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August 5, 1953

Colonel John R. Wood, Chairman
Medical Research and Development Board
Department of the Army
Office of the Surgeon General
Main Navy Building, Room 2532
Eighteenth Street and Constitution Avanue, N.W.
Washington 25, D.C.

Dear Colonel Wood:

Attached you will find copies of the preliminary report that Dr. Reid wants to give on our bacteriologic study in the combined flash burn and radiation injury matter. He wants to give this before the American Society of Bacteriologists at their coming meeting. May I have the approval of your office for this?

Yours sincerely,

Everett Idris Evans, M.D.

bjm
Enclosures

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The influence of x-radiation on mortality following thermal flash burns: the site of tissue injury as a factor determining the type of invading bacteria

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Tissue injury due to atomic bomb explosion is caused by blast, thermal burn, or irradiation or by some combination of the three. The importance of each factor in producing injury or death is dependent upon the distance of the bomb victim from the point of the explosion, since the attenuation of radiant and thermal energy occurs at differing rates with increasing distance from the center of the blast as indicated in Fig. 1.

Of particular interest to us has been the intermediate zone approximately 4200 to 7000 feet from the hypocenter. In this zone the victim is exposed to thermal injury and irradiation which in combination appeared from the observations of Japanese medical scientists at the Hiroshima and Nagasaki disasters to produce a mortality higher than could be explained on the basis of either alone. The purpose of our studies is an attempt to better understand the mechanism underlying this increased mortality.

Earlier studies in which 20% thermal contact burns were produced on two groups of animals, one group of which was exposed to 100r whole body x-radiation showed that a 73%

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mortality rate occurred in the irradiated group as compared with a mortality of 12% in the non-irradiated dogs. Death in the former group was definitely related to a beta streptococcus septicemia.

Because the thermal contact burns produced in the earlier studies did not simulate exactly those which are produced by an atomic blast and in order to further study the effects of this combined type of injury, this present study was carried out. We are confining our report in this paper to those effects in which bacteria appear to play an important role.

Thermal burns covering 20% of the body surface were produced on 40 dogs, half of which were immediately thereafter exposed to 100r whole body irradiation. Both burns and irradiation were carried out with the animals under anaesthesia.

The burns were administered by a special apparatus utilizing a 24 inch U. S. Army searchlight with an ellipsoidol mirror. Each burn had an area of 20.7 sq. cm. and an appropriate number of such burns were placed on each dog to equal 20% of the animal's total skin surface area as determined by the Cowgill-Drabkin formula. The time for each burn was one second, utilizing 8.0 cal./cm^2/second of thermal energy. This resulted in a deep second degree burn. 100r whole body irradiation was delivered by means of a 1000 KVP resonant transformer, roentgen ray tube employing a tungsten target at right angles to the electron beam. Half of the total dose was delivered to each side of the dog.

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Subsequently wound and blood cultures were taken daily for the first 12 days and every other day thereafter until the 21st day, at which time the experiments were terminated. As indicated in Table 1, 239 blood cultures were taken on the 20 dogs that received flash burns only, and of this number 23.8% were positive with micrococci and streptococci of the alpha hemolytic and gamma types predominating. Of the 221 cultures taken from the burned and irradiated dogs, 21.26% were positive with a similar flora except for the relatively high incidence of beta hemolytic streptococci. In both groups the greatest number of positive cultures were obtained between the 6th and 10th days. (Fig. 2) In contrast to numerous other reports in which animals have been exposed to mid-lethal or lethal x-radiation alone, gram negative bacteria of the Enterobacteriaceae were of extremely rare occurrence. The same organisms predominant in the blood were also present in the wounds. As controls 10 dogs exposed to 100r whole body irradiation but not burned were cultured over a similar period of time. Of the 140 blood cultures taken from these animals, only 2 or 1.42% were positive. In both instances the organisms isolated were micrococci. Since this degree of irradiation did not predispose to a bacteremia, it is apparent that the tissue damage due to burn alone was responsible for the high incidence of bacteremia in the two groups of dogs. The similar flora in the blood and wounds indicates further that this was the source of the bacteria invading the blood stream.

