A Comparison of Serum Antibiotic Concentrations Achieved in Calves with Intratracheal Administration of Procaine Penicillin G, Ampicillin Trihydrate, Tylosin, Oxytetracycline Hydrochloride, Chloramphenicol, Chloramphenicol Sodium Succinate, Dihydrostreptomycin Sulfate and Neomycin Sulfate with Those Achieved with Intravenous, Intramuscular and Subcutaneous Administration.

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Summary

Procaine penicillin G (PEN), ampicillin trihydrate (AMP), tylosin (TYL), oxytetracycline (OTC), chloramphenicol (CHL), chloramphenicol sodium succinate (CHLSS), dihydrostreptomycin sulfate (DHS) and neomycin sulfate (NEO) were administered to calves by the intratracheal (IT) route of administration and the resulting serum antibiotic concentrations compared with those achieved with other routes, including intravenous (IV), intramuscular (IM) and subcutaneous (SC).

PEN, AMP, TYL, OTC and CHL appeared to be more rapidly absorbed from the lung than from IM or SC injection sites, resulting in more rapid and higher serum antibiotic concentration peaks, followed by more rapidly declining serum antibiotic concentrations. The latter phenomenon was thought to be a result of high rates of antibiotic excretion associated with high early serum concentration peaks. The lack of a drug reservoir at the site of administration was also thought to be a factor.

In contrast, CHLSS, DHS and NEO appeared to be less rapidly absorbed from the lung than from IM and SC injection sites, resulting in lower serum antibiotic concentration peaks and similarly (DHS, NEO) or less rapidly (CHLSS) declining serum antibiotic concentrations.

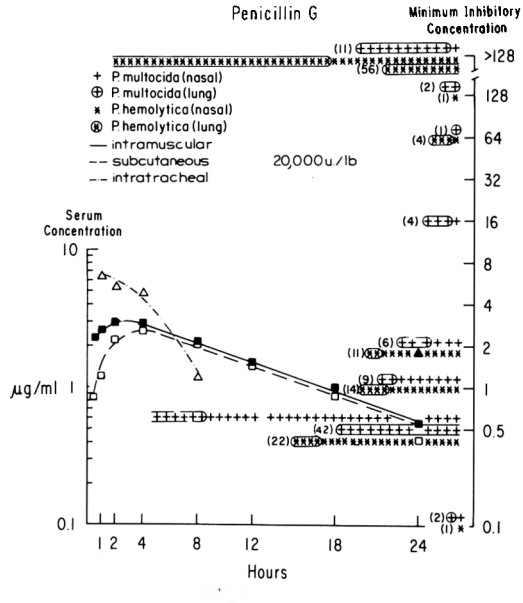

Figure 1. Serum penicillin G concentrations, after administration of procaine penicillin G, aqueous suspension, to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

Table 1. Serum Penicillin G Concentrations After Administration of Procaine Penicillin G, Aqueous Suspension, to Normal Calves.

Dosage (units/lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours 0.5	1	2	4	8	12	18	24
		M	2.3 (a) ±0.46	2.7 (b,c) ±0.7	3.0 ±0.67	2.9 ±0.57	2.1 ±0.35	1.5 ±0.15	1.0 ±0.41	0.65 ±0.22
	im	3								
		R	1.9-2.8	2.0-3.4	2.4-3.7	2.4-3.5	1.9-2.5	1.3-1.6	0.58-1.4	0.44-0.88
		M	0.84 (a) ±0.29	1.2 (b,d) ±0.45	2.4 (e) ±0.85	2.6 ±1.32	2.0 ±0.6	1.4 ±0.67	0.89 ±0.38	0.42 ±0.16
	sc	5								
20,000		R	0.56-1.3	0.72-1.7	1.6-3.8	1.6-4.9	1.7-1.9	0.84-2.5	0.46-1.3	0.28-0.66
		M	NS	6.7 (c,d) ±0.2	5.5 (e) ±1.8	4.9 ±4.3	1.3 ±1.4	SNM	SNM	SNM
	it	3								
		R	NS	6.4-6.8	3.6-7.2	0.82-9.4	0.11-2.8	0.0-1.4	0.0 0.38	0.0 0.24

M = mean ± standard deviation. R = range. NS = not sampled. SNM = some samples not measurable. im = intramuscular. sc = subcutaneous. it = intratracheal. Values having the same superscript are significantly different (e, P = < 0.025; b, P = < 0.01; a, P = < 0.005; c,d, P = < 0.001).

