50 CRP-positive postoperative sera examined, it would be necessary to study the blood picture in other CRP-positive conditions before their relevance could be established.

Summary. A study was made of the sera of surgical patients in which preoperative serum was negative for CRP and postoperative serum was strongly CRP-positive. In all cases there was a marked elevation in the alpha globulin fraction of the positive postoperative serum. When the CRP was removed from the postoperative serum, there was a significant reduction in alpha globulin, chiefly in the alpha 1 globulin fraction. When this CRP-positive serum was fractionated with ammonium sulfate, the fraction containing CRP contained no gamma globulin. It was concluded that CRP which appears following surgery is an alpha globulin.

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Effect of Gamma Irradiation on Pigs Fed Low Vitamin A Rations.* (27696)

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Little information is available concerning the relationship of irradiation of large animals and nutritional stress. It is not known whether a nutritional deficiency in such animals might have an effect on the severity of radiation damage. A detailed chronological description of the symptoms associated with a single, acute low level irradiation of swine is also lacking. The present study was conducted to determine the effect of low level irradiation on Vit. A low and control pigs and to observe the development of lesions due to radiation damage.

Methods and materials. In a preliminary study to establish dosage levels, 10 pigs were irradiated at 200-1,000 r as shown in Table I. These crossbred pigs were 8 weeks old and weighed approximately 30 lb.

In the present study, 60 crossbred male and female pigs, weaned at 2 weeks of age, were allotted to 2 groups of 30 on the basis of weight, sex and litter. The pigs were placed in concrete fattening pens with feed and water supplied *ad libitum*. One group of pigs received a basal ration (Table II) containing 0.341 mg of carotene (equivalent to 170.5 I.U. of Vit. A) per pound of total feed. The other group received the same basal ration supplemented with 2,000 I.U. of Vit. A acetate per pound of feed.

The pigs were weighed weekly and blood samples were taken from the anterior vena cava at 2-3-week intervals for Vit. A analysis. Two pigs were removed from the Vit. A low group at 11 weeks due to abdominal hernia.

At the end of 13 weeks, each of the 2 groups was divided into 3 lots. Two of the lots were composed of 10 pigs which most closely approached the average body weight of their respective ration group. The remain-

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ing pigs went into the third group. One of the first groups from each ration was randomly selected for irradiation with the other group of 10 serving as controls. The remaining lot from each group was carried on its respective ration. The irradiated pigs were subjected to 350 r of whole body gamma irradiation from a 6,000 curie cobalt-60 facility. The pigs were placed in small wood and wire mesh cages to prevent movement. The cages were centered 9 feet from the source. The 350 r were administered at the rate of 11.1 r/minute, one-half of the dose given to each side of the pig. The pigs were exposed to the irradiation for a total of 33 minutes. The irradiated and non-irradiated pigs continued to receive their respective control and Vit. A low rations for 3 weeks following irradiation, and were observed at frequent intervals to study the manifestation of the irradiation syndrome.

Total white blood cell counts were made on the irradiated pigs one day before and one week after irradiation. Total W.B.C. counts were also made on the 2 groups of non-irradiated control pigs.

Eight barrows from the non-irradiated groups were slaughtered during the third week following irradiation to obtain tissue samples for chemical and histological examination. Tissue samples were taken from the irradiated pigs at time of sacrifice.

Standard methods(1,2) were used to determine the Vit. A content in blood and liver. Weight gains for the first 13 weeks were statistically analyzed according to Snedecor(3).

Results. Survival time of the 10 pigs irradiated in the preliminary study decreased as amount of irradiation received was increased (Table I).

Irradiation response. The first pig died 7 days after receiving the 350 r of gamma irradiation. By the end of 15 days all of the control and 9 of the 10 Vit. A low pigs had died. The average survival periods for control and Vit. A low pigs were 234 and 286 hours, respectively. The relatively short survival times (Table III) do not agree entirely with those obtained in our preliminary study or with those reported in the literature. Tullis *et al.*(4) reported a LD 50/30 of 350-400 r for the pig with 2,000 KVP X-radiation. Tennessee work(5) with the pig indicated a LD 50/30 days of 618 r. Munson and Calloway(6) reported a LD 100/30 of 600-676 r from a Co^{60} source for the pig. The considerable variation in LD 50/30 day values found in the literature will be discussed later.

