.05$) after 24 hrs. After 48 hrs, the mean values of serum- [Cl^-] decreased again towards the initial values. However, it remained at a significant slight higher level (108.6-112.2 mmol/l, $P<0.01$) compared with the initial values in the young camels of 3-4 m.

Fig. 4.27a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Cl^-] (mmol/l) in clinically healthy young camels (Mean values).

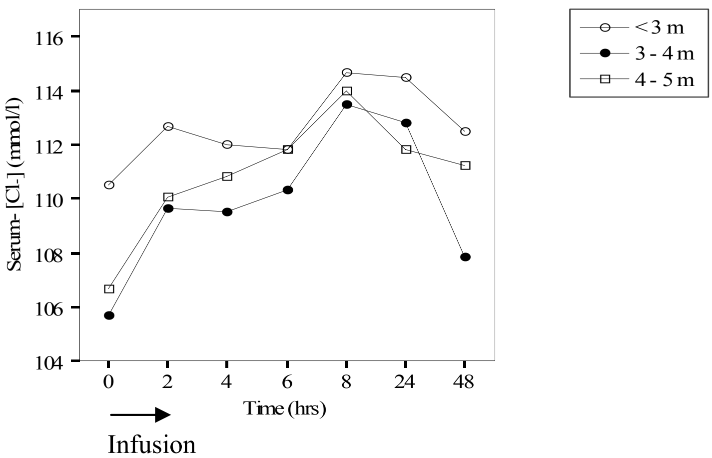
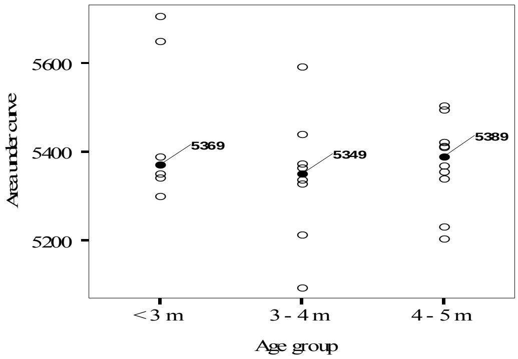


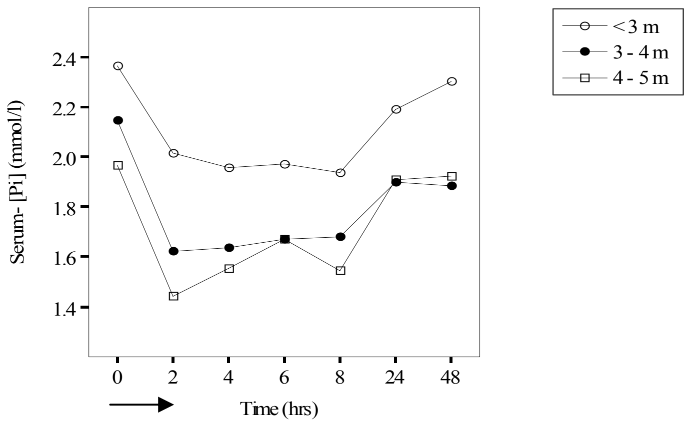
Fig. 4.27b shows that there was a gradual increase in the camels' response to the experimentally induced metabolic acidosis. However, the age had no significant effect on the camels' response.

Fig. 4.27b Changes in serum- [Cl$^-$] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Serum- [Pi]: Fig. 4.28a shows that the initial mean values of serum- [Pi] for the young camels were low (2.0-2.4 mmol/l) compared with the control data for the young camels (3.1±0.5 mmol/l, Table 10a). Generally, intravenous infusion of 5M NH_4Cl caused a sharp significant decrease (P<0.01) in the mean values of serum- [Pi] by 2 hrs after the beginning of the infusion in all age groups. After 4-6 hrs, the mean values of serum- [Pi] maintained at a significant lower steady level (1.5-2.0 mmol/l, P<0.01) than the initial values. The pronounced significant decrease (P<0.001) in serum- [Pi] was observed after 8 hrs in all young camels. After 48 hrs, the serum- [Pi] increased again towards normal to values ranging from 1.9 to 2.3 mmol/l. However, it remained significantly lower (P<0.05) compared with the initial values in the old camels of 3-4 m.

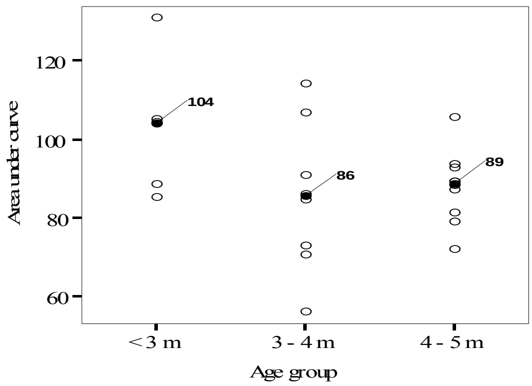
Fig. 4.28a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) serum- [Pi] (mmol/l) in clinically healthy young camels (Mean values).



Infusion

Fig. 4.28b indicates that the younger camels (<3 m) showed the higher response to the intravenous infusion compared with the other age groups. However, this pattern of response was not statistically significant.