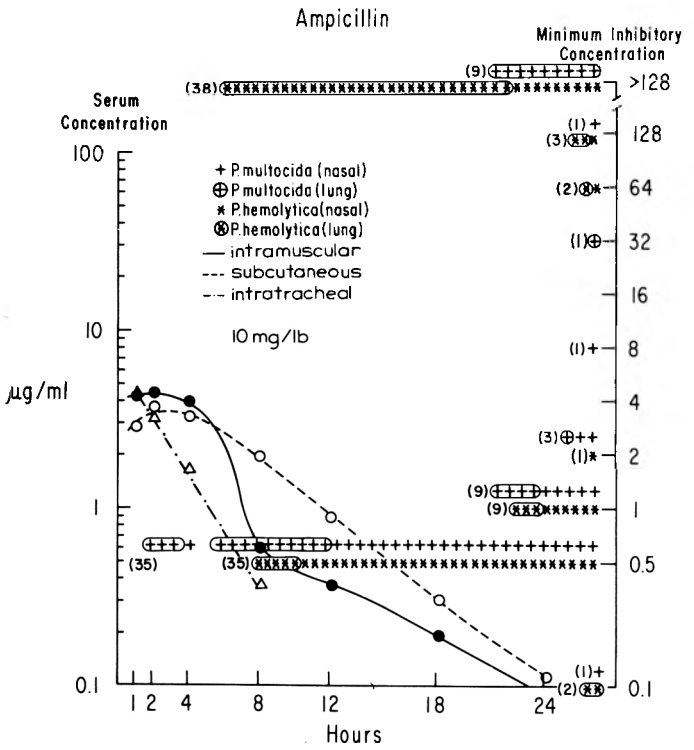

Figure 2. Serum ampicillin concentrations, after administration of Polyflex (R) to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

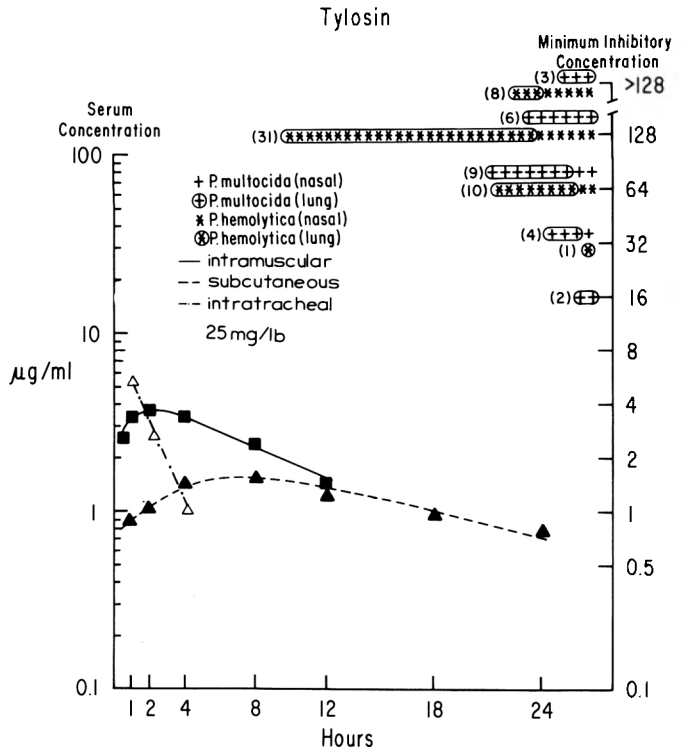

Figure 3. Serum tylosin concentrations, after administration of Tylan 200 (R) to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

Table 2. Serum Ampicillin Concentrations After Administration of Polyflex* to Normal Calves.

Dosage (mg./lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours: 1	2	4	8	12	18	24
		M	4.2(a) ±1.08	4.3 ±1.07	3.9 (b) ±0.76	0.59 (c) ±0.1	0.36 (e) ±0.07	0.19 ±0.05	0.09 ±0.05
	im	6							
		R	3.1-5.6	2.9-5.8	2.9-4.6	0.49-0.78	0.28-0.45	0.14-0.27	0.019-0.17
		M	2.8(a) ±0.78	3.6 ±1.39	3.2 ±0.92	1.9 (c,d) ±0.35	0.87 (e) ±0.36	0.3 ±0.21	0.11 ±0.06
10	sc	6							
		R	2.0-4.2	2.2-5.6	2.1-4.6	1.3-2.3	0.64-1.6	0.12-0.68	0.018-0.19
		M	4.7 ±3.1	3.4 ±2.4	1.7 (b) ±1.3	0.4 (d) ±0.3	SNM	SNM	NM
	it	3							
		R	1.4-7.6	0.9-5.6	0.3-2.8	0.04-0.7	0.0-0.2	0.0-0.04	NM

*Ampicillin trihydrate. Veterinary Products, Bristol Laboratories, Div. of Bristol Myers Co., Syracuse, NY 13201. im=intramuscular. sc=subcutaneous. it=intratracheal. M=mean±standard deviation. R=range. SNM=some samples not measurable. Values having the same superscript are significantly different (a, P=<00.5; b, P=<0.024; e, P=<0.01; c, d, P=<0.0001).

