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Plasma Transfusion in Calves with Failure of Passive Colostral Transfer

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Abstract: Plasma administration was studied in newborn calves with failure of passive colostral transfer (FPCT).

Eighteen sick Holstein calves with FPCT (Experimental group) and 6 healthy Holstein calves known to have consumed colostrum (Control group) were used as a materials.

Failure of passive colostral transfer was confirmed by a negative gluteraldehyde coagulation test (GACT). Calves with FPCT were weighed on presentation and were randomly divided in to three groups (each group consisted of 6 calves) in those treatment was designed as follows; Experimental group I (EG I) calves were treated with antimicrobials, fluids, various supportive measures, and plasma transfusion was given at the dose of 30 ml/kg body weight. Experimental group II (EG II) calves were treated with antimicrobials, fluids, various supportive measures, and plasma transfusion was given at the dose of 40 ml/kg body weight. Experimental group III (EG III) calves were treated with antimicrobials, fluids and various supportive measures.

The mean concentrations of serum total protein were significantly greater in calves of control group as compared to calves of EGI, EGII and EGIII ($p<0.05$). The mean concentrations of serum total protein significantly increased in calves of EGI and EGII after the treatment ($p<0.05$).

The mean concentrations of all serum protein fractions except β-globulin fraction were significantly greater in calves of control group as compared to calves of EGI, EGII and EGIII ($p<0.05$). Calves administered plasma at the dose of 40 ml/kg body weight, I.V. (EGII) showed increased serum α-globulin and γ-globulin concentrations. Serum albumin and β-globulin fractions were not influenced by plasma administration ($p>0.05$).

The result of the study showed that plasma transfusion at the dose of 40 ml/kg body weight could restore protective levels of Ig and could provide considerable recovery in calves with severe FPCT.

Key Words: Calf, Failure of Passif Colostrum Transfer, Plasma transfusion, Protein electrophoresis

Passif Kolostral Transfer Yetmezliği Olan Buzağılarda Plazma Transfüzyonu

Özet : Pasif kolostral transfer yetmezliği (FPCT) olan yeni doğmuş buzağılarda plazma transfüzyonunun önemi araştırıldı.

Materyal olarak pasif kolostral transfer yetmezliği olan 18 holştayn ırkı (Deneysel grup) ve kolostrum tükettiği bilinen 6 sağlıklı (Kontrol grup) buzağı kullanıldı.

Pasif kolostral transfer yetmezliği glutaraldehid koagülasyon testinin (GACT) negatif sonucuyla doğrulandı. FPCT olan buzağılar tartıldı ve rastgele üç gruba ayrıldı (Her grup 6 buzağıdan oluşturuldu). Birinci deneme grubundaki buzağılara (EG I) antibiyotik, sıvı ve destekleyici tedavilerle birlikte 30 ml/kg dozunda plazma transfüzyonu uygulandı. İkinci deneme grubundaki buzağılar (EG II) antibiyotik, sıvı ve destekleyici tedavilerle birlikte 40 ml/kg dozunda plazma transfüzyonu ile tedavi edildi. Üçüncü deneme grubundaki buzağılar (EG III) ise antibiyotik, sıvı ve destekleyici tedavilerle tedavi edildi.

Ortalama serum total protein konsantrasyonu EG I, EG II ve EG III buzağılarında kontrol grubu buzağılara göre önemli derecede düşüktü ($p<0.05$).

Ortalama serum total protein konsantrasyonu tedaviden sonra EG I ve EG II'de önemli derecede yükseldi ($p<0.05$).

β-globulin fraksiyonu hariç tüm serum protein fraksiyonlarının ortalama konsantrasyonları EG I, EG II ve EG III buzağılarda kontrol grubu buzağılara göre önemli derecede düşüktü ($p<0.05$).

Plazma transfüzyonunun 40 ml/kg dozunda uygulandığı EG II buzağılarda serum α-globulin ve γ-globulin konsantrasyonlarının önemli derecede arttığı görüldü ($p<0.05$). Serum albumin ve β-globulin fraksiyonlarında plazma transfüzyonundan sonra önemli artış gözlenmedi ($P>0.05$).