Fig. 4.28b Changes in serum- [Pi] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Serum- [Protein]: The detailed results presented in Fig. 4.29a show marked changes in serum- [Protein]. The initial mean values were in the normal range for the control data (54.8±4 g/l, Table 10a). The general pattern of response indicated that there was a sharp significant decrease (P<0.05) in the mean values of serum- [Protein] in all young camels after 2-6 hrs. After 6 hrs, the serum- [Protein] tended to increase again towards normal until 24 hrs. However, this increase in serum- [Protein] remained at a significant lower level (P<0.05) compared with the initial values in the young camels (3-4 m). Then the serum- [Protein] increased again towards normal after 48 hrs.

Fig. 4.29a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Protein] (g/l) in clinically healthy young camels (Mean values).

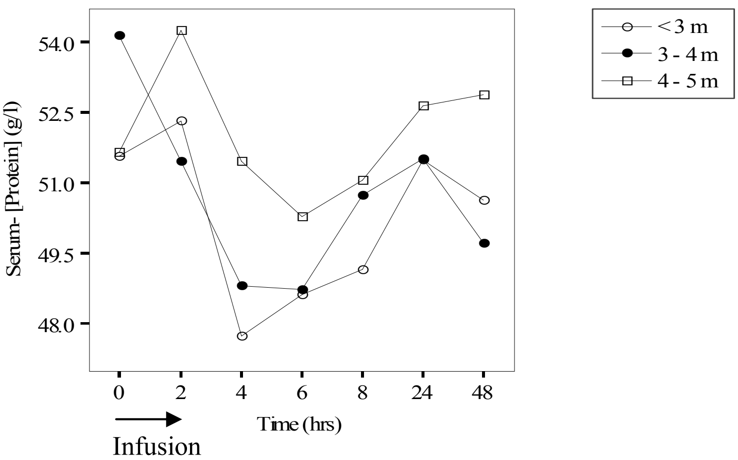
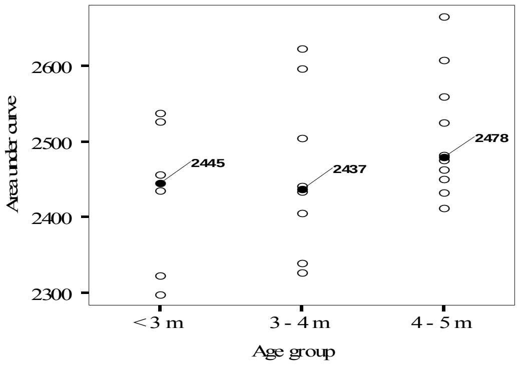


Fig. 4.29b indicates that the old camels of 4-5 m showed the higher response to the intravenous infusion. However, the age had no significant effect on the camels' response to the experimentally induced metabolic acidosis.

Fig. 4.29b Changes in serum- [Protein] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Serum- [Albumin]: Fig. 4.30a shows a close relationship between the serum- [Albumin] and the age of the young camels. The results also indicated that the younger camels (<3 m) had higher mean value of serum- [Albumin] (32.6 g/l) compared with the other age groups (28.5-29.6 g/l). After 4 hrs, there was a sharp decrease (P<0.01) in the mean values of serum- [Albumin] in the old camels (4-5 m). Then the mean values of serum- [Albumin] increased gradually towards normal after 24 hrs. However, there was a drop in the mean value of serum- [Albumin] after 48 hrs below the initial value in the young camels (3-4 m).

Fig. 4.30a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [Albumin] (g/l) in clinically healthy young camels (Mean values).

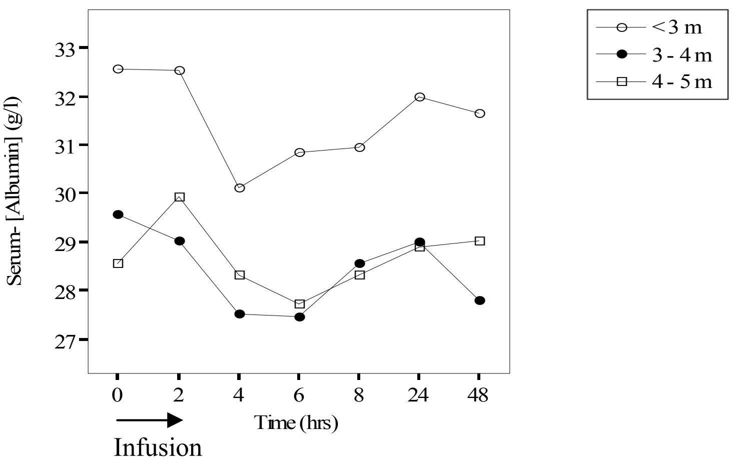
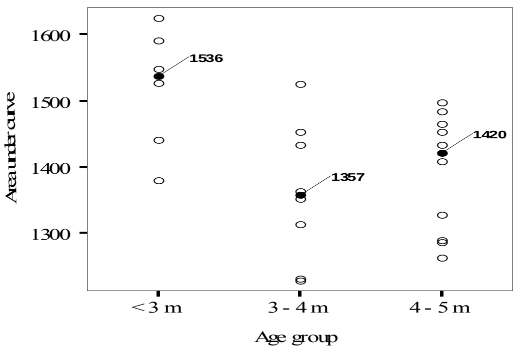