Table 3. Serum Tylosin Concentrations After Administration of Tylan 200* to Normal Calves

Dosage (mg./lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours: 0.5	1	2	4	8	12	18	24
		M	2.6 ±0.14	3.45 (a) ±0.64	3.7 (b) ±1.41	3.45 ±2.33	2.38 ±1.17	1.45 ±0.35	SNM	NM
	im	2								
		R	2.5-2.7	3.0-3.9	2.7-4.7	1.8-5.1	1.55-3.2	1.2-1.7	0.0-0.62	NM
		M	NS	0.86 (a,c) ±0.22	1.1 (b,d) ±0.19	1.4 ±0.39	1.5 ±0.28	1.2 ±0.18	0.94 ±0.10	0.76 ±0.13
25	sc	3								
		R	NS	0.66-1.1	0.84-1.2	0.94-1.5	1.25-1.8	1.05-1.4	0.86-1.05	0.62-0.88
		M	NS	5.5 (c) ±0.4	2.7 (d) ±0.4	1.0 ±0.0	NM	NM	NM	NM
	it	2								
		R	NS	5.2-5.8	2.4-3.0	1.0	NM	NM	NM	NM

*Tylosin. Elanco Products Co., a Div. of Eli Lilly and Co., Indianapolis, Ind. 46206. im = intramuscular. sc = subcutaneous. it = intratracheal. M = mean ± standard deviation. R = range. SNM = some samples not measurable. NM = not measurable. NS = no sample. Values having the same superscript are significantly different (a,d, P = < 0.01; b, P = < 0.05; c, P = < .001).

No potentially useful advantage for IT administration over IM, SC or IV administration could be identified relative to achieving or maintaining effective therapeutic serum antibiotic concentrations.

Methods and Materials

The results from IM, SC and IV administration of antibiotics and the minimum inhibitory concentrations for pasteurella bacteria have been previously reported[1], but are presented for comparison with the results from IT administration

The bacteria were isolated over a two-year period from resident cattle in a 13,000-head capacity feedlot located 25 miles north of Davis. *P. hemolytica* and *P. multocida* were recovered from the lungs of fatal pneumonia cases at necropsy and from nasal secretions of cattle with signs of respiratory disease prior to administration of antimicrobics. Most fatal cases of pneumonia had been treated with antimicrobics, but had failed to respond. Nasal secretions were obtained by inserting a sterile swab deep into the ventral nasal meatus. Bacteria were isolated, identified, recultured in brain-heart broth and stored at −60°C. Minimum inhibitory concentrations (MIC) were determined using an agar plate dilution technique[2]

Serum antibiotic concentrations were determined in normal Holstein steers and bulls following administration by IT, IM, SC or IV injection. Calves were purchased weighing 300 to 400 lbs. and utilized until they were 700 to 800 lbs. in weight, when they were replaced. With IM, SC or IV administration, the calculated dose of antibiotic was

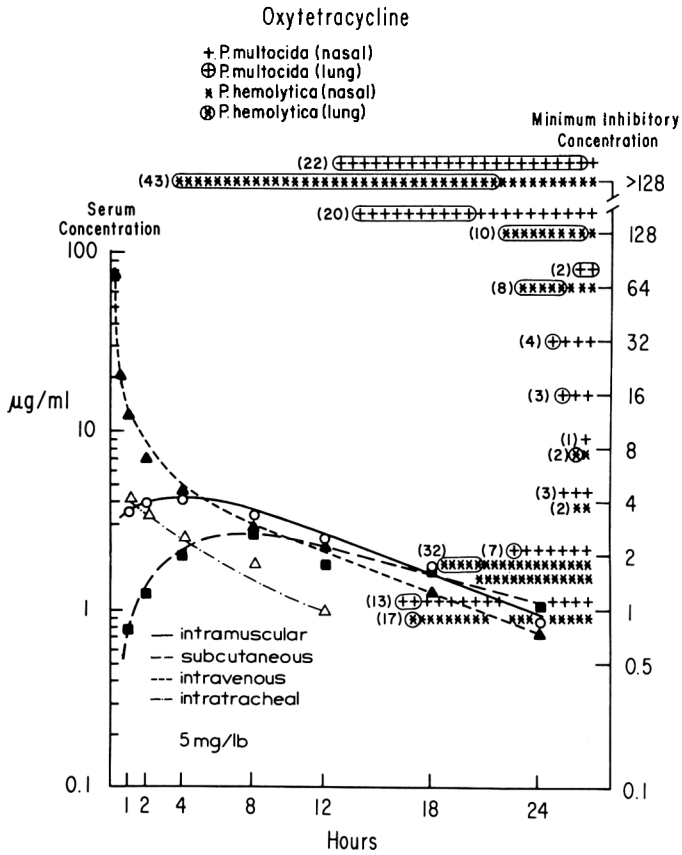

Figure 4. Serum oxytetracycline concentrations, after administration of Terramycin Injectable Solution (R) to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