Çalışma sonucunda, şiddetli FPCT olan buzağılarda, 40 ml/kg dozunda plazma transfüzyonunun plazma immun globulin seviyesini restore ettiği ve tedavide önemli olduğu sonucuna varıldı.

Anahtar Sözcükler: Buzağı, Pasif kolostral transfer yetmezliği, Plazma transfüzyonu, Protein elektroforezis

Introduction

Colostrum is the primary source of passive natural protective antibody for the neonatal ruminant. Early ingestion of immunoglobulin (Ig) rich milk is critical for neonatal calf survival: colostrum deprivation results in neonatal failure of passive transfer of antibody and is associated with increased morbidity and mortality (1, 2, 3, 4). Partial or complete FPTA has been reported to occur in 25-65% of naturally suckled calves (5). Ninty percent of calves dying in the first week of life had not absorbed adequate amounts of Ig. Of those dying in the second and third week of life, 80% had inadequate Ig concentrations (1, 6).

Several methods of Ig assesment can be used to detect FPCT. Dehydration will falsely elevate Ig concentration in all, hovewer the single radial immunodiffusion and serum electrophoresis tests not result in false elevation of Ig measurements (1, 3).

Serum total protein concentration (TP) less than 5.0 g/dl is cause for concern: greater than 5.0 g/dl may be partially or completely protective in the normally hydrated calf that is only a few days old (4, 7).

The gluteraldehyde cougulation test (GACT) is an effective and rapid means of screening large numbers of calves in a field. The time required for complete coagulation is inversely proportional to Ig concertration of the sample. Sample from neonatel calves with high serum Ig concentration cougulate within five to fifteen minutes (1, 6, 8, 9).

Electrophoresis is a laboratory technique by which serum proteins can be fractionated and serum albumin and individual gamma globulin classes to which Ig shows good correlation can be quantified. Gamma globulin levels below 1 g/dl indicate partial failure of colostral Ig absorbtion, while values less than 0.4 g/dl are associated with severe Ig deficiency (1, 7).

Therapy for FPTA and associated diseasses may include administration of antimicrobials, fluids, various supportive measures and attempts to restore protective levels of circulating Ig (2, 10). Because FPTA is frequently encountered after gut clousure to absorbtion of exogenous Ig, administration of Ig in plasma or whole blood has been used to restore protective levels of Ig. An amprical dosage of 10-20 ml/kg I.V. has been suggested for neonatal septicemia (11). On the other hand, Anderson et al (2) have suggested that administration of plasma at the recommended dose of 20 ml/kg did not produce protective levels of circulating Ig.

In the present study, plasma administration was studied in newborn calves with FPCT. The purposes of the study were (1) to evaluate the diagnostic accuracy of GACT, serum TP concentration and serum gamma globulin concentration in calves with FPCT; and (2) to compare levels of gamma globulin fraction in calves administered plasma at the dose of 30 ml/kg and 40 ml/kg I.V. In addition, the therapeutic effects of plasma transfusion in calves with FPCT were investigated.

Materials and Methods

Animal and desing: 18 sick Holstein calves with FPCT (aged 2 to 10 days old, weighed 15-40 kg (Experimental group) which were referred to the Clinic of Internal Medicine, Faculty of Veterinary Medicine, University of Selçuk and 6 healthy Holstein calves known to have consumed colostrum (Control group) (aged 2-10 days old weighed 30-45 kg) belonging to Central Animal Research Institute, Ministere of Agriculture were used as a materials.

Failure of passive colostral transfer was confirmed by a negative GACT test (8). Calves with FPCT were weighed on presentation and were randomly divided to three groups (each group consisted of 6 calves) in those treatment was designed as follows; Experimental group I (EG I) calves were treated with antimicrobials, fluids, various supportive measures, and plasma transfusion was given at the dose of 30 ml/kg body weight. Experimental group II (EG II) calves were treated with antimicrobials, fluids, various supportive measures, and plasma transfusion was given at the dose of 40 ml/kg body weigt. Experimental groups III (EGIII) calves were treated with antimicrobials, fluids and various supportive measures.