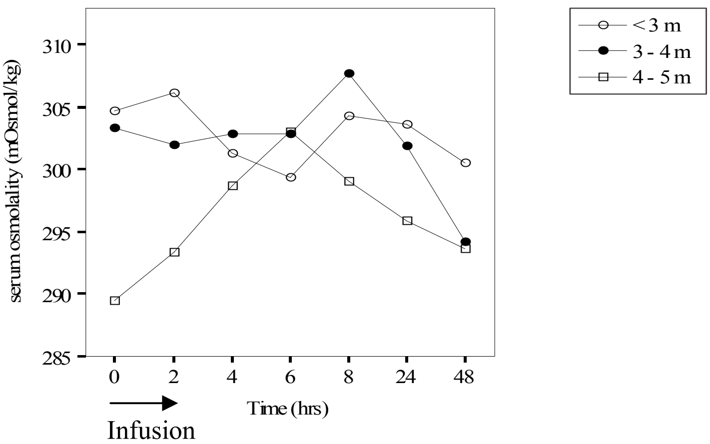
Fig. 4.30b shows that the age had marked influence on the camels' response. The younger camels (<3 m) showed the significant higher response (P<0.05) to the intravenous infusion compared with the young camels (3-4 m).

Fig. 4.30b Changes in serum- [Albumin] expressed as AUC in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



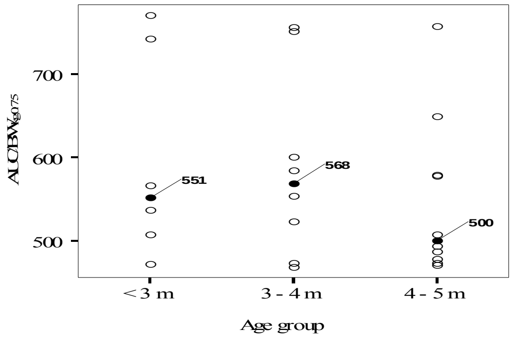
Serum osmolality: Fig. 4.31a shows that the initial mean values decreased gradually with age. Generally, the serum osmolality for the young camels (3-4 m) showed an unorganised non-significant pattern of response to the intravenous infusion. There was a gradual increase (P<0.05) in the mean values of serum osmolality in the old camels (4-5 m) after 6 hrs. By 24 and 48 hrs after the beginning of the infusion, the serum osmolality decreased towards normal to values ranging from 293 to 304 mOsmol/kg and the significant decrease (P<0.05) was observed in the old camels of 4-5 m.

Fig. 4.31a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum osmolality (mOsmol/kg) in clinically healthy young camels (Mean values).



The results also indicate that neither the age nor $BW_{kg}^{0.75}$ had a significant influence on the camels' response to the metabolic acidosis (Fig. 4.31b).

Fig. 4.31b Changes in serum osmolality expressed as AUC/$BW_{kg}^{0.75}$ in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



4.2.5 Acid-base parameters of the experimental young camels

Blood pH: Fig. 4.32a indicates that the initial mean values of pH (7.42) were in the normal range for the control data (7.42±0.01, Table 10b). The general pattern of the camels' response showed that by 2 hrs after the beginning of the infusion, there was a sharp decrease ($P<0.01$) in the mean values of venous blood pH until 4 hrs. The most pronounced decrease ($P<0.001$) in blood pH was observed after 4 hrs in all young camels. After 8 hrs, the venous pH remained significantly lower ($P<0.01$) than the initial values in all young camels. After 24 and 48 hrs, there was a gradual increase in venous blood pH in all groups towards normal values ranging from 7.41 to 7.42. However, after 24 hrs the venous blood pH for the old camels (4-5 m) remained significantly lower ($P<0.05$) than the initial values.

Fig. 4.32a Effect of intravenous infusion of ammonium chloride (5 M NH_4Cl) on venous blood pH in clinically healthy young camels (Mean values).

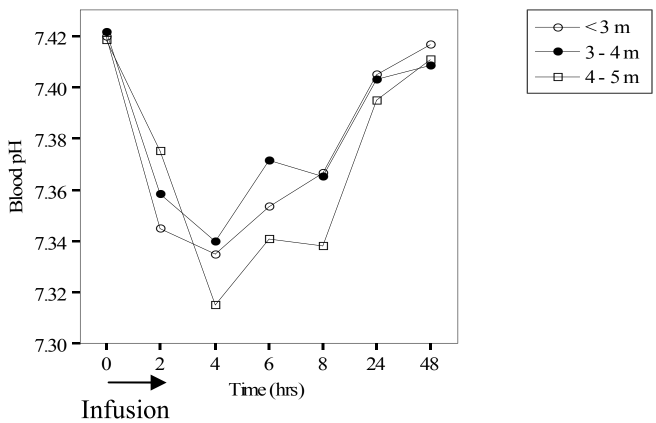
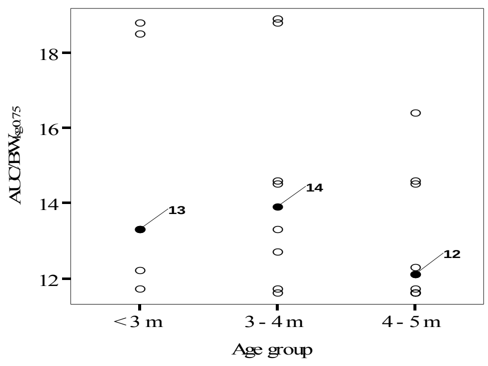


Fig. 4.32b indicates the age and $BW_{kg}^{0.75}$ had no significant effect on the camels' response to the experimentally induced metabolic acidosis.