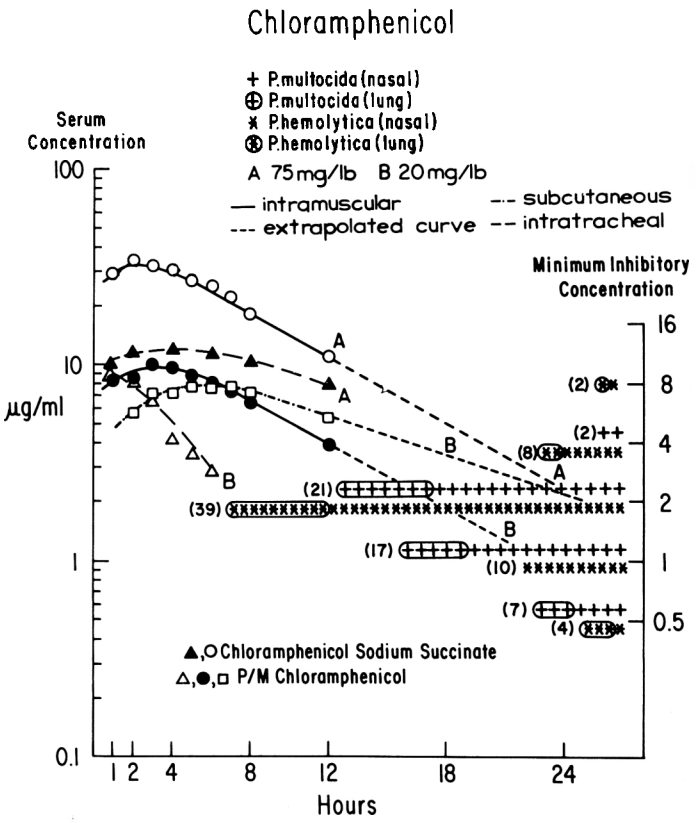

Figure 5. Serum chloramphenicol concentrations, after administration of Chloromycetin Sodium Succinate (R) and P/M Chloramphenicol, Oral Solution (R), to normal calves in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

Table 4. Serum Oxytetracycline Concentrations After Administration of Terramycin Injectable Solution* to Normal Calves

Dosage (mg/lb b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours 0.08	0.5	1	2	4	8	12	18	24
		M	NS	NS	3.4 (a,b) ±1.0	3.8 (f,g) ±0.7	4.0 (k) ±1.0	3.3 (m,n) ±0.7	2.4 (p) ±0.7	1.7 ±0.5	0.8 ±0.3
	im	6									
		R	NS	NS	2.5-5.0	2.7-4.9	3.0-5.2	2.7-4.6	2.0-3.8	1.2-2.6	0.6-1.3
		M	NS	NS	0.8 (a,c,d) ±0.4	1.2 (f,h,i) ±0.4	2.0 (k,l) ±0.7	2.5 (m) ±1.0	1.7 (q) ±0.4	1.6 ±0.3	1.0 ±0.2
	sc	6									
		R	NS	NS	0.5-1.3	0.5-1.7	1.0-2.8	1.6-4.2	1.4-2.4	1.2-2.0	0.8-1.4
		M	74.0 ±16.9	19.7 ±4.4	11.9 (b,c,e) ±2.4	6.8 (g,h,j) ±1.4	4.5 (l) ±0.8	2.8 (o) ±0.6	2.2 (r) ±0.7	SNS	0.7 ±0.5
	iv	5									
		R	58.0-94.0	14.5-26.0	9.0-15.0	5.9-9.0	3.7-5.6	1.7-3.2	1.3-3.0	0.8-1.5	0.3-1.4
		M	NS	NS	4.3 (d,e) ±1.7	3.5 (i,j) ±1.6	2.6 ±1.2	1.7 (n,o) ±0.9	1.0 (p,q,r) ±0.5	SNM	NM
	it	3									
		R	NS	NS	2.4-5.6	1.8-4.8	1.3-3.5	0.7-2.5	0.5-1.5	0.0-0.6	NM