Death was preceded in most cases by a consistent series of symptoms. The initial response immediately after irradiation was a

TABLE I. Preliminary Study on Survival Times of Pigs Irradiated at Different Dosage Levels.

Dosage level	Survival time in hr		
	Pig 1	Pig 2	Avg
200 r	—*	—*	
400 r	311	364	337
600 r	301	295	298
800 r	313	295	304
1,000 r	168	184	174

* Both pigs receiving 200 r were alive 70 days after irradiation.

TABLE II. Basal Ration.

Ingredient	%
Ground white corn	58.20
Soybean meal (50% protein)	23.60
Cane sugar	10.00
Animal fat (stabilized)	3.00
Bonemeal	2.00
Salt	.50
Trace minerals	.10
B-vitamin supplement*	.20
B_{12} supplement†	.10
Vit. D and E‡	2.00
Aurofac-10§	.30
	100.00

* Supplies 8 mg riboflavin, 18 mg niacin, 8 mg pantothenic acid, and 20 mg choline per lb of feed.
† Supplies 9-10 μg of Vit. B_{12} per lb of feed.
‡ Contains 400 ICU of Vit. D and 25 IU of Vit. E per lb of feed. 2,000 IU of Vit. A were added to the premix in the control ration.
§ Supplies 30 mg of Aureomycin per lb of feed.

TABLE III. Survival Times of Pigs Irradiated with 350 r.

	Control	Vit. A-deficient
Avg survival time, hr	233	278
Individual survival times, hr	172, 196, 207, 219, 234, 235, 236, 258, 260, 314	207, 224, 260, 285, 289, 298, 302, 304, 335, —*

* This pig survived the 3-wk post-irradiation period and was still alive 36 days after irradiation at the time this paper was written.

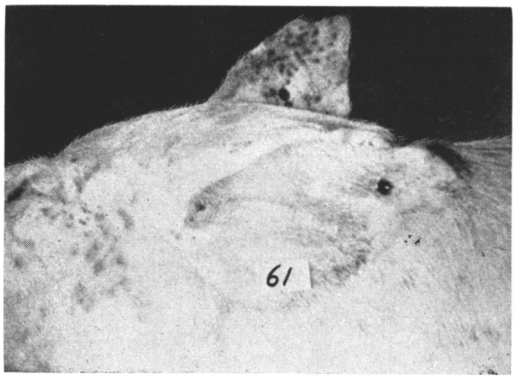

FIG. 1. Skin hemorrhages associated with gamma radiation. Pig received 600 r, air dose, from Co^{60} source at the rate of 6.0 r/min.

sluggish behavior accompanied by mild scouring. The pigs appeared to recover temporarily from the sluggish condition by one or 2 days after irradiation. The scouring continued for 3 or 4 days in most cases, after which the feces became fairly firm and normal in appearance. The sluggish condition reappeared 5 or 6 days after irradiation, when small skin hemorrhages appeared over a major portion of the body, particularly on the ears, belly and inner side of the legs (Fig. 1). Eight or 9 days post-irradiation, blood appeared in the feces and urine in increasing amounts. These symptoms increased in severity up to time of death. Immediately preceding death, the respiratory rate increased markedly and some muscular spasms were noted. The pigs which survived the longest developed hemorrhages in and around the mouth and eyes. A partial loss of coordination of the hindquarters also occurred in pigs with longer survival times. The pigs living 13 days or more vomited appreciable amounts of blood.

There were characteristic necropsy lesions. In all cases, the lymph nodes were severely hemorrhaged. The serosa of the large and small intestine, stomach and bladder displayed hemorrhages in varying degrees of severity. The heart and lungs were also hemorrhaged in numerous cases, particularly in pigs surviving longest. The kidneys contained extensive hemorrhaging in the medulla in most cases as did the fat covering the body. The apparent increase in capillary fragility demonstrated here is in good agreement with the hemorrhagic syndrome reported by Cronkite(7) for swine exposed to radiation from an atomic blast. He observed an increased capillary fragility and a progressive thrombopenia in the irradiated swine.

