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An evaluation of iron-dextran supplementation in piglets administered by injection on the first, third or fourth day after birth

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SUMMARY

The aims of the study were to evaluate the effect of iron-dextran injection given on the first, third or fourth day after birth on haematology in piglets. An advanced automated blood analyser; *Technicon H*1®*, which performs a complete blood cell count and leukocyte differential counts was used to analyse the blood. Six litters of Norwegian Landrace x Yorkshire piglets were included in the study. The day after birth (day 1), half of the piglets in each litter (split litters) were injected subcutaneously with 180 mg iron as iron-dextran (1·5 ml Idofer®). The untreated piglets from two of the litters were injected with the same amount of iron-dextran on day 3, and those from the remaining four litters on day 4. The piglets were weighed and blood samples collected on days 1, 3 or 4, 7, 14 and 21. Erythropoiesis, but not leukocyte count, responded to injection on day 1 compared with injection on the third or fourth day. The difference between groups in haematological parameters was greatest on day 7. The two groups of piglets treated on day 1 had a haemoglobin concentration (Hb) ±SD of 92 g litre^{-1} (±9) and 94 g litre^{-1} (±9), and the piglets treated on day 3 had a Hb of 81 g litre^{-1} (±7) and the one treated on day 4 had a Hb of 78 g litre^{-1} (±7) on day 7. On days 14 and 21 there were no differences between groups. This study indicates that some piglets were anaemic and responded to subcutanous iron injection on day 1.

DOMESTIC piglets are born with very low iron reserves and receive too little iron from sows' milk (Venn et al 1947). Modern pig husbandry practices prevent contact with soil, the main source of iron for piglets in the wild. Pigs have been bred for high weight gain for many years, and this has also affected iron requirements in piglets. The Norwegian Landrace breed is a very fast growing breed with large litter size and high birth weight. The average weight on the day after birth in pure Norwegian Landrace and cross-bred Yorkshire piglets has been found to be between 1·5 and 1·9 kg in different studies. The average haemoglobin concentration (Hb) the day after birth has been found to be between 78 and 92 g litre^{-1} and average numbr of erythrocytes (RBC) between 3·7 and 4·5 x 10^{9} litre^{-1} in these herds (Egeli and Framstad 1998a,b, Egeli et al 1998c). This indicates that the Norwegian Landrace and crossbred Yorkshire piglets are born anaemic. If this anaemia is caused by iron deficiency, the piglets should be treated soon after birth. On the other hand possible detrimental effects of high doses of iron to newborn piglets may not make it suitable to treat early in life especially if the piglets do not need, or are not able to utilise the iron administered (Bollwahn et al 1972, Holmgren 1996, Egeli and Framstad 1998a).

The aims of the study were to evaluate the effect on haematology of iron-dextran injection on the first, third or fourth day after birth in piglets with high birth weight and weight gain. An automatic blood analyser, *Technicon H*1®* (Bayer Instruments Corp., Tarrytown, NY, USA) which perform complete blood cell counts and leukocyte differential counts, and is able to detect early changes in red cell subpopulations, was used in this study to evaluate haematological changes in the early postnatal period in piglets treated with iron on three different days.

MATERIALS AND METHODS

The study took place in a commercial herd which as kept under a good standard of health care and husbandry. All the investigations and treatments were performed by a veterinarian. The litters were kept with the sows in farrowing crates on a concrete floor covered with sawdust. Two-thirds of the floor was solid but the area behind the sows was perforated. The floor was scraped clean every day. The sows were fed commercial pelleted food and sour milk, but the piglets received only sow's milk and no creep feed. The pigs were first to fifth litters, litter size to weaning ranged from nine to 13 piglets. The sows were free from sarcoptic manage, routinely treated for gastrointestinal helminths, and vaccinated against porcine parvovirus, swine erysipelas and *Escherichia coli* infections. The piglets were treated prophylactically with 20 mg kg^{-1} toltrazuril (Baycox®: Kiel, Germany) against coccidiosis on the fifth day after birth. The male piglets were not castrated during the study. The study was ethically discussed and found to follow the laws concerning research animals.