Fig. 4.32b Changes in venous blood pH expressed as AUC/$BW_{kg}^{0.75}$ in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



Stewart's variables

Serum- [SID_3]: Fig. 4.33a indicates the initial mean values of serum- [SID_3] were low compared with the young camels in the control data (46.6±3.7 mmol/l, Table 10b). However, it is in the normal range for the adults camels in the control data (43.4±2.4-44.5±2.2 mmol/l, Table 10b). Intravenous infusion of 5M NH_4Cl induced a marked decrease in serum- [SID_3] in all groups from the mean initial values of 42.7±2.5-43.4±1.9 mmol/l to 37.1±2.6-39.2±2.8 mmol/l after 8 hrs. After 2 hrs, there was a sharp decrease ($P<0.01$) in the serum- [SID_3] until 24 hrs in all age groups. After 48 hrs, the serum- [SID_3] showed the higher significant decrease ($P<0.001$) during the experimental period in all age groups.

Fig. 4.33a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [SID_3] (mmol/l) in clinically healthy young camels (Mean values).

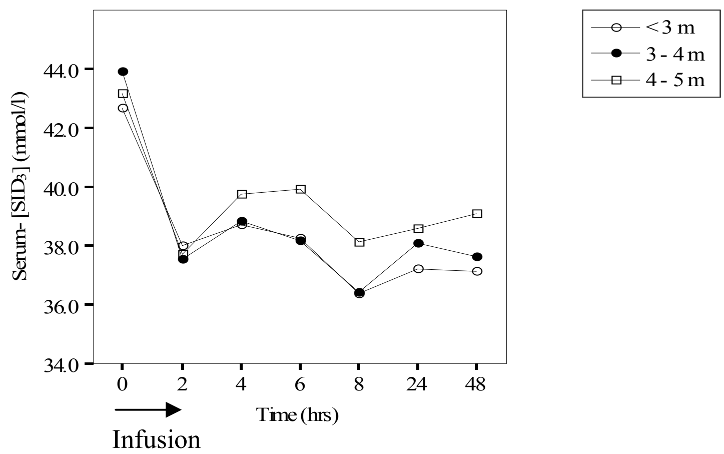
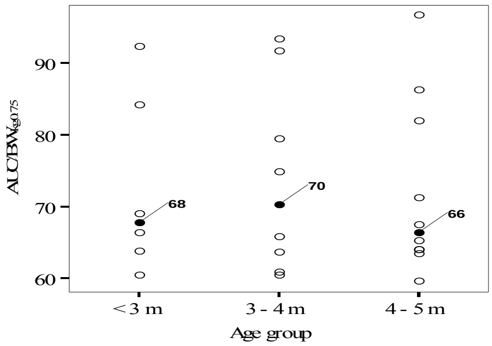


Fig. 4.33b shows an unorganised pattern of response in relation to the changes in $BW_{kg}^{0.75}$. The age had no effect on the camels' response as observed in calves.

Fig. 4.33b Changes in serum- [SID_3] expressed as AUC/$BW_{kg}^{0.75}$ in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



According to the Equation (1): Fig. 4.33c indicates that the changes in serum- [Na^+] cause a slight significant decrease in serum- [SID_3] in all young camels (R^2 = 0.12-0.17, P<0.05).

Fig. 4.33c The relationship between serum- [SID_3] (mmol/l) and serum- [Na^+] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.

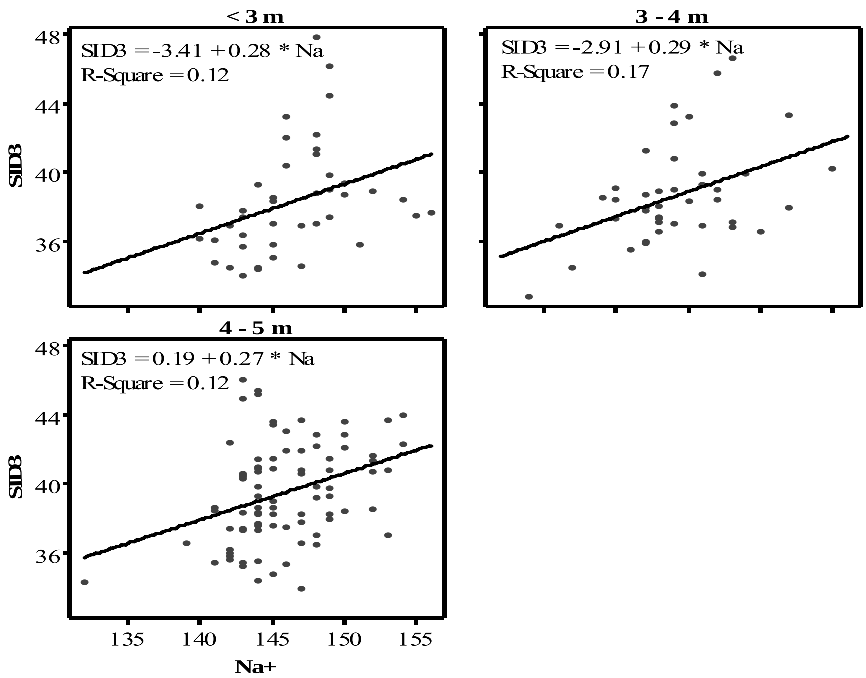


Fig. 4.33d shows that the changes in serum- [SID_3] in young camels were also correlated to marked changes in serum- [K^+] (R^2 = 0.12-0.31, P<0.01).

Fig. 4.33d The relationship between serum- [SID_3] (mmol/l) and serum- [K^+] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.

