TABLE I.
Occurrence of Secretin in Small Bowel of Controls.

Case	Age	Sex	Pathology	Time interval between death & gut removal, hr	SI yield, mg	Secretin assay (units/mg)	Total secretin unitage
BU*	12 hr	M	Congenital atelectasis	10	22.0	.28; .23	5.7
PO*	24 mo.	F	Encephalitis	19	55.3	<0.2; .08	4.4
WA	2 wk	M	Acute diarrhea	4	13.8	.28	3.9
WI*	9 mo.	M	Acute bronchiolitis	6	41.1	.30; .33	13.
TE	23 mo.	M	Pneumonia; congenital heart disease; Mongolism	28	77.9	.25; .25; .26	19.
EV	7 mo.	M	Amyotonia congenita	29	27.6	.32	8.8
PR*	16 mo.	F	Meningococcus meningitis	11	54.2	.34; .34; .38	19.
WS*	6 yr	F	Leukemia	5	176.	.67; .71; .72	123.
RO	7 yr	M	Acute glomerulonephritis	8	30.3	1.0; 1.4	36.
ST	6 mo.	M	Leukemia	6	82.1	.71; .77; .77	62.
SH	1 mo.	F	Acute diarrhea	20	18.9	.09	1.7

* Negroid.

TABLE II.
Secretin Content of Small Bowel in Cystic Fibrosis of the Pancreas.

Case	Age	Sex	Time interval between death & gut removal, hr	SI yield, mg	Units secretin/mg*	Total secretin unitage
GC	5 mo.	M	3	87.6	.26;* .25	22
CW	5 yr	F	5	188	1.0; 1.05	188
PO	5 yr	F	5	245	.33; .37; .37	88
SB	6 yr	F	11†	253	.40; .40	101

* Assay result obtained with an unanesthetized dog with a permanent pancreatic fistula.
† This bowel specimen, which also contained almost all of the duodenum in addition to three feet of jejunum, was packed in dry ice for a period of 10 hours after autopsy.

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Effect of Adrenalectomy on Radiation Induced Mortality of the Mouse.* (17899)

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The relationship of the adrenal-pituitary system to radiation illness has been studied intensely. LeBlond and Segal(1) demonstrated that local destructive irradiation of part of the body resulted in generalized thymo-lymphatic atrophy, which was prevented by adrenalectomy. However, adrenalectomy does not influence the atrophy of lymphoid tissue following direct irradiation. Patt, *et al.*(2,3,4), in a series of studies, dem-

* The opinions or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or the endorsement of the Navy Department.

1. LeBlond, C. P., and Segal, G., *Am. J. Roent.*, 1942, v47, 302.

onstrated a characteristic sequence of events in the adrenals of the irradiated rat. The changes were prevented by hypophysectomy. They concluded that "the radiosensitivity of intact or adrenalectomized mice, with or without exogenous adrenal cortical steroids, is similar". Their conclusions were based on similar mortalities of adrenalectomized and normal mice exposed to one dose of x-ray. This demonstration of the failure of adrenalectomy to increase the mortality of ionizing radiation was inconsistent with past observations on the effect of adrenalectomy on stresses in general. Therefore, we felt it desirable to repeat this work, determining the effect of adrenalectomy on the entire lethal dose curve.

Methods. White Swiss, male, inbred mice, 45 days old were adrenalectomized in a one stage operation through the trans-lumbar route. Combined intraperitoneal sodium pentobarbital and ether inhalation anesthesia was used. Post operatively the mice were given one injection of 0.2 ml of aqueous cortical extract (Wilson) after which they were maintained on Purina Chow and 1% saline. Sham operations in which the adrenals were exposed and replaced were performed by the same methods. The animals were irradiated at the rate of 15 r per minute with the angular beam of a 2.0 Mev GE industrial X-ray tube. The use and properties of this tube have been previously described(5,6). Var-

TABLE I.

Mortality Data for Irradiated Adrenalectomized, Sham Operated, Non-operated Controls and Pooled Mortality Data for 1949. (White Swiss Mice).

Dose X-ray in r	Adrenalectomized 15 days before irradiation			Adrenalectomized 48 hr before irradiation			Sham operated 48 hr before irradiation			Non-operated irradiated controls			Pooled irradiated controls for 1949		
	No. dying	No. exposed	% mortality	No. dying	No. exposed	% mortality	No. dying	No. exposed	% mortality	No. dying	No. exposed	% mortality	No. dying	No. exposed	% mortality
350				1	6	16				0	26	0	0	26	0
400				14	29	48	0	15	0	0	20	0	0	20	0
450	1	6	16.6	5	18	28				1	26	3.8	1	26	4
550	8	18	44.	6	18	33				0	26	0	2	50	8
600				20	28	71	4	15	26	0	20	0	0	20	0
650	12	24	50.	15	26	57				4	26	15	6	62	9
720				6	6	100				10	26	38	10	26	38
750	21	24	87.	11	12	92							300	484	62
775										16	32	50	16	32	50
850	12	12	100.							27	32	84	317	373	85
950	12	12	100.							30	32	90	65	68	96
1050										32	32	100	56	56	100
0	0	12		7	38	18	0	15							