Plasma: Healthy cows belonging to Konya Central Animal Research Institute, with no history of infectious disease were selected as doners. In this selection, it was confirmed by serum protein electrophoresis that doner cows had gammaglobulin concentration more than 2 g/dl. Blood samples were collected into sterile container containing heparin (4.5 IU/ml of blood) with a closed system, than were immediately centrifugated at 4°C at 500 rpms for 15 minutes. Plasma samples were manually taken from the large collection bag into the small 450 ml plastic plasma bags under sterile condition. These were cut free of their connecting tubing was immediately clipped to seal it and maintain sterility. The plastic plasma bags were stored at -20°C to be used when needded. Before plasma transfusion,

the plastic plasma bags were place in a circulating warm water bath at 37°C and were slowly brought to body temperature during the thawing process.

Plasma transfusion for each calves was given once at the rate of 1 liter/hr on the first day of the treatment.

Clinical and laboratory measurements: Rectal temperatures, presence of illness and the result of the treatment were recorded daily for the first 7 days and on day 14 and 28. Blood samples for the determination of Packed cell volume (PCV), Hemoglobin concantration (Hb), white blood cell count (WBC), and serum TP values, GACT, and protein electrophoresis were collected before the treatment, the day after treatment and on day 7, 14 and 28.

Serum total protein concentrations were measured by the commercial kid (Biobak: BATP-1000) using schimadzu spectroph otometer (UV-Vis 2000 model). GACT test was performed by mixing 0.5 ml calf serum with 50 µl, 10% gluteraldehyde solution (Merck No 4239) in a test tube and was observed for coagulation for 30 minutes. A positive reaction was characterized by formation of fibrin, opaque, yellow clot at the bottom of the test tube that did not move when the tube was inverted. Serum protein fractions were determined with gell electrophoresis by the method described by Patel and Lott (12).

Statistical analysis: Statistical significance was tested using variation analysis between the pre-treatment and post-treatment values for each paremeter and among all the groups (control, EG I, EG II and EG III groups). Duncan test was performed on the values which were found to be significant statistically. Correlation was performed between γ-globulin fraction and the other paremeters (13).

Results

One calf from EGI and 2 calves from EG III died between the first and 14th day of the treatment. Complications such as omphalitis and allopecia at the various body parts were observed in two calves from EGI and EGIII groups after treatment. The remaining calves showed considerable recovery during the first 7 days of the treatment.

There were no significant differences in rectal temperatures among the groups, although ature control group of calves tended to have lower mean rectal temperature

The result of the GACT were negative in the calves of experimental groups (EG I, EG II and EG III) before the treatment. 3 calves in EG I and all calves in EG II had positive GACT results on the first day of the treatment. All calves in EG III had negative GACT results during the study, while control group of calves had positive GACT results.

The mean (+SD) values of PCV, Hb concentrations and WBC count of the experimental groups (EG I, EG II and EG III) and control group are given at Table 1, 2 and 3. There were no significant differences ($p>0.05$) in PCV, Hb concentration and WBC count among the experimental groups and control group and for time after treatment.

Table 1. Mean (±SD) pre-infusion and post infusion values of PCV. (Day 1 values are aproximately 24 hours post-infusion)

	D A Y S					
	0	1	7	14	28	F
EG I	38.667±4.341 (n:6)	31.800±2.596 (n:5)	34.800±2.534 (n:5)	32.600±1.631 (n:5)	34.200±1.148 (n:5)	0.925
EG II	36.667±2.565 (n:6)	32.833±0.980 (n:6)	31.500±1.204 (n:6)	32.000±1.461 (n:6)	32.000±1.549 (n:6)	1.538
EG III	35.400±3.076 (n:5)	31.500±2.992 (n:5)	32.000±4.082 (n:4)	31.000±3.786 (n:3)	32.667±1.764 (n:3)	0.302
CG	38.333±2.092 (n:6)	36.333±2.290 (n:6)	35.333±1.706 (n:6)	34.667±1.820 (n:6)	33.167±1.662 (n:6)	0.999
F	0.222	1.007	0.790	0.611	0.341	

No statistically significant differences were determined.