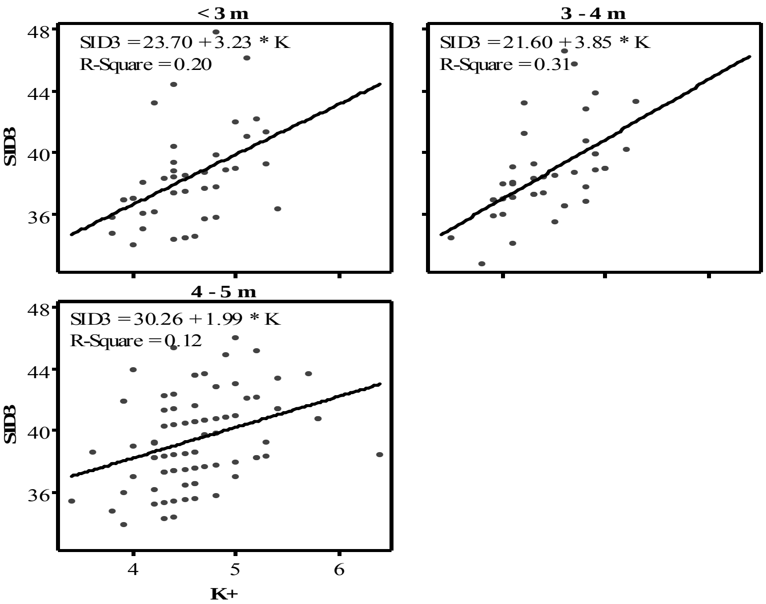
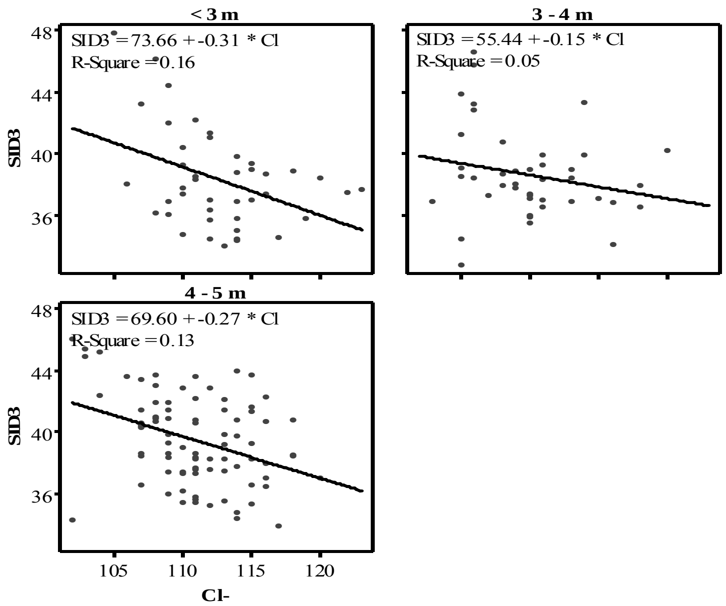


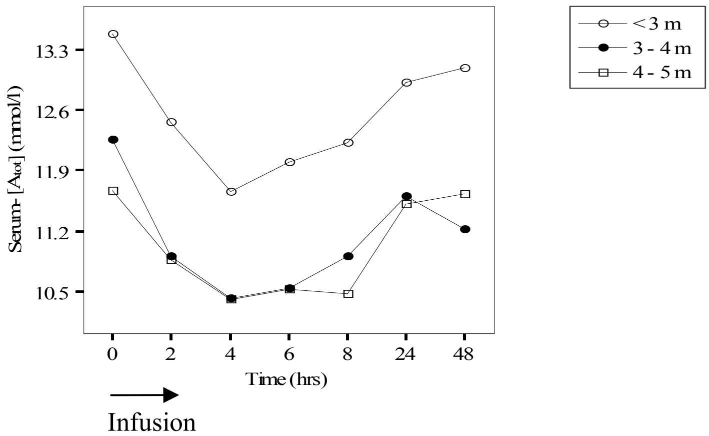
Fig. 4.33e indicates that the changes in serum- [SID_3] in all young camels were correlated to the changes in serum- [Cl^-] (R^2 = 0.13-0.16, P<0.01) except in the old camels (3-4 m).

Fig. 4.33e The relationship between serum- [SID_3] (mmol/l) and serum- [Cl^-] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.



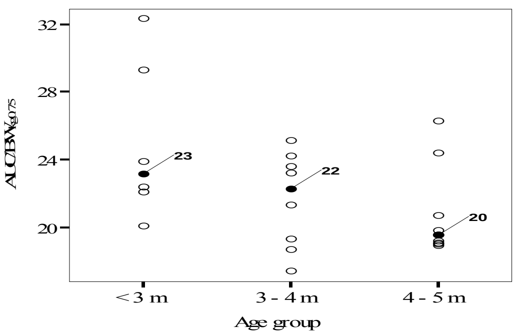
Serum- [A_{tot}]: Fig. 4.34a indicates that the initial mean values of serum- [A_{tot}] (11.8-13.5 mmol/l) were lower compared with the control data (12.4±1.4-14.7±1.2 mmol/l, Table 10b). Generally, there was a sharp decrease ($P<0.05$) in the mean values of serum- [A_{tot}] after 2 hrs in all young camels. After 4 hrs, the serum- [A_{tot}] remained at a significant lower level ($P<0.001$) than the initial values which was characterised by the pronounced decrease throughout the experimental period. After 8 hrs, the serum- [A_{tot}] remained significantly lower ($P<0.05$) than the initial values. After 24 and 48 hrs, the serum- [A_{tot}] increased again towards the initial values.