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Following irradiation of the burned animals and subsequent to an initial peak increase in leucocytes at 8 hours postburn, there is a leucopenia which coincides with the greatest incidence of positive blood cultures as indicated in Fig. 3. The white blood counts on a group of 20 animals irradiated only were similar to those obtained on the burned and irradiated animals except for the absence of the initial striking rise in the first 8 hours due to the burn that occurred in the latter group. In the burned dogs only, there is a marked leucocytosis reaching its peak on the 10th day, which also corresponds closely with the peak incidence of positive blood cultures in this group. No apparent relationship exists between the leucocyte count and the incidence of bacteremia in either group. However, we have found that while only 1 or 0.041% of the blood cultures from the burned animals were positive for beta hemolytic streptococci, 14 or 6.3% of those from the burned and irradiated dogs were positive for this organism. On the basis of number of animals with a beta hemolytic streptococcus septicemia, 5% of the burned and 30% of the burned and irradiated animals were so infected. Typing by the Lancefield method indicated that these streptococci were predominantly of the G, L, and C types, similar types also being found in the relatively heavily infected wound cultures. The presence of this organism in the blood of the irradiated dogs was definitely related to the death of the animals. The

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mortality rate in this group was 23.8%. Two animals died in the burned group, a mortality of 10%. In neither case was a hemolytic streptococcus associated with death. Although the mortality rate due to combined thermal flash burn and 100r irradiation is considerably less than that following thermal contact burn and 100r irradiation, the sequence of events is otherwise similar.

This degree of irradiation, although insufficient to injure the intestinal mucosa and allow entrance of the coliform bacteria as appears to occur with mid-lethal or lethal x-radiation, was sufficient to depress the body's reaction to tissue injury to the point where either the local defense mechanisms are unable to prevent the entrance into the blood of virulent organisms or are unable to destroy these organisms once they gain entrance.

Summary

Experimental studies on dogs indicate that thermal flash burn and irradiation of such a degree that each in itself is relatively non-lethal does, in combination, produce an increased mortality in experimental animals.

A bacteremia due to micrococci and streptococci of relatively low virulence entering through the burn wound occurs in both the burned and burned and irradiated animals. The 100r x-radiation alone does not predispose the animals to a bacteremia. This bacteremia appears to be a transient phenomenon in the burned animals alone. However, in the burned and irradiated

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animals the depression of the body's defense mechanism by irradiation as evidenced in part by the leucopenia which occurs enables more virulent bacteria organisms to enter from the wound site and produce a fatal septicemia.

The site of the tissue injury and the local flora therein appears to determine the type of invading bacteria.

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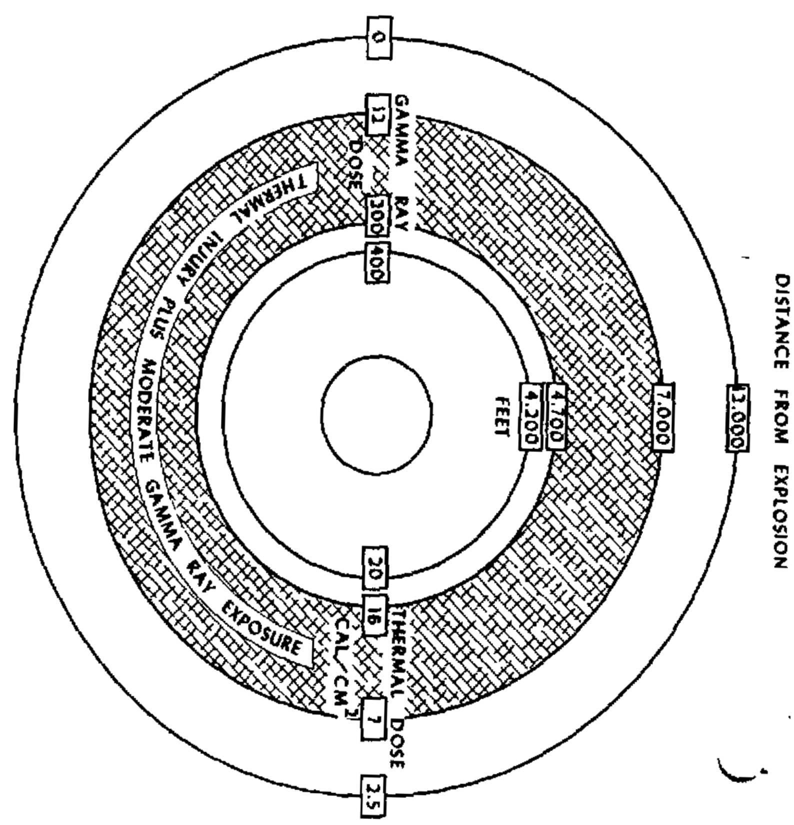