Trial 1

Forty-eight Norwegian Landrace x Yorkshire piglets from four litters were divided randomly into two groups (split litters). All piglets were individually tattooed with a number in the ear. The piglets in one group received 180 mg iron as

TABLE 1: Haematology during the preweaning period in Trial 1 (Mean ± SD). The piglets in T1D1 were injected with 180 mg iron as iron-dextran on day 1 and the piglets in T1D4 on day 4

	Day 1		Day 4		Day 7		Day 14		Day 21	
	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4
Hb	90	84	80	70[b]	94	78[c]	103	103	103	103
g litre^{-1}	(14)	(14)	(10)	(9)	(9)	(7)	(8)	(7)	(9)	(12)
RBC	4·48	4·13	3·83	3·59	4·29	3·75[b]	4·79	4·77	5·52	5·49
(x 1012 litre^{-1})	(0·72)	(0·74)	(0·57)	(0·56)	(0·62)	(0·51)	(0·60)	(0·56)	(0·50)	(0·64)
MCV	64·5	65·0	69·3	64·0[c]	73·7	69·6[a]	67·9	68·5	61·4	60·7
(fl)	(3·5)	(3·3)	(4·1)	(3·3)	(5·5)	(4·6)	(5·5)	(5·3)	(4·3)	(5·4)
MCH	20·0	20·3	21·0	19·8b	22·0	20·9[a]	21·5	21·7	18·7	18·9
(pg)	(1·3)	(1·0)	(1·2)	(1·6)	(1·4)	(1·3)	(1·5)	(1·6)	(1·6)	(2·0)
MCHC	311	313	303	308	299	301	317	317	305	310
(g litre–1)	(10)	(8)	(6)	(15)	(9)	(8)	(10)	(9)	(8)	(9)
RDW (per cent)	16·8	16·9	24·3	18·7c	22·2	27·3c	18·1	20·2c	18·2	20·1
HDW (g litre–1)	31·7	32·5	30·7	33·9[a]	24·8	29·5[c]	22·9	24·6[b]	23·9	25·0

SD in parenthesis. a = P<0·05, b = P<0·01, c = P<0·001 between groups

colloidal ferri-dextran (Idofer®; St. Galen, Switzerland) by subcutaneous injection in the inguinal area 19-26 hours after birth (day 1). This group was designated T1D1 (trial 1, treated day 1). The piglets in the other group received identical iron treatment on the fourth day after birth, this group being designated T1D4 (trial 1, treated day 4). All the piglets were weighed, and 1 ml blood collected using ethylenediaminetetra-acetic acid (EDTA) as an anticoagulant, using a method described previously (Framstad et al 1988), before treatment in the morning on day 1 and on days 4, 7, 14 and 21. One sow suffered from mastitis-metritis-agalactia (MMA) and three of her piglets were raised by other sows.

Trial 2

Twenty piglets (two litters) were divided in two groups (split litters). One group of piglets was given 180 mg iron as colloidal ferri-dextran (Idofer®) by subcutaneous injection 12–24 hours after birth (day 1), the group being designated T2D1 (trial 2, treated day 1). The piglets in the other group were given identical iron treatment on the third day after birth, this group being designated T2D3 (trial 2, treated day 3). The piglets were weighed and 1 ml blood was collected as in trial 1 on days 1, 3, 7 and 14.

An automated blood analyser; the *Technicon H*1®* (H*1) was used in this study. H*1 utilises the principles of automated cytochemistry and laser light scatter in a flow cytometer to perform cell counts and leukocyte differential counts (Simson et al 1988). Erythrograms of the distribution of erythrocyte size and haemoglobin concentration were also presented visually by the H*1 for each piglet. The erythrocyte count (RBC), haemoglobin concentration (Hb), mean cell volume (MCV), erythrocyte distribution width (i.e., coefficient of variation of the RBC volume histogram) (RDW) and haemoglobin distribution width (i.e. standard deviation of the haemoglobin concentration histogram) (HDW), as well as the number of leukocytes (WBC), neutrophilic granulocytes (NEUT), lymphocytes (LYMP), monocytes (MONO), eosinophilic granulocytes (EOS), basophilic granulocytes (BASO) and large unstained cells (LUC), were measured by the H*1. The mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were estimated by the H*1 from RBC and Hb in MCH and from RBC, Hb and MCV in MCHC. All samples taken on other days were stored for practical reasons in a refrigerator for 24 hours before analysis.