Other than the shorter survival time of control pigs, no variation in irradiation response could be attributed to Vit. A intake of the pigs.

Total white cell counts. The average total white cell counts (Table V) for the irradiated control and Vit. A low pigs before and one week after irradiation were 23,600 and 7,610 and 25,400 and 6,630 per cmm, respectively. Trum *et al.*(8) reported a drop of about the same magnitude in white cell numbers in pigs exposed to gamma radiation from Zr^{95}/Nb^{95} sources. Values for the non-irradiated pigs in the present study were 24,486 and 19,578 cells per cmm for control and Vit. A low pigs, respectively. The irradiation had approximately the same effect on both dietary groups.

Blood and liver Vit. A. The initial level of Vit. A in the blood at 3 weeks of age was

TABLE IV. Vit. A Content of Blood and Livers.

Treatment groups	Blood (μg/100 ml plasma) 1 wk*	13 wk†	16 wk	Liver‡ (μg/g, fresh) 16 wk
Control	25.5	21.0	23.9	29.5
Irrad. control	25.5	21.5	—	31.0
Vit. A-low pigs	25.5	6.7§	5.3	.54§
Irrad. Vit. A-low pigs	25.5	7.1§	—	.41§

* No. of weeks on experiment.
† Pigs were irradiated at the end of 13 wk.
‡ Liver values are the mean of 8 animals/group.
§ $P < .01$.

TABLE V. Effect of Irradiation on Total White Blood Cell Count.

Treatment groups	Total WBC/mm³ Before irrad.	1 wk after irrad.
Control	—	24,486*
Irrad. control	23,600	7,610
Vit. A-low pigs	—	19,578
Irrad. Vit. A-low pigs	25,400	6,630

* Each value is the mean of 10 pigs.

TABLE VI. Rate of Gain, Feed Intake and Feed per Pound of Gain for Pre-Irradiation Period (1-13 Weeks).

Treatment groups	A.D.G.	Feed intake (lb)	Feed/lb gain
Control	.92	2.12	2.30
Vit. A-low pigs	.84	1.89	2.25

25.5 μg per 100 ml of plasma. Vit. A levels in the blood at the end of the 13-week pre-irradiation period were 21.55 and 7.17 μg per 100 ml of plasma for control and Vit. A low groups, respectively ($P<.01$) (Table IV). The level in the non-irradiated Vit. A low pigs continued to drop during the 3 weeks following irradiation. At the end of the post-irradiation period, Vit. A levels were 23.9 and 5.3 μg per 100 ml of plasma in non-irradiated control and Vit. A low groups, respectively.

Very little evidence of Vit. A deficiency could be found in the Vit. A low pigs. A few pigs seemed to walk with a slight stagger, but this condition seemed to disappear after the pig moved around a short time.

Analysis of the livers from 16 control and 16 Vit. A low pigs revealed a significant difference in Vit. A content (Table IV). The control and Vit. A low livers contained 30.2 and .48 μg per gram of fresh liver, respectively. It is interesting to note such low Vit. A levels in livers and blood while the pigs were eating well and displayed little or no outward deficiency symptoms. Hentges *et al.* (9) and Frape *et al.*(10) have reported Vit. A levels in blood and livers of Vit. A deficient pigs comparable to those reported here. These workers, however, observed a characteristic loss of coordination, weak back and legs which we did not observe.

Performance data. Weight gains, feed intake and feed efficiency values for the 2 ration groups in the pre-irradiation period are given in Table VI. Average daily gains for control and Vit. A low pigs were 0.92 and 0.84 lb, respectively. This difference in gain was not statistically significant. Feed intake and feed efficiency figures for the same period for control and Vit. A low groups were 2.12 and 2.30 and 1.89 and 2.25 lb, respectively.