*Oxytetracycline hydrochloride. Agricultural Div., Pfizer, Inc., New York, NY 10017. im=intramuscular. sc=subcutaneous. iv=intravenous. It=intratracheal. M=mean±standard deviation. R=range. NS=not sampled. SNS=some calves not sampled. NM=not measurable. SNM=some samples not measurable. Values having the same superscript are significantly different (m, o, q, r, P=<0.05; j, n, p, P=<0.025; e, P=<0.01; d, g, i, k, P=<0.005; a, b, c, f, h, l, P=*k*0.001).

injected into the right-dorsal cervical musculature, the right cervical subcutaneous tissues, or the right jugular vein. A maximum volume of 10 ml. was injected into any single IM or SC site. For IT administration, the calculated dose was dissolved [ampicillin trihydrate[a] (AMP); oxytetracycline hydrochloride[b] (OTC); chloramphenicol[c] (CHL); chloramphenicol sodium succinate[d] (CHLSS); dihydrostreptomycin sulfate (DHS); neomycin sulfate[e] (NEO)] or suspended [PROCAINE PENICILLIN G, suspension (PEN); tylosin[f] (TYL)] in a volume of sterile physiological saline solution equal to 1 ml. per lb. of body wt. This was then injected into the tracheal lumen by gravity flow through a 16 ga. needle inserted between tracheal rings in the mid-cervical region. Serial blood samples were obtained from the left jugular vein using disposable needles and evacuated glass tubes. Blood samples were usually obtained only at 1, 2, 4, 8, 12, 18 and 24 hours post-administration. Samples were allowed to clot at room temperature for approximately 1 hour, then centrifuged, and the serum removed and stored at −60°C until assay could be performed.

Two antibiotic assay methods were utilized. When high serum concentrations were anticipated, the large plate technique was utilized[3]. When low concentrations were anticipated, the penny cylinder technique was used[4]. Good correlation between the two methods was observed. All samples were analyzed in triplicate and the results averaged. Assay organisms were obtained from Difco Laboratories *(Bacillus subtulis* and *B. cereus)* and the American Culture Collection *(Sarcina lutea* and *Bordetella bronchisepticus). Statistical significance of the data was determined with student's t test.*

Results

Serum PEN concentrations reached maximum (peak) values more rapidly after IT administration (post-

[a]Polyflex (R). Veterinary Products, Bristol Laboratories, Div. of Bristol Myers Co., Syracuse, N.Y. 13021. [b]Terramycin Injectable Solution (R). Agricultural Div., Pfizer, Inc., New York, N.Y. 10017. [c]P/M Chloramphenicol, Oral Solution (R). Pitman-Moore, Inc., Washington Crossing, N.J. 08560. [d]Chloromycetin Sodium Succinate (R). Parke, Davis and Co., Detroit, Mich. 48232. [e]Biosol Liquid (R). Upjohn Veterinary Products, Kalamazoo, Mich. 49001. [f]Tylan-200 (R). Elanco Products Co., a Div. of Eli Lilly and Co., Indianapolis, Ind. 46206.

Table 5. Serum Chloramphenicol Concentrations After Administration of Chloromycetin Sodium Succinate* and P/M Chloramphenicol, Oral Solution**, to Normal Calves

Dosage (mg./lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at post administration hours 1	2	3	4	5	6	7	8	12	18	24
		M	8.3 ±5.8	8.5 ±2.6	10.0 (a) ±1.0	9.6 (b) ±1.33	8.8 (c) ±1.1	8.0 (e) ±0.4	7.2 ±0.68	6.4 ±1.1	3.8 (g) ±0.25	NM	NM
	im	3											
		R	5.0-15.0	6.7-11.5	9.0-11.0	8.8-11.1	8.0-10.1	7.6-8.4	6.4-7.7	5.4-7.6	3.5-4.0	NM	NM
		M	SNM	5.7 ±1.02	7.1 ±2.2	7.1 ±2.3	7.6 (d) ±1.2	7.6 (f) ±1.2	7.7 ±1.6	7.1 ±1.7	5.3 (g) ±0.64	SNM	NM
20**	sc	3											
		R	0.0-3.5	4.5-6.4	5.6-9.6	5.6-9.8	6.9-9.0	6.8-9.0	6.8-9.6	6.0-9.0	4.8-6.0	NM-3.2	NM
		M	8.9 ±1.1	7.3 ±0.7	5.8 (a) ±0.5	4.3 (b) ±0.4	3.7 (c,d) ±0.1	3.0 (e,f) ±0.6	NS	SNM	NM	NM	NM
	it	2											
		R	8.1-9.6	6.8-7.8	5.4-6.1	4.0-4.6	3.6-3.7	2.6-3.4	NS	0.0-2.2	0.0	0.0	0.0
		M	28.8 (h) ±2.8	34.0 (i) ±8.5	32.0 ±2.7	30.5 (j) ±3.7	27.0 ±3.5	25.1 (k) ±2.5	22.0 ±4.0	18.0 ±1.7	SNM	NM	NM
	im	4											
		R	25.2-31.5	26.0-45.0	28.0-34.0	26.0-35.0	24.0-32.0	23.0-27.5	17.5-26.5	16.0-20.0	NM-14.0	NM	NM
		M	10.0 (h) ±5.9	13.3 (i) ±7.4	NS	13.8 (j) ±7.3	NS	13.3 (k) ±6.1	NS	11.4 ±5.9	7.4 ±3.9	SNM	SNM
	it	3											
		R	4.3-16.0	4.8-18.5	NS	5.4-18.5	NS	6.5-18.0	NS	4.6-15.5	3.2-11.0	0.0-6.3	0.0-3.0