2. Patt, H. M., Swift, M. N., Tyree, E. B., and John, E. S., *Am. J. Physiol*, 1947, v150, 480.

3. Patt, H. M., Swift, M. M., Tyree, E. B., and Straube, R. L., *Science*, 1948, v108, 475.

4. Straube, R. L., Patt, H. M., Tyree, E. B., and Smith, D. E., PROC. SOC. EXP. BIOL. AND MED., 1948, v71, 539.

5. Chapman, W. H., Sipe, C. R., Eltzholtz, D. C., Cronkite, E. P., Lawrence, G. H., and Chambers, F. W., Jr., A Method for the Simultaneous Exposure of Large Numbers of Animals to Single Dose High Intensity Total Body X-ray Irradiation. Project NM 007 039, Report No. 14, 12 Aug., 1948. Naval Medical Research Institute, Bethesda, Md.

6. Chambers, F. W., Jr., Morgan, J. E., and Istock, J. T., Output Characteristics of a Commercial X-ray Generator at 2,000 KVP Project NM 006 012 08 26, 7 Dec., 1949. Naval Medical Research Institute, Bethesda, Md.

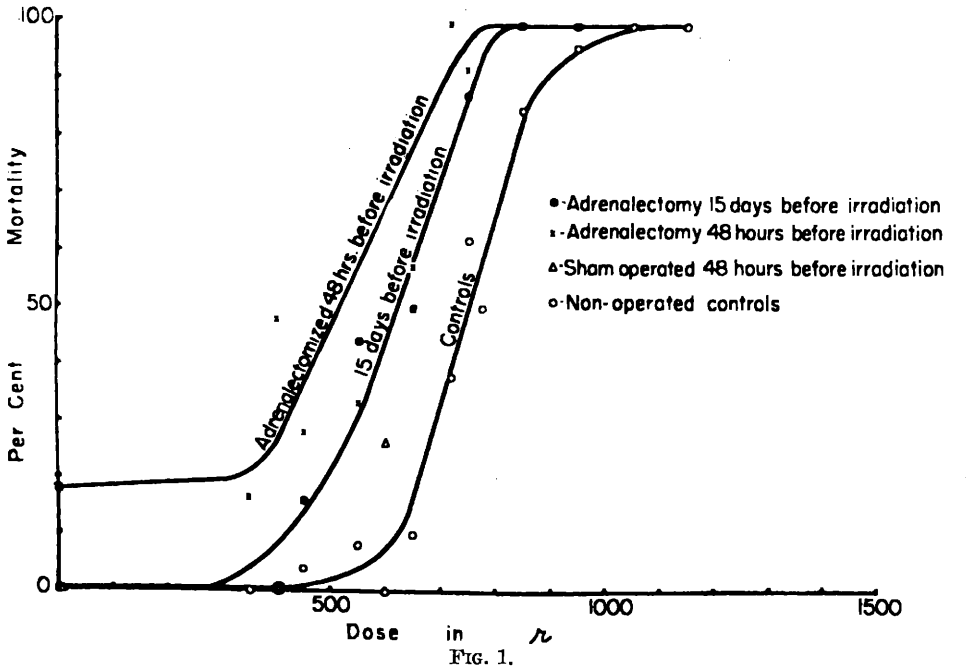

FIG. 1.

28-day dosage mortality curves for adrenalectomized mice, sham operated controls and non-operated controls.