Table 2. Mean (±SD) pre-infusion and post infusion values of Hb. (Day 1 are values aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	9.500±1.094 (n:6)	8.840±1.186 (n:5)	7.940±0.424 (n:5)	7.580±0.700 (n:5)	8.360±0.462 (n:5)	0.801
EG II	8.933±0.801 (n:6)	8.867±0.720 (n:6)	8.667±0.437 (n:6)	8.317±0.248 (n:6)	8.900±0.437 (n:6)	0.205
EG III	10.440±1.586 (n:5)	8.920±0.836 (n:5)	9.825±1.644 (n:4)	7.733±0.240 (n:3)	9.333±0.437 (n:3)	0.596
CG	7.383±0.293 (n:6)	8.300±0.636 (n:6)	8.433±0.067 (n:6)	8.417±0.111 (n:6)	7.933±0.320 (n:6)	2.364
F	1.617	0.125	1.126	1.132	1.645	

No statistically significant differences were determined.

Table 3. Mean (±SD) pre-infusion and post infusion values of WBC (mm^3). (Day 1 are values aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	10616±2828 (n:6)	10280±1552 (n:5)	7960±953 (n:5)	6860±655 (n:5)	7600±878 (n:5)	0.956
EG II	8200±1923 (n:6)	9100±1965 (n:6)	9000±1921 (n:6)	7166±1632 (n:6)	9333±2335 (n:6)	0.203
EG III	6080±917 (n:5)	6640±868 (n:5)	5775±356 (n:4)	7400±1442 (n:3)	7400±1442 (n:3)	0.456
CG	6733±658 (n:6)	8066±1826 (n:6)	9800±1911 (n:6)	6166±836 (n:6)	5900±120 (n:6)	1.597
F	1.154	0.782	1.001	0.188	1.274	

No statistically significant differences were determined.

The mean concentrations of serum total protein were significantly greater in calves of control group as compared to calves of EG I, EG II and EGIII (Table 4). The mean concentrations of serum total protein significantly increased in calves of EG I and EG II after the treatment ($p<0.05$).

The mean concentrations of all serum protein fractions except β-globulin of control raction were significantly greater in calves of control group as compared to calves of EG I, EG II and EG III (Table 5, 6, 7, 8). Serum α-globulin and γ-globul in concentrations were comparable in calves given plasma at the dose of 40 ml/kg body weight, I.V. Calves administered plasma at the dose of 40 ml/kg body weight, I.V. (EG II) showed increased serum α-globulin and γ-globulin concentrations. Serum albumin and β-globulin fractions were not influenced by plasma administration ($p>0.05$).

Adverse reactions were not observed when the plasma transfusion was given at the rate of 1L/hr.

There was a significant correlation between serum TP and γ-globulin levels with a correlation coefficient of 0.399.

Discussion

The result of this study showed that GACT and protein electrophoresis have a diagnostic accurancy in the determination of FPCT. Plasma transfusion at the dose of 40 ml/kg body weight provide sufficient γ-globulin concentration in calves with FPCT.

Table 4. Mean (±SD) pre-infusion and post infusion values of TP (g/dl). (Day 1 values are aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	4.017±0.111 (n:6) by	5.180±0.248 (n:5) bx	4.920±0.362 (n:5) bx	5.540±0.262 (n:5) abx	5.120±0.183 (n:5) abx	6.165**
EG II	4.033±0.123 (n:6) bz	5.717±0.241 (n:6) bx	4.833±0.071 (n:6) bx	5.133±0.316 (n:6) bcy	4.833±0.165 (n:6) by	9.013**
EG III	4.183±0.083 (n:6) bz	4.050±0.106 (n:6) cz	4.380±0.139 (n:5) byz	4.800±0.173 (n:4) acx	4.600±0.100 (n:4) bxy	6.272**
CG	6.600±0.259 (n:6) ax	6.733±0.262 (n:6) ax	6.283±0.274 (n:6) axy	5.950±0.177 (n:6) ayz	5.567±0.217 (n:6) az	3.942*
F	62.794**	26.473**	12.777**	3.784*	5.098*	

* p<0.05 ** p<0.01
abc : Different letters in the column indicate the significant differences. x, y, z : Different letters in the line indicate the significant differences.