*Chloramphenicol sodium succinate. Parke, Davis and Co., Detroit, MI 48232. **Pitman-Moore, Inc., Washington Crossing, NJ 08560. im = intramuscular. sc = subcutaneous. it = intratracheal. M =mean ± standard deviation, R = range. NM = not measurable. SNM = some samples not measurable. NS = not sampled. Values having the same superscript are significantly different (a,b,d,f,g,k, P = <0.025; c,i,j, P = < 0.01; e,h, P = < 0.005).

administration hour 1 = PA1) than after IM administration (PA2) or SC administration (PA4) (Table 1 and Figure 1). The peak concentration obtained with IT administration was higher than the peaks obtained with IM or SC administration. The serum PEN concentration achieved with IT administration was significantly higher than with IM administration at PA1 (P= < 0.001) and SC administration at PA1 (P= <0.001) and PA2 (P= < 0.025). From PA8, serum PEN concentrations tended to be lower with IT than with IM or SC administration.

Serum AMP concentrations reached peak values sooner after IT administration (PA1) than after IM or SC administration (PA2) (Table 2 and Figure 2). The peak concentration obtained with IT administration was higher than with IM or SC administration. The serum AMP concentration obtained with IT administration was significantly lower than with IM administration at PA4 (P= < 0.025) and SC administration at PA8 (P = < 0.001).

Serum TYL concentrations reached peak values sooner after IT (PA1) than after IM (PA2) or SC (PA8) administration (Table 3 and Figure 3). The peak concentration obtained with IT administration was higher than with IM or SC administration. The serum TYL concentration obtained with IT administration was significantly greater than with SC administration at PA1 (P = < 0.001) and PA2 (P = < 0.01). From PA4, serum TYL concentrations were lower with IT than with IM or SC administration, and from PA8 were undetectable.

Table 6. Serum Dihydrostreptomycin Concentrations After Administration of Dihydrostreptomycin Sulfate to Normal Calves.

Dosage (mg./lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours 0.5	1	2	4	8	12	18	24
		M	40.0 ±11.3	64.0 ±28.3	68.0 ±21.2	44.0 (a) ±2.12	19.0 ±5.66	7.0 ±2.12	SNM	NM
	im	2								
		R	32.0-48.0	44.0-84.0	53.0-83.0	42.0-45.0	15.0-23.0	5.4-8.4	0.0-3.3	NM
		M	NM	74.0 ±21.2	63.3 ±16.6	29.0 (a) ±1.4	10.3 ±2.33	4.1 ±1.3	NM	NM
25	sc	2								
		R	NM	59.0-89.0	51.5-75.0	28.0-30.0	8.6-11.9	3.1-5.0	NM	NM
		M	NS	36.7 ±23.1	35.5 ±24.3	21.3 ±14.8	13.0 ±10.6	8.0 ±8.5	2.4 ±3.8	SNM
	it	3								
		R	NS	10.0-50.0	7.4-50.0	5.0-34.0	1.5-22.5	0.18-17.0	0.03-6.8	0.0-0.5

im =intramuscular. sc = subcutaneous. it = intratracheal. M = mean ± standard deviation. R = range. SNM = some samples not measurable. NM = not measurable. NS = not sampled. Values having the same superscript are significantly different (a, P = $<$0.025).

Table 7. Serum Neomycin Concentrations After Administration of Biosol Liquid* to Normal Calves.