Comparison of two means was performed using the *t*-test (Altman 1993). The development of haematological parameters within groups was examined using a paired *t*-test. Relationships between the changes in MCV from day 1 to day 4 and Hb on day 1, and also between changes in MCV from day 4 to day 7 and Hb on day 4, were plotted and determined in trial 1 using linear regression (Altman 1993).

RESULTS

Tables 1 and 2 show the development and differences between groups in haematological parameters in the two trials in the pre-weaning period. Hb and RBC counts decreased in both groups from day 1 to day 3 or 4 (P<0·001), and increased to the day 1 level in T1D1 and T2D1 on day 7. The piglets injected on day 3 or 4 had a lesser increase to day 7. MCV, MCH and RDW developed differently in the two groups from day 1 to day 3 or 4. As the new immature red cells are larger, there will be an increase in MCV and RDW when the production of new cells are high. With high haemoglobin production, MCH will also increase. In both trials the iron-treated piglets showed an increase in MCV and MCH and a higher increase in RDW than the untreated piglets from day 1 to day 3 or 4 (P<0·001). T2D3 and T1D4 piglets had an increase in MCV, MCH and RDW from day 3 or 4 to day 7 (P<0·001). HDW also showed a more rapid decrease in the piglets treated with iron on day 1 than the other groups. MCHC decreased from day 1 to day 7 in all groups (P<0·001). T1D1 piglets had higher Hb, MCH (P<0·01), MCV and RDW (P<0·001) than T1D4 piglets on day 4 and higher Hb (P<0·001), RBC (P<0·01), MCH and MCV (P<0·05) on day 7. T2D1 piglets had higher MCV, MCH and RDW than T2D3 piglets on day 3 (P<0·05), and higher Hb and RBC on day 7 (P<0·05). RDW was in T1D1 piglets lower than in T1D4 piglets on day 7 and day 14 (P<0·001), and HDW was lower on days 4, 7 (P<0·001) and 14 (P≤0·01). T2D1 piglets had lower RDW than T2D3 piglets on day 7 (P<0·01), and lower HDW on day 3 (P<0·01) and day 7 (P<0·05). In T1 Hb, RDW and HDW were of the same order of magnitude on day 14 and day 21. MCV, MCH and MCHC decreased from day 14 to

TABLE 2: Haematology during the preweaning period in Trial 2 (Mean ± SD). The piglets in T2D1 were injected with 180 mg iron as iron-dextran on Day 1 and the piglets in T2D3 on day 3

	Day 1		Day 3		Day 7		Day 14	
	T2D1	T2D3	T2D1	T2D3	T2D1	T2D3	T2D1	T2D3
Hb	93	88	82	72	92	81[a]	109	103
(g litre^{-1})	(24)	(16)	(16)	(11)	(9)	(7)	(13)	(8)
RBC	4·21	4·04	3·73	3·39	4·07	3·62[a]	5·02	4·74
(x 1012 litre^{-1})	(0·97)	(0·70)	(0·74)	(0·48)	(0·45)	(0·24)	(0·54)	(0·29)
MCV	72·0	71·1	74·1	69·9[a]	79·0	79·2	71·2	72·3
(fl)	(3·7)	(1·9)	4·0)	(1·5)	(7·3)	(1·9)	(2·0)	(3·1)
MCH	21·9	21·9	22·1	21·1[a]	22·7	22·4	21·7	21·7
(pg)	(1·0)	(0·5)	(1·0)	(0·7)	(1·7)	(0·7)	(0·8)	(0·8)
MCHC	305	308	298	301	288	283	305	301
(g litre^{-1})	(7)	(8)	(9)	(6)	(9)	(6)	(10)	(9)
RDW (per cent)	17·7	17·0	22·3	18·2[a]	23·7	28·6[b]	19·1	20·8
HDW (g litre^{-1})	31·2	32·0	27·7	30·9[b]	27·0	29·5[a]	22·7	23·6

SD in parenthesis, a = P<0·05, b = P<0·01, c = P<0·001 between groups

TABLE 3: WBC and differential counts in absolute numbers during the preweaning period in Trial 1 (Mean ± SD). The piglets in T1D1 were injected with 180 mg iron as iron-dextran on day 1 and the piglets in T1D4 on day 4