Table 5. Mean (±SD) pre-infusion and post infusion values of Alb (g/dl). (Day 1 values are aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	1.888±0.162 (n:6) b	2.067±0.204 (n:5) b	2.192±0.201 (n:5)	2.152±0.235 (n:5)	2.082±0.100 (n:5)	0.369
EG II	1.863±0.258 (n:6) b	2.047±0.099 (n:6) b	1.952±0.112 (n:6)	1.993±0.165 (n:6)	1.927±0.057 (n:6)	0.982
EG III	1.915±0.119 (n:6) b	1.860±0.113 (n:6) c	1.830±0.105 (n:5)	2.068±0.028 (n:4)	1.843±0.218 (n:4)	1.353
CK	2.577±0.150 (n:6) a	2.462±0.150 (n:6) a	2.488±0.154 (n:6)	2.452±0.159 (n:6)	2.278±0.149 (n:6)	0.506
F	3.677*	3.688*	2.938-	1.490-	2.153-	

* p<0.05
abc : Different letters in the column indicate the significant differences.

Table 6. Mean (±SD) pre-infusion and post infusion values of α-globulin (g/dl). (Day 1 values are aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	0.827±0.184 (n:6) b	1.248±0.162 (n:5) a	1.152±0.185 (n:5)	1.200±0.227 (n:5)	1.278±0.138 (n:5)	1.621
EG II	0.820±0.131 (n:6) bz	1.667±0.172 (n:6) ax	1.510±0.226 (n:6) yz	1.485±0.258 (n:6) xy	1.465±0.243 (n:6) yz	3.881*
EG III	0.923±0.153 (n:6) b	0.873±0.147 (n:6) b	1.050±0.184 (n:5)	0.948±0.252 (n:4)	1.268±0.235 (n:4)	0.639
CK	1.668±0.148 (n:6) a	1.362±0.181 (n:6) a	1.382±0.212 (n:6)	0.957±0.042 (n:6)	1.362±0.181 (n:6)	2.398
F	6.945**	3.561*	1.023	2.689	0.199	

* p<0.05 ** p<0.01
abc : Different letters in the column indicate the significant differences. x, y, z : Different letters in the line indicate the significant differences.

Table 7. Mean (±SD) pre-infusion and post infusion values of β-globulin (g/dl). (Day 1 values are aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	0.707±0.077 (n:6)	0.960±0.121 (n:5)	0.948±0.140 (n:5)	1.088±0.101 (n:5)	0.974±0.212 (n:5)	1.160
EG II	0.710±0.085 (n:6)	0.987±0.061 (n:6)	0.722±0.112 (n:6)	0.750±0.139 (n:6)	0.652±0.115 (n:6)	0.225
EG III	0.752±0.106 (n:6)	0.868±0.043 (n:6)	0.736±0.109 (n:5)	0.945±0.042 (n:4)	0.763±0.086 (n:4)	0.438
CK	1.095±0.199 (n:6)	1.265±0.152 (n:6)	1.068±0.152 (n:6)	1.098±0.077 (n:6)	0.903±0.131 (n:6)	1.946
F	2.194	2.450	1.720	1.568	1.015	

No statistically significant differences were determined.

Table 8. Mean (±SD) pre-infusion and post infusion values of γ-globulin (g/dl). (Day 1 values are aproximately 24 hours post-infusion.)

	D A Y S					
	0	1	7	14	28	F
EG I	0.361±0.038 (n:6) b	0.860±0.122 (n:5) bc	0.622±0.106 (n:5)	0.613±0.149 (n:5)	0.756±0.146 (n:5)	1.731
EG II	0.370±0.051 (n:6) by	1.340±0.208 (n:6) ax	0.875±0.238 (n:6) xy	0.840±0.146 (n:6) bxy	0.753±0.225 (n:6) y	3.428*
EG III	0.233±0.043 (n:6) b	0.400±0.088 (n:5) c	0.742±0.279 (n:5)	0.580±0.254 (n:4) b	0.615±0.118 (n:4)	1.431
CK	1.390±0.234 (n:6) a	1.378±0.257 (n:6) ab	1.320±0.235 (n:6)	1.422±0.045 (n:6) a	1.103±0.225 (n:6)	0.289
F	11.932**	3.226*	1.836	7.316**	1.085	

* $p<0.05$ ** $p<0.01$

abc : Different letters in the column indicate the significant differences.

x, y, z : Different letters in the line indicate the significant differences.