Fig. 4.34a Effect of intravenous infusion of ammonium chloride (5M NH_4Cl) on serum- [A_{tot}] (mmol/l) in clinically healthy young camels (Mean values).



The critical evaluation of the changes in the serum- [A_{tot}] suggested the age and metabolic body weight have no significant effect on the camels' response (Fig. 4.34b).

Fig. 4.34b Changes in serum- [A_{tot}] expressed as $AUC/BW_{kg}^{0.75}$ in clinically healthy young camels with experimentally induced metabolic acidosis (Median values).



According to the equation (2): Figs. 4.34c and 4.34d show that the decrease in serum- [A_{tot}] was strongly correlated to the decrease in serum- [Albumin] and serum- [Pi] (R^2 = 0.62-0.71, 0.66-0.83, $P<0.01$, respectively).

Fig. 4.34c The relationship between serum- [A_{tot}] (mmol/l) and serum- [Albumin] (g/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.

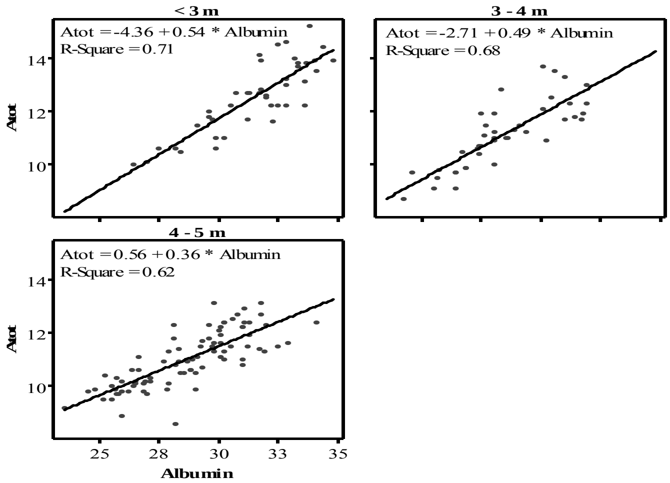
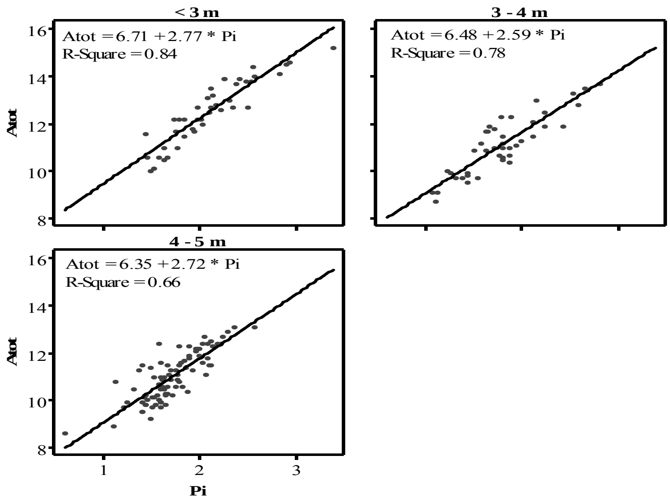


Fig. 4.34d Changes in serum- [A_{tot}] (mmol/l) in relation to changes serum- [Pi] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.



The relationship between venous blood pH and Stewart's variables: Fig. 4.35a shows that the changes in the blood pH in response to the changes in serum- [SID_3] were not clear in the younger camels (<3 m) and in the old camels (4-5 m) (R^2 = 0.03 and 0.001, respectively). However, the young camels (3- 4 m) showed a significant decrease in blood pH in response to the decrease in serum- [SID_3] (R^2 = 0.1, P<0.05).

Fig. 4.35a The relationship between venous blood pH and serum- [SID_3] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.