WBC	Day 1		Day 4		Day 7		Day 14		Day 21	
(x 10^9 litre^{-1})	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4	T1D1	T1D4
WBC	9·3	7·6[a]	11·1	9·3	11·2	12·1	8·1	7·0	15·7	15·4
	(2·4)	(1·7)	(3·8)	(2·8)	(2·6)	(3·3)	(4·1)	(2·0)	(4·2)	(2·9)
NEUT	6·8	5·1[b]	6·6	4·8[a]	5·9	6·2	3·0	2·3	3·9	4·0
	(2·1)	(1·5)	(3·0)	(2·4)	(1·7)	(2·9)	(1·7)	(0·9)	(1·2)	(1·7)
LYMP	2·0	1·9	3·5	3·7	4·5	5·1	4·3	4·2	10·7	10·2
	(0·4)	(0·6)	(1·3)	(1·2)	(1·2)	(1·4)	(2·7)	(1·3)	(3·2)	(1·8)
MONO	0·21	0·17	0·35	0·32	0·28	0·33	0·19	0·15	0·42	0·40
	(0·08)	(0·06)	(0·15)	(0·17)	(0·11)	(0·12)	(0·10)	(0·06)	(0·13)	(0·10)
EOS	0·12	0·12	0·23	0·17	0·19	0·16	0·08	0·14	0·14	0·12
	(0·06)	(0·06)	(0·17)	(0·11)	(0·13)	(0·11)	(0·05)	(0·15)	(0·11)	(0·11)
BASO	0·01	0·01	0·03	0·03	0·04	0·04	0·05	0·04	0·09	0·08
	(0·01)	(0·01)	(0·02)	(0·02)	(0·02)	(0·03)	(0·09)	(0·05)	(0·04)	(0·04)
LUC	0·19	0·18	0·27	0·25	0·31	0·31	0·18	0·15	0·56	0·52
	(0·09)	(0·13)	(0·12)	(0·11)	(0·17)	(0·15)	(0·12)	(0·07)	(0·18)	(0·15)

SD in parenthesis. a = P<0·05, b = P<0·01, c = P<0·001 between groups

Clinically, the piglets in T1D4 were observed to be paler than the piglets in T1D1 on day 4.

The development in total white cell counts (WBC) and the results from the differential counts in Trail 1 are shown in Table 3. WBC increased from day 1 to day 7 (P<0·05 in T1D1, and P<0·001 in T1D4). Values in both groups decreased from day 7 to day 14 (P<0·01) and increased from day 14 to day 21 (P<0·001). There was a difference between groups in WBC (P<0·05) and NEUT (P<0·01) on day 1 with the highest values in T1D1. The difference in NEUT was still present on day 4 (P<0·05). Changes in WBC in trial 2 followed the same main pattern as in trial 1. Values were of the same order of magnitude, and there were no differences between groups.

Fig 1 shows the plots and linear regression of the relationship between Hb on day 1 and the changes in MCV from day 1 to day 4 in T1D1 (Fig 1a) and in T1D4 (Fig 1b). It also shows the relationship between Hb on day 4 and the changes in MCV from day 4 to day 7 in T1D1 (Fig 1c) and T1D4 (Fig 1d). While MCV increase with production of new immature cells, Fig 1(a and d) shows that the piglets with the lowest initial Hb produced more new cells than the piglets with highest initial Hb after they had received iron on day 1 (Fig 1a) or day 4 (Fig 1d). Fig 1(c) show that the piglets treated piglets with highest Hb on day 4. Iron deficiency lead to a production of microcytic cells. Fig 1(b) shows that the untreated piglets with lowest initial Hb produced more microcytic cells from day 1 to day 4 than the untreated piglets with highest initial Hb levels.

Average bodyweight in T1D1 and in T1D4 were, respectively, 1·79 and 1·77 kg on day 1, 3·05 and 2·98 kg on day 7, 5·23 and 5·16 kg on day 14, and 7·15 and 6·95 kg on day 21. The corresponding figures for T2D1 and T2D3 were, respectively, 2·0 and 1·87 kg on day 1, 3·43 and 3·25 kg on day 7, and 5·80 and 6·21 kg on day 14.