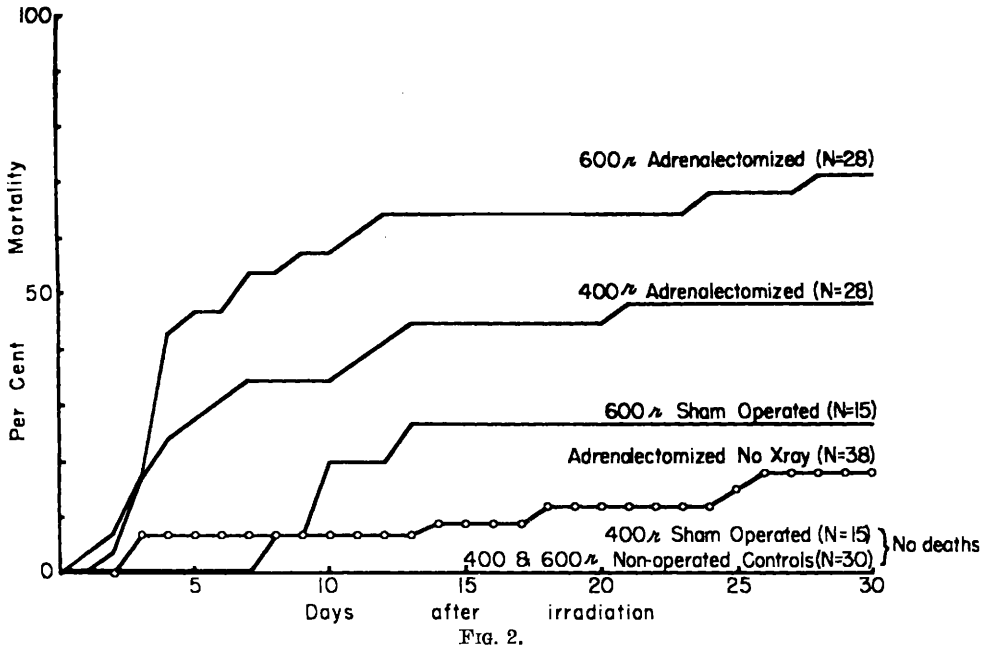

FIG. 2.

Cumulative morality curves of irradiated adrenalectomized mice, sham operated controls, adrenalectomized non-irradiated controls and non-operated controls. For the year 1949 600 r on log-probit analysis corresponded to a mortality of 7%.

ious doses of x-ray were given. The control and operated animals were simultaneously exposed.

Results. Table I and Fig. 1 demonstrate that the mortality of radiation illness is increased by adrenalectomy. The LD_{50} is de-

TABLE II.
Mean Survival Time of Control and Adrenalectomized Mice That Died After Exposure to Various Doses of 2.0 Mev X-ray.
Mean survival time in days ± standard error.

X-ray dose in r	Control mice	Adrenalectomized mice
350	—	8.0 ± .72
400	—	6.8 ± .38
450	—	7.5 ± .41
550	—	7.7 ± .52
600	—	7.3 ± .25
650	10.5 ± .9	7.2 ± .48
720	12.5 ± .5	3.0 ± .68
750	11.0 ± .01	3.5 ± .53
775	13.2 ± .24	—
850	12.8 ± .15	3.2 ± .67
900	10.4	—
950	11.4 ± .06	—
1000	8.8	—
1050	9.8 ± .05	—
1150	6.2 ± .06	—
1920	4.2 ± .04	—
7300	4.5 ± .004	—
9000	4.2 ± .004	—
18000	4.2 ± .007	—
26700	3.7 ± .002	—
64000	0.07	—
128,000	0.07	—

creased by approximately 130 r when mice were adrenalectomized 15 days before irradiation. When mice were irradiated 48 hours after adrenalectomy they seemed even more sensitive to irradiation. It is difficult to properly evaluate this phase of the experiment because of the mortality of the non-irradiated adrenalectomized group. In Fig. 2 the cumulative mortality curves of adrenalectomized, sham operated, and non-operated controls exposed to 400 and 600 r are presented. There were no deaths in the 400 and 600 r non-operated controls and the 400 r sham-operated controls. The mortality of the adrenalectomized animals is significantly greater than that of the sham-operated controls. The mean survival time of mice dying during the 28 day observation period is tabulated in Table II. It is apparent that the survival time of the adrenalectomized mice that died is drastically reduced. In fact, it is roughly comparable to the survival time of mice receiving between 1,000 and 30,000 r. In addition the mice apparently die from "shock" because at autopsy evidence of infection and hemorrhage was rarely seen in the adrenalectomized mice. It will be of considerable interest to see if the histo-pathology and hematology of the irradiated adrenalectomized mouse corresponds to that of normal mice receiving the same or larger amounts of radiation.

All of the adrenalectomized mice that survived irradiation for a period of 28 days were placed on distilled water. None died. Apparently accessory adrenal tissue or fragments had undergone sufficient regeneration to protect the mice significantly against both the effects of irradiation and a low sodium chloride intake. By inference one might say that the adrenalectomized mice would have been even more sensitive to irradiation had a permanent total adrenalectomy been achieved. At autopsy it was not possible to find characteristic adrenal tissue. Bits of tissue from the region of the adrenal vein were sectioned and cells suggestive of adrenal cortical cells were found. Perhaps these mice should be termed "adrenal insufficient" rather than adrenalectomized because of their great capacity to restore adrenal function from fragments or accessory adrenal tissue†.

Conclusions. 1. The adrenalectomized or "adrenal insufficient" mouse is more sensitive to irradiation than the normal mouse. 2. The survival time of adrenalectomized mice is shortened. 3. The cause of death in the adrenalectomized irradiated mouse is apparently due to mechanisms other than infection and hemorrhage.

† Since completion of this work Dr. Henry Kaplan, Department of Radiology, Stanford University School of Medicine, has informed us of technics by which mice can be permanently adrenalectomized and maintained in good health.

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