FIG. 1.—Thermal and gamma ray exposures at various distances from nominal bomb, assuming negligible atmospheric attenuation.

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Table 1

The Comparative Incidence of Beta Hemolytic Streptococci in the Blood and Wounds of Dogs Exposed to Flash Burns and to Flash Burns and Irradiation

Culture source	Type wound	Number cultures	Number positive	Percent	Beta strep.	Percent
Blood	flash burns	239	57	23.8	1	.041
	flash burns +100 r	221	47	21.26	14	6.3
	irradiated	140	2	1.42	0	0
Wounds	flash	185			47	25.4
	flash burns +100 r	159			85	53.4

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Figure 2

Incidence of Positive Blood Cultures According to Day of Culture.

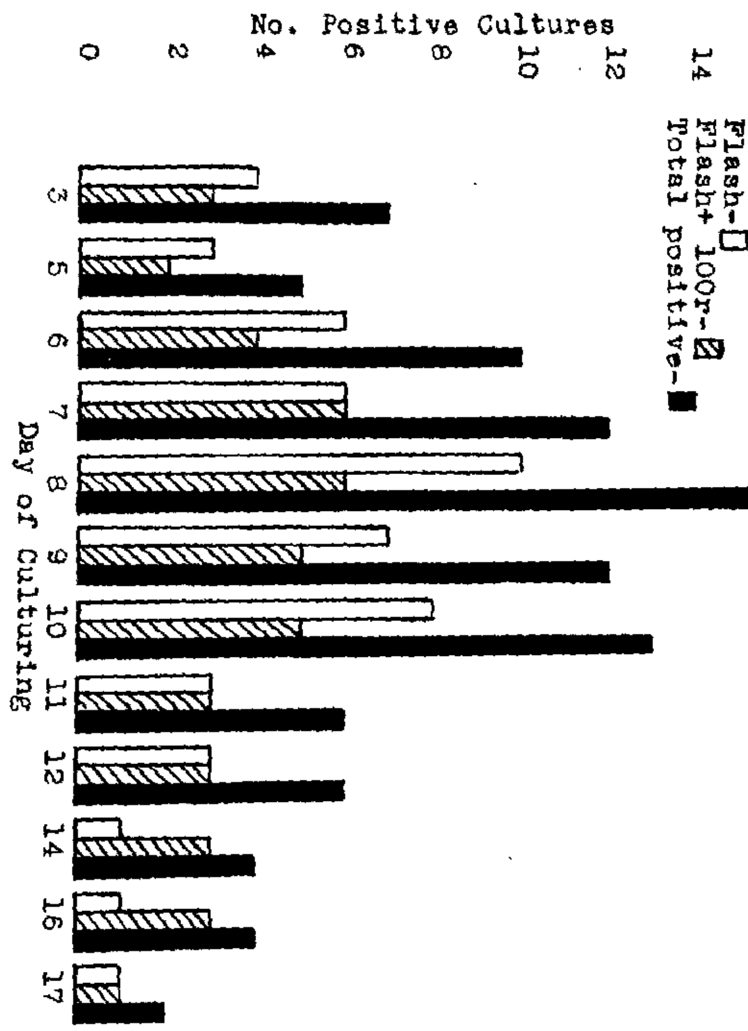

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