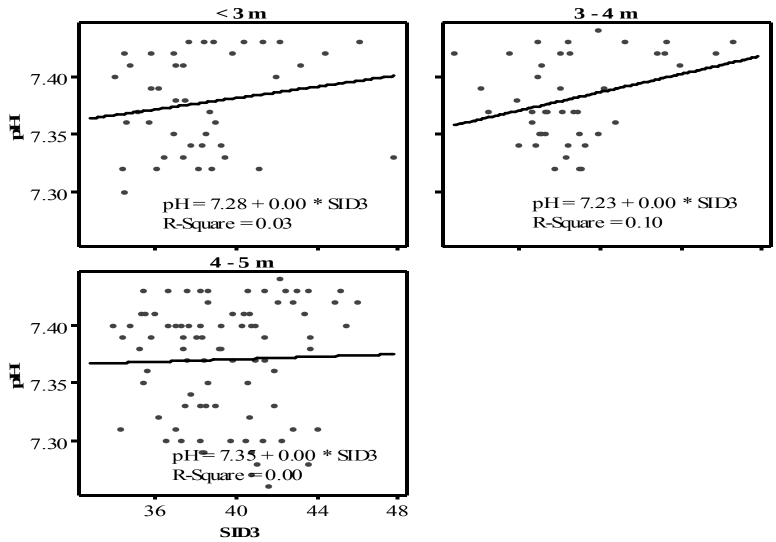
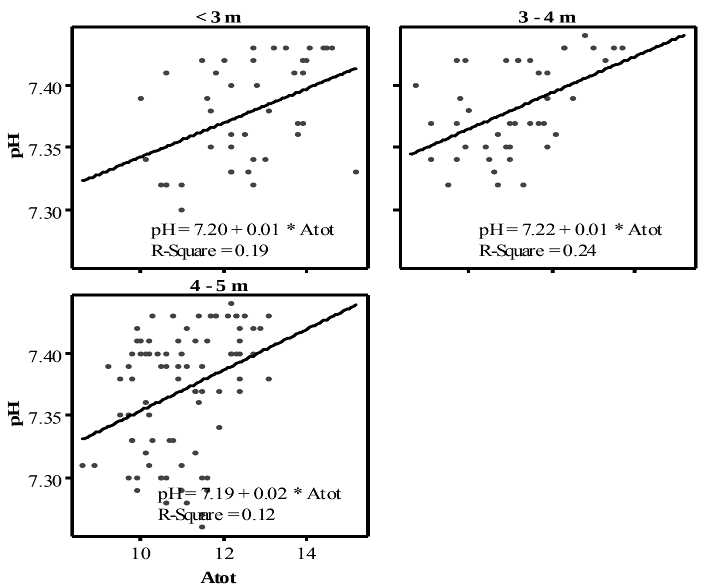


Fig. 4.35b indicates that the changes in serum- [A_{tot}] were associated with strong changes in blood pH in all young camels as indicated by R^2 values (0.12-0.24, P<0.01).

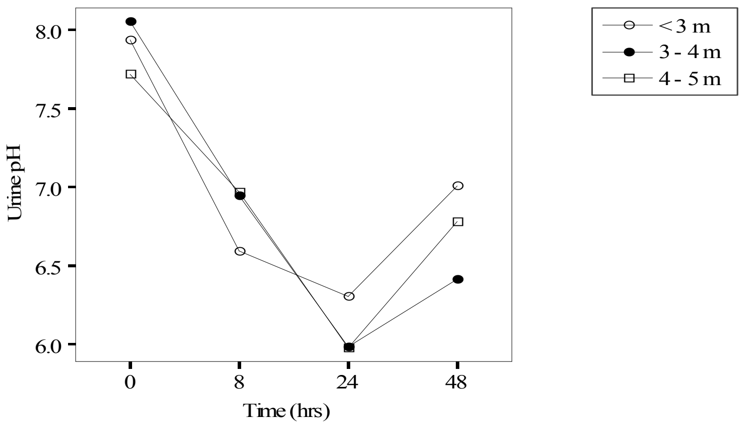
Fig. 4.35b The relationship between venous blood pH and serum- [A_{tot}] (mmol/l) in clinically healthy young camels with experimentally induced metabolic acidosis. (Linear regression equation: y = ax + b; R^2: Coefficient of determination). The regression line applies only the investigated range of the findings.



4.2.6 Urine parameters of the experimental young camels

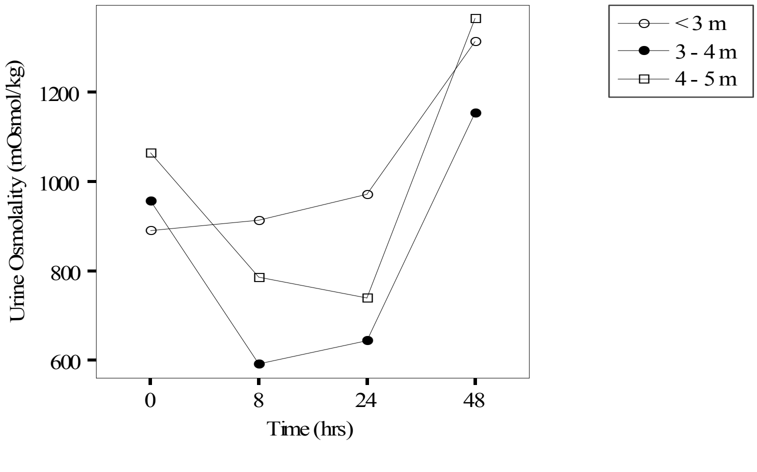
Urine pH: Fig. 4.36 shows that the urine pH decreased sharply ($P<0.01$) by 8-24 hrs after the intravenous infusion of 5M NH_4Cl in all age groups. The maximal significant decrease ($P<0.001$) was observed after 24 hrs. By 48 hrs after the beginning of the infusion, the urine pH tended to maintain at a significant lower level ($P<0.05$) in all age groups (6.5-7.0) compared with the initial pH (7.7-8.0).

Fig. 4.36 Changes in urine pH in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).



Urine osmolality: Fig. 4.37 shows that the mean values of urine osmolality decreased sharply during the experimental period of 8 hrs and after 24 hrs. The significant decrease ($P<0.05$) was observed in the young camels (3-4 m).By 48 hrs after the beginning of the infusion, the urine osmolality showed the maximal increase in all age groups.

Fig. 4.37 Changes in urine osmolality (mOsmol/kg) in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).