Dosage (mg./lb. b.w.)	Route of administration	No. of Calves	Serum concentrations (ugm./ml.) at postadministration hours. 1	2	4	8	12	18	24
		M	106.0(a) ±12.5	104.0(b) ±3.46	52.7 ±6.64	20.3 ±4.39	10.1 ±0.64	4.0 ±0.72	2.5 ±0.61
	im	3							
		R	96.0-120.0	102.0-108.0	45.0-56.5	15.2-23.0	9.4-10.5	3.5-4.8	1.8-3.0
40									
		M	18.9 (a) ±21.7	38.7 (b) ±30.2	36.1 ±34.4	10.1 ±8.5	SNM	SNM	SNM
	it	3							
		R	5.8-44.0	4.1-60.0	1.2-70.0	0.3-15.0	0.0-6.8	0.0-5.8	0.0-2.4

*Neomycin sulfate. Upjohn Veterinary Products, Kalamazoo, Mich 49001. im=intramuscular. it=intratracheal. M=mean±standard deviation. R=range. SNM=some samples not measurable. Values having the same superscript are significantly different (b, P=$<$0.025; a, P=$<$0.005).

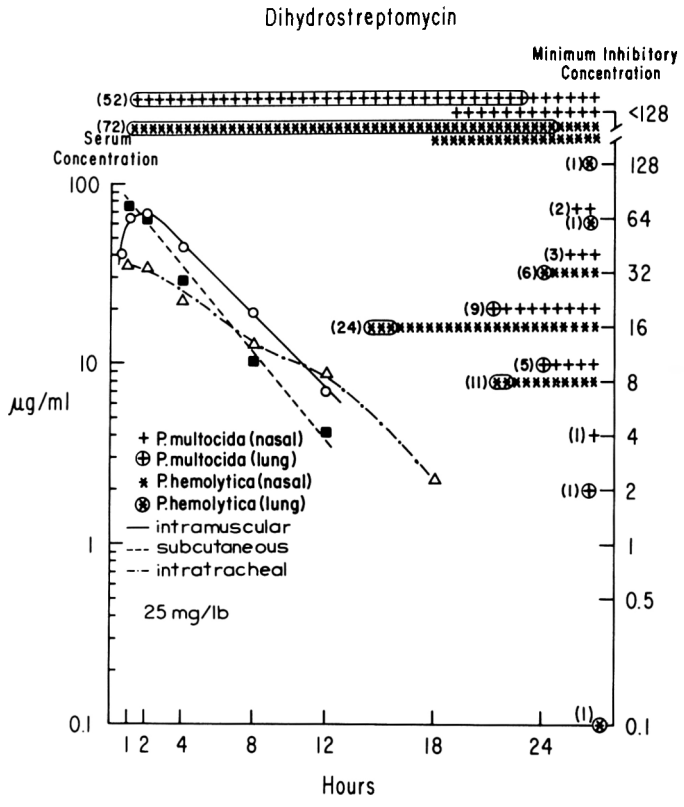

Figure 6. Serum dihydrostreptomycin concentrations, after administration of dihydrostreptomycin sulfate to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

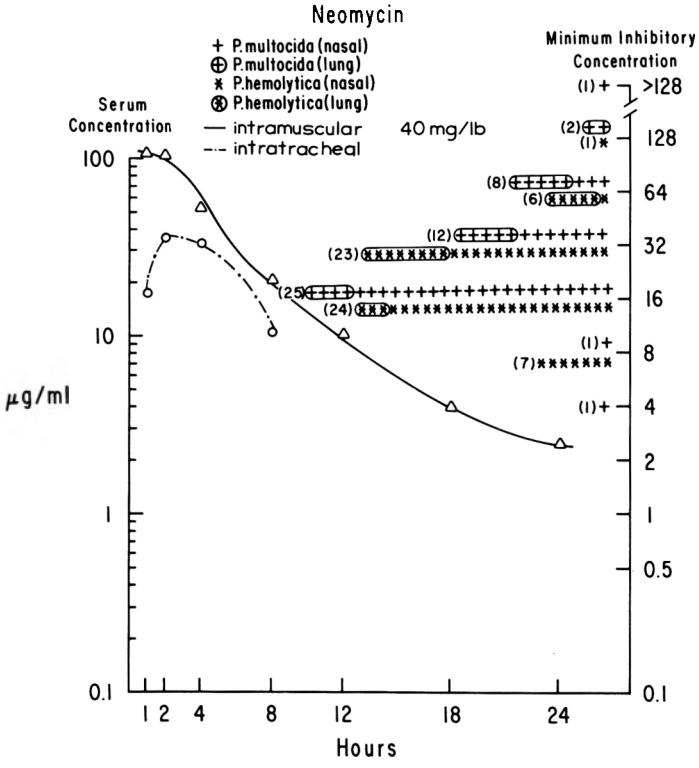

Figure 7. Serum neomycin concentrations, after administration of Biosol Liquid (R) to normal calves, in relation to minimum inhibitory concentrations for *Pasteurella hemolytica* and *P. multocida* isolates.