Seven piglets (four in T1D1 and three in T1D4) were treated for arthritis or infected wounds, and were excluded from the study. One blood sample taken on day 7 was excluded because of coagulation, as were two differential leukocyte counts on day 14 because of analytical problems.

Three piglets in T2D1 and one piglet in T2D3 were treated for arthritis and two piglets in T2D3 died, and all six were excluded from the study. One piglet in T2D3 was ill on day 14, and results for this piglet on this day were excluded.

DISCUSSION

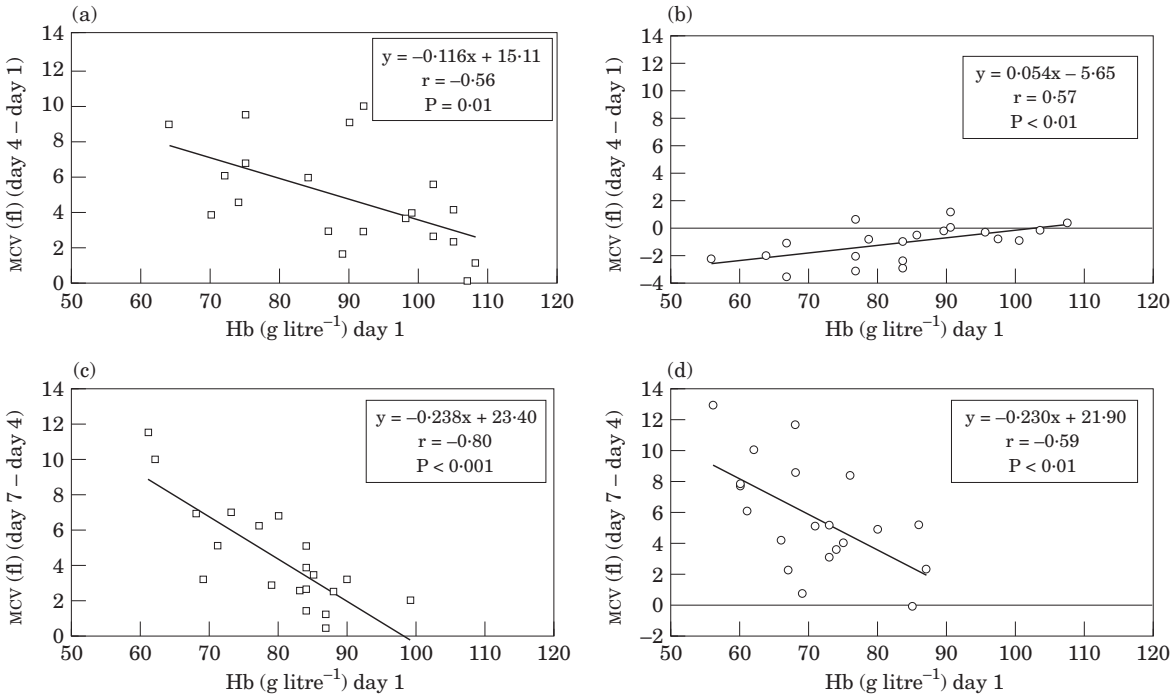

FIG 1: (a-d): Changes in MCV between the first (day 1) and the fourth day after birth (day 4) plotted against Hb level on day 1 in Group T1D1 (Fig 1a) and Group T1D4 (Fig 1b), and also changes in MCV between day 4 and day 7 plotted against Hb levels on day 4 in group T1D1 (Fig 1c) and Group T1D4 (Fig 1d). The piglets in T1D1 were injected with 180 mg iron as iron-dextran on day 1 and the piglets in T1D4 on day 4

evaluated in one- and 14-day-old piglets (Egeli et al 1998d). In that study the differential counts determined automatically were also compared with microscopic manual differential counts. In a group of 20 piglets the average values without and after one and two days of storage were very consistent (Egeli et al 1998d). There was also a high correlation between the automatic and manual differential counts for netrophils and lymphocytes in one- and 14-day-old piglets (r=0·85–0·93), and the average values between the two methods in all white cell types were almost the same. The H*1 counts thousands of cells compared with only 100-200 in manual microscopic counts and is thereby more reliable (Davies and Fisher 1991). The H*1 report provided a lot of information on each piglet and was quite appropriate to evaluate erythropoiesis, anaemia, and changes in leukocyte number and differential counts in piglets.