Fractional excretion of electrolytes (FE): The results for the effect of intravenous infusion of 5M NH_4Cl on the fractional excretion of electrolytes is shown in Figs. 4.38a, 4.38b, 4.38c and 4.38d. Fig. 4.38a shows that the initial mean values of FE $_{Na+}$ were less than 0.1 %. In response to the experimentally induced metabolic acidosis there was a sharp increase (P<0.01) in the FE $_{Na+}$ after 8 hrs in the young camels (3-4 m). After 24 and 48 hrs, the FE $_{Na+}$ decreased to values lay close to the initial values.

Fig. 4.38a Changes in the fractional excretion of sodium (FE $_{Na+}$) in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).

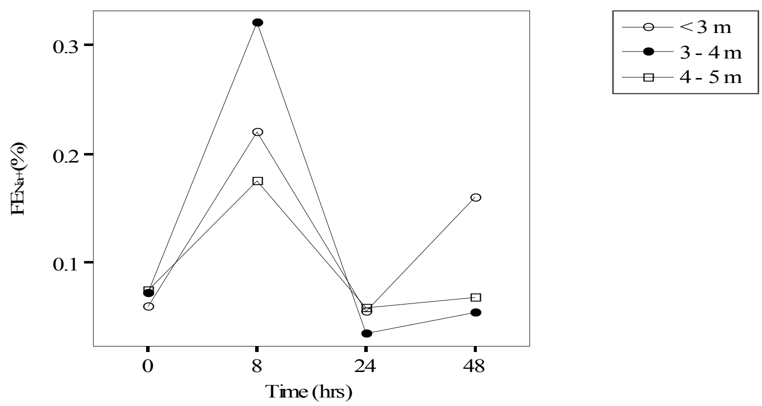


Fig. 4.38b indicates that the initial mean values of FE $_{K+}$ were between 10-15 %. In all age groups, there was a sharp increase in the mean values of the FE $_{K+}$ after 8 hrs. In the old camels of 4-5 m, the FE $_{K+}$ increased significantly (P<0.05) after 8 hrs and then decreased sharply (P<0.05) after 24 hrs to values less than the initial values. After 48 hrs, the mean values of the FE $_{K+}$ increased again towards the initial values in all age groups.

Fig. 4.38b Changes in the fractional excretion of potassium (FE $_{K+}$) in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).

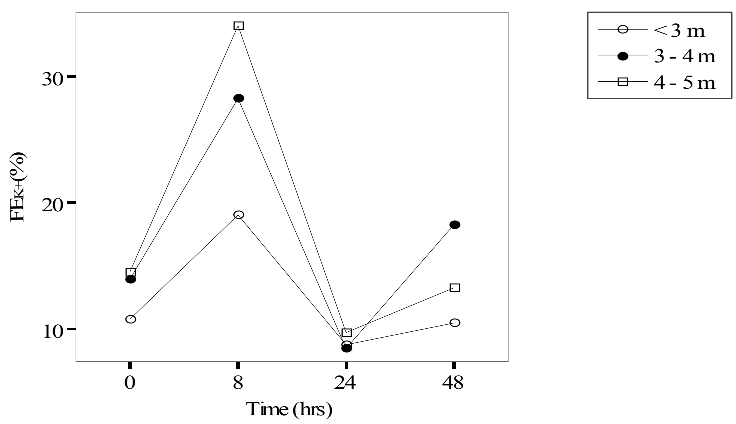


Fig. 4.38c shows that the initial mean values of FE $_{Cl-}$ were between 1.2-1.6 %. Generally, there was a sharp significant increase (P<0.05) in the mean values of the FE $_{Cl-}$ by 8 hrs after the infusion in the old camels (4-5 m). Then the FE $_{Cl^-}$ decreased gradually after 24 and 48 hrs.

Fig. 4.38c Changes in the fractional excretion of chloride (FE $_{Cl-}$) in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).

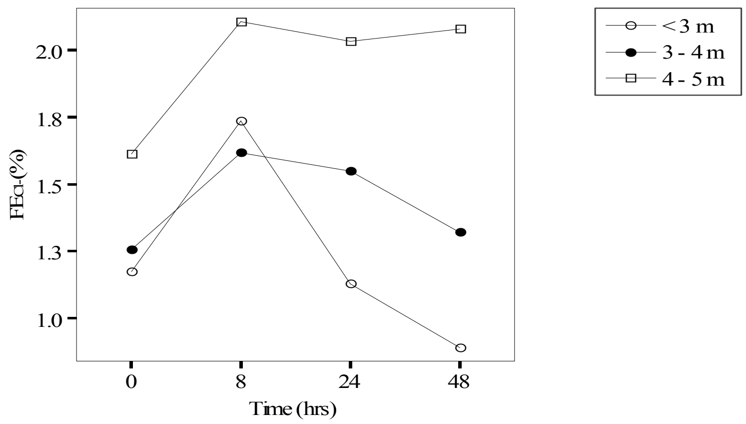


Fig. 4.38d indicates that the initial mean values of FE $_{Pi}$ were between 0.2-0.7 %. The general pattern of the renal response showed that there was a sharp significant increase (P<0.01) in the mean values FE $_{Pi}$ after 8 and 24 hrs. However, the younger camels (<3 m) showed the minimal response to the experimentally induced metabolic acidosis. After 48 hrs, the FE $_{Pi}$ decreased sharply (P<0.01) towards the initial values after 48 hrs. However, the young camels (3-4 m) showed a sight increase after 48 hrs above the initial values.

Fig. 4.38d Changes in the fractional excretion of inorganic phosphate (FE $_{Pi}$) in clinically healthy young camels with experimentally induced metabolic acidosis (Mean values).