Weight gains, feed intake and feed efficiency values for the post-irradiation periods are presented in Table VII. Average daily gains for the irradiated control and Vit. A low pigs were 1.94 and 1.77 lb, respectively. Average daily gains for irradiated control and Vit. A low pigs were 0.77 and 1.21 lb, respectively. However, these figures are based on one week's weights and, therefore, are not too meaningful. Figures for feed intake of control and low Vit. A irradiated pigs were 2.02 and 2.20 lb per day. Due to the variation in survival times, feed intake values are also only approximate. Feed intake and feed efficiency values for non-irradiated control and Vit. A low pigs were 5.16 and 2.66 and 4.84 and 2.73 lb, respectively, for the 3-week period.

Discussion. The reason for the marked difference in survival times reported here and those found in the literature for similar dosage levels is not readily apparent. It is possible that the relatively rapid rate of administration in this study of 11.1 r in air per minute may have influenced survival time. Work by Dacquisto and Blackburn(11) using 250 KV X-radiation tends to substantiate this possibility. These workers reported that reducing the rate from 30 to 3 r per minute increased the LD 50/30 day dosage level 38%. Trum *et al.*(8) irradiated pigs at the low rate of 1½ r/hour and administered as much as 610 r with no visible effects appearing in a 90-day period. Apparently, the rate at which the dosage is given is important in determining mean survival time. This effect of rate of administration could also explain in part the longer survival times (14 days) for the pigs receiving 400 r in the preliminary study as

TABLE VII. Rate of Gain, Feed Intake and Feed per Pound of Gain for the Post-Irradiation Period (14-16 Weeks).

Treatment groups	A.D.G.	Feed intake (lb)	Feed/lb gain
Control*	1.94	5.16	2.66
Control-irrad.†	.77	2.02	2.62
Vit. A-low pigs*	1.77	4.84	2.73
Vit. A-low pigs-irrad.†	1.21	2.20	1.82

* Data are for 3 wk following irradiation.
† Data are for 1 wk following irradiation.

compared to survival times of 10 to 12 days in the present experiment where the dose was 350 r. The rate in our preliminary work in this study was approximately 6 r per mm in air. Work at the Univ. of Tennessee(5) using gamma irradiation from Co^{60} and Zr^{95}/Nb^{95} sources tends to rule out the possibility that lethal dose or survival time is influenced by body size. These workers, however, were reporting on dosage levels of 455 to 1,250 r, which are above the 350 r level used in this study.

The lack of visual symptoms in the pigs fed the Vit. A low ration may have been due to several factors. First, the level of carotene in the basal ration was higher than that used by other investigators, thus, a longer time was required to develop a low level of Vit. A in the blood and liver. Secondly, the pigs were not carried for as long a period, once the blood levels in the Vit. A low pigs had dropped below 7 μg of Vit. A per 100 ml of plasma.

The maintenance of appetite and fairly good rate of gain demonstrated by the Vit. A low pigs, however, agrees with the results of Frape *et al.*(10) and Hentges *et al.*(9).

Summary. 1. Pigs irradiated with 350 r bilaterally at the rate of 11 r per minute 9 feet from source survived an average of 254 hours. 2. A moderate Vit. A deficiency had no effect on irradiation damage; in fact, the Vit. A low pigs lived an average of 2 days longer. 3. Pigs fed low levels of Vit. A and with very low liver and blood Vit. A levels showed no gross manifestations of a deficiency of Vit. A. Feed intake and growth rate were fairly normal. 4. Irradiation lowered the total white blood cell count rapidly. 5. The major symptoms of irradiation damage were: (a) depression, (b) skin hemorrhages, (c) hemorrhaging from eyes and mouth, (d) increased respiration, (e) mild muscular spasms just prior to death, (f) extensive hemorrhage of lymph nodes plus varying amounts of hemorrhage in the kidneys, heart, urinary bladder, intestine and stomach.

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Efficiency of Antibiotics in Supplementing the Growth Effect of Beta Carotene in Vitamin A-Depleted Rats.* (27697)

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It has been shown(1) that chlortetracycline, incorporated into a Vit. A-deficient diet markedly influenced the growth stimulating effect of supplementary beta carotene or Vit. A in Vit. A-deficient rats, the magnitude of the influence depending on amount of antibiotic incorporated in the deficient diet and

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