Serum OTC concentrations reached peak values more rapidly after IT administration (PA1) than after IM (PA4) or SC (PA8) administration (Table 4 and Figure 4). The peak concentration obtained with IT administration was higher than with IM or SC administration. The serum OTC concentration obtained with IT administration was significantly greater than with SC administration at PA1 and PA2 ($P = < 0.005$), but was significantly less than with IM administration at PA8 ($P = < 0.01$) and PA12 ($P = < 0.005$) and SC administration at PA12 ($P = < 0.05$). Serum OTC concentrations obtained with IT administration were significantly less than those obtained with IV administration at PA1 ($P = < 0.01$), PA2 ($P = < 0.01$), PA8 and PA12 ($P = < 0.05$).

Serum CHL concentrations reached peak values sooner after IT administration (PA1) than after IM (PA3) or SC (PA7) administration (Table 5 and Figure 5). The peak concentration obtained with IT administration was higher than with SC administration but lower than obtained with IM administration. Serum CHL concentrations obtained with IT administration were significantly less than with IM administration at PA3 and PA4 ($P = < 0.025$), PA5 ($P = < 0.01$) and PA6 ($P = < 0.005$) and SC administration at PA5 and PA6 ($P = < 0.025$).

Serum CHL concentrations reached peak values less rapidly after administration of CHLSS by the IT route (PA4) than after IM administration (PA2) (Table 5 and Figure 5). The peak concentration obtained with IT administration was less than that obtained with IM administration. Serum CHL concentrations obtained with IT administration of CHLSS were significantly less than those obtained with IM administration at PA1 ($P = < 0.005$), PA2 and PA4 ($P = < 0.01$), and PA6 ($P = < 0.025$).

Serum DHS concentrations reached peak values sooner after IT and SC administration (PA1) than after IM administration (PA2) (Table 6 and Figure 6). The peak concentration obtained with IT administration was less than with IM or SC administration.

Serum NEO concentrations reached peak values less rapidly after IT administration (PA2) than after IM administration (PA1). Serum NEO concentrations obtained with IT administration were significantly less than with IM administration at PA1 ($P = < 0.005$) and PA2 ($P = < 0.025$).

Discussion

Peak serum antibiotic concentrations were achieved more rapidly, reached higher maximum values and declined more rapidly following administration of PEN, AMP, TYL and

OTC by the IT route than when the IM or SC routes were utilized (Tables 1-4 and Figures 1-4). Very similar results were obtained with CHL, except that the peak serum concentration obtained with IT administration was slightly less than with IM administration (Table 5 and Figure 5). These data suggest that PEN, AMP, TYL, OTC and CHL are much more readily absorbed from the lung than from IM or SC injection sites. The rapid disappearance of these antibiotics from serum after IT administration is probably caused by high rates of excretion associated with the rapid achievement of high peak serum concentrations, as well as the lack of drug reservior at the site of administration.

The results obtained with CHLSS, DHS and NEO contrasted with those just described. Peak serum concentrations were, in general, achieved less rapidly and were lower with IT administration than with IM or SC administration (Tables 5-7 and Figures 5-7). These data suggest that CHLSS, DHS and NEO are less readily absorbed from the lung than from IM or SC injection sites. DHS and NEO belong to the aminoglycoside group of antibiotics, which are distinguished by their inability to diffuse through certain membranes such as cell membranes and the gastrointestinal mucosa. This characteristic may be responsible for the reduced pulmonary absorption rates suggested by the data.

CHLSS must be converted to CHL before it can be detected by the assay system which was utilized in this study. The data obtained with CHLSS could be explained either by reduced absorption rates from the lung or by reduced rates of conversion from CHLSS to CHL associated with the IT route of administration.

References

1. Hjerpe, C. A., and Routen, T. A.: Practical and Theoretical Considerations Concerning Treatment of Bacterial Pneumonia in Feedlot Cattle, With Special Reference to Antimicrobic Therapy. Proc. 9th Ann. Conv. AABP, San Francisco, 1976. p. 97. - 2. Ericsson, H. M., and Sherris, J. C.: Antibiotic Sensitivity Testing, Report of an International Collaborative Study. Acta. Path. Microbiol. Scand. Sect. B (1971) Supp. 217. - 3. Bennett, J. V., Brodie, J., Benner, E. J., and Kirby, W.: Simplified Accurate Method of Antibiotic Assay of Clinical Specimens, Appl. Microbiol. 14 (1966) 170. - 4. Grove, D. C., and Randall, W. A.: Assay Methods of Antibiotics, A Laboratory Manual. Med. Encyclopedia, Inc., New York, 1955.