Glutaraldehyde cougulation test is a semiquantitative test for γ-globulin in cattle and other species (8, 9). There is a significant relationship between serum γ-globulin concentration and the GACT result. Tennant et al (8) have reported that all GACT results were negative in calves with serum γ-globulin ≤0.4g/dl had positive GACT results. The result of GACT have showed wide variations in 30 calves with γ-globulin concentrations between ≥0.4 g/dl and <1 g/dl. Thirteen of the 30 had incomplete reactions, 6 were positive and remaining were negative. The result of this study was in accordance with the result of Tennant et al (8). All calves in EG I, EG II and EG III having negative GACT results had serum γ-globulin concentration ≤0.4 g/dl. The mean (±SD) serum γ-globulin concentration in control group of calves was found to be 1.390±0.234 g/dl, and all these calves gave positive GACT results. All calves in EG II had positive GACT results on the first day of the treatment. In this group of calves, the mean (±SD) γ-globulin concantration rised to 1.340±0.208 g/dl. The mean (±SD) serum γ-globulin concantration in calves of EG I increased to 0.860±0.122 g/dl on the first day of the treatment 3 of the 6 calves in this group had positive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (calves with γ-globulin content ≤0.4 g/dl).

In accordance with the result of the others (14, 15), the level of serum TP showed a good correlation ($p\leq0.01$) to the level γ-globulin in calves. Serum TP concentration less than 5.0 g/dl in calves it the result of FPCT. Preferred serum values are greater than 6.0

g/dl (1, 7). In this study, the mean (±SD) serum total protein concentration of control group was found to be 6.600±0.259 g/dl. The mean (±SD) serum total protein concentration of EG I, EG II and EG III were respectively found to be 4.017±0.111 g/dl, 4.313±123 g/dl and 4.183±0.083 g/dl After plasma transfusion serum total protein concentration in EG I and EG II significantly increased to 5.180±0.248 g/dl and 5.717±0.241 g/dl respectively. Paralel increments in γ-globulin concentrations were observed in both EG I and EG II. However, the result of GACT did not correlate well to serns. This could not be accurtive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (cate diagnostic index in teh determination otive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (cf FPCtive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (c.results showed that GACT has sensitivity in the diagnosis of severe FPCT (cis thetive and the remaining had negative GACT results. These results showed that GACT has sen

Protein electrophoresis is spesific laboratory technique to determine γ-globulin concentration by which FPCT is evaluated more accurately because false elevation of Ig measurements due to tive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (cdehydration not result (1, 4, 7). γ-glolevels below 1 g/dl indicate partial failure of cotion, while values less than 0.4 g/dl are associated with severe Ig deficiency. The values between >0.4 g/dl and <1 g/dl indicatetive and the remaining had negative GACT results. These results showed that GACT has sensitivity in the diagnosis of severe FPCT (c that calves havntal group results showed that GACT has sensitivity in the diagnosis of severe FPCT (cis thetive and the remaining had negative GACT results. These results showed that GACT has senof trations lower than 0.4 g/dl, while controations higher than 1 g/dl. GACT results showed wide variation in calves with γ-globulin concentration between ≥0.4 g/dl and <1 g/dl, while γ-globulin concentration showed real immun status of calves. Although determination of γ-globulin concentrations by electrophoresis takes 8-12 hours to be performed and requires special equipment, the result of this study showed that electrophoresis more accurate diagnostic test to determine FHunt et al (10) informed that adverse reactions to plasma transfusion eitrgic in nature or occur in response to volume overload might develop. In this study, howhiserse reactions were not observed during and after plasma transfusion.

An infusion rate of 5 ml/kg/hr has been recommesfusions (16), but administrations at this rate is very time consuming. An infusion rate of 1 liters/hr appeared safe for calves with sev

This result showed that restoration of Ig levels by plasma transfusion can be life savign in calves with seve

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