Many of the piglets in this study had low Hb on day 1 and must be considered to have been anaemic at birth (Fig 1a and b). The low Hb on day 1 could have been due to an iron deficiency anaemia. In adults, iron deficiency anaemia is easily diagnosed as a microcytic hypochromic anaemia (Jain 1986). In newborn piglets, differences between piglets in plasma expansion and hydration could affect Hb and RBC on day 1 (Egeli and Framstad 1998a). MCV, MCH, MCHC, RDW and HDW at birth are also difficult to evaluate because of immaturity of the cells. Both Hb and RBC can be expected to decrease from birth to day 4 due to plasma expansion and the rapid growth of the piglets, irrespective of iron treatment (Bollwahn et al 1972, Furugouri 1975, Egeli and Framstad 1998a). Such an anaemia is considered to be physiological. the most suitable, because it will increase with the production of more macrocytic cells and decrease with the presence of more microcytic cells, while RDW will increase with increasing numbers of both cell types. From Table 1, it can be seen that MCV values were nearly the same on day 1 and day 4 in untreated piglets. If the piglets with lowest Hb on day 1 had an iron deficiency anaemia, MCV would be expected to decrease in these untreated piglets on day 4 because of production of microcytic cells. This was confirmed to be the case, as seen in Fig 1b, by the significant positive correlation between Hb level on day 1 and the changes in MCV from day 1 to day 4, showing, that untreated piglets with low Hb on day 1 produced microcytic erythrocytes.

A delay in the utilisation of iron in injected newborn piglets may mean that there is no advantage injecting iron-dextran very early after birth, since Vrigazov and Dilov (1976) could not detect labelled iron from iron-dextran in the erythrocytes of piglets until 24 hours after injection, and Braude et al (1962) found that orally-administered inorganic iron was available for haemoglobin synthesis more rapidly than iron from injected iron-dextran. The explanation for this could be that iron-dextran needs to undergo 'reticulo-endothelial digestion' before the iron is available for incorporation into transferrin (Morgan and Finch 1966, Kornfeld et al 1969). Furugouri (1975) found that transport protein levels and iron-binding-capacity were very low in newborn piglets even when erythropoietic activity seemed to be high. Bollwahn et al (1972) found no difference between groups in Hb, RBC and packed cell volume on day 7 when piglets were injected on day 3 or immediately after birth. This was

present study, in which piglets treated on day 1 were still ahead on day 7 compared with the piglets treated on day 3 or day 4 (Tables 1 and 2). In trial 1, the observed differences between groups with regard to Hb, MCV, MCH, RDW and HDW on day 4, showed that the production of haemoglobin and erythrocytes were both higher in the group injected with iron-dextran on day 1 than in the untreated group T1D4. In trial 2 on day 3, the piglets that had been injected with iron-dextran two days earlier had higher MCV, MCH and RDW, but lower HDW than the untreated piglets T2D3. Some of these piglets were only two-and-a-half-days old. The present study indicates that piglets are able to synthesise haemoglobin from day 1, and respond quickly to iron-dextran injections. An explanation could be that the piglets in the present trial were heavier than those in most of the previously reported studies dealing with erythropoiesis in newborn piglets. Moreover, the piglets in Bollwahn's study was delivered by caesarean section, which might have interfered with maturity development and affected haematological parameters in the piglets. Thorén-Tolling (1975) found that iron stores in the liver were proportional to birth weight. Large litter size coupled with high birth weight of the piglets, increases the demands for iron transfer from the sow to the foetuses. The higher erythropoietic activity found on day 3 in the present study in a two-and-half-day old piglet injected with iron-dextran two days earlier, than in an untreated piglet, indicate that the demand for additional iron supply and already arisen. This might also explain the rapid reaction after iron supplementation.

From Tables 1 and 2, it can be seen that MCV increased from day 1 to day 7 and RDW from day 1 to day 4 in the piglets injected with iron-dextran on day 1. There was a significant negative correlation between Hb on day 1 and the increase in MCV from day 1 to day 4, in piglets given iron treatment on day 1 (Fig 1a). These findings strongly indicate a higher erythropoietic activity in the iron-treated piglets with the lowest Hb on day 1. The piglets with highest Hb did not respond as well to iron treatment. This also indicates that iron deficiency anaemia already existed in some piglets on day 1. Looking at Fig 1(a) and (d) the main changes in MCV seen in T1D4 between day 4 and 7 were the same as those seen between day 1 and 4 in T1D1. In orally iron-treated piglets, absorption of iron is regulated in relation to body iron stores and erythropoietic activity (Bothwell et al 1958). The injection of iron disturbs this regulation mechanism, and iron is available in excess. The results presented here indicate that intestinal absorption of iron is not the only important factor regulating haemoglobin production in newborn piglets. In older piglets, oxygen tension and Hb regulate erythropoietin production (Sjaastad et al 1992). Iron has been found not only to be a building block in haemoglobin production, but also a stimulus for erythropoietin synthesis in anaemic piglets (Sjaastad et al 1996). In iron-treated newborn piglets, erythropoietin was found to increase during the first day of life and then decrease over the next three days (Sjaastad et al 1992). In the present study, the reason why, the piglets with the lowest Hb on day 1, which also had access to iron (i.e. received iron treatment), showed the highest erythropoetic activity, might be that erythropoietin production was stimulated more markedly in these piglets.

piglets before birth. While HDW decreased from day 1 in the piglets injected with iron-dextran at that time, it first decreased from day 3 or day 4 in the piglets injected on those respective days. HDW seemed to be a more sensitive parameter than MCHC in detecting erythropoietic activity in the first week after birth. Although MCHC decreased from day 1 to day 7, there was no difference between groups. Both MCV and RDW have previously been found to be sensitive indicators of active erythropoiesis in piglets (Holter et al 1991, Egeli and Framstad 1998a).

On days 14 and 21, there were no differences between groups in RBC, Hb, MCV, MCH and MCHC. In trial 1, average Hb, RDW, and HDW within groups were the same on days 14 and 21, but MCV, MCH and MCHC decreased from day 14 to day 21. About 40 mg iron needs to be absorbed per 1 kg weight gain if Hb is to be maintained at 100 g/litre^{-1}. On this basis the amount of iron injected into the piglets in the present trial would have covered their iron requirements for about two weeks. This corresponds well with the blood values found, which indicated a slowing down in production of haemoglobin from about day 14, presumably due to depletion of iron reserves.

The changes in WBC and differential counts (Table 3) largely correspond with the development in white cell populations described by Jain (1986) and Imlah and McTaggart (1977). The increase in lymphocytes and thereby WBC found on day 21 in the present study, seems, however, to have occurred earlier than previously described in the available literature. The high neutrophil counts at birth can be explained by the high cortisone level at that time (Brenner and Gürtler 1977). Some authors found elevated WBC and neutrophil counts in piglets in response to iron treatment compared with those in untreated piglets, or in piglets treated with smaller amounts of iron (Kay et al 1980, Furugouri et al 1983). Bacterial challenge together with access to iron could have caused the increase in WBC in the iron-treated piglets in the mentioned studies. Iron deficiency or access to iron might also interfere with WBC production. In humans and rats, myeloperoxidase activity and the ability of neutrophils to kill bacteria were found to be impaired in iron deficiency anaemia (Dallman 1986). The neutrophil count was found to decrease in anaemic piglets compared with iron-treated animals (Gainer et al 1985). The results in the present study are confused by the significant difference found between group in WBC and neutrophiles on day 1. However, by day 7, the difference had diminished. The results indicate that access to iron from day 1 does not stimulate the production of leukocytes or neutrophiles compared with iron injection on day 4. The values for WBC found in the present study on day 4 were lower than those found in the iron-treated piglets in the study of Kay et al (1980) and Furugouri et al (1983).

CONCLUSION

Some piglets already suffered from an iron deficiency anaemia on day 1 and responded quickly to subcutaneous iron-dextran injections. The piglets treated on day 1 were still ahead on day 7 compared with the piglets treated on day 3 or 4. Differences between groups were beginning to

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Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

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Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

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API

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LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

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Sync your system to PACER to automate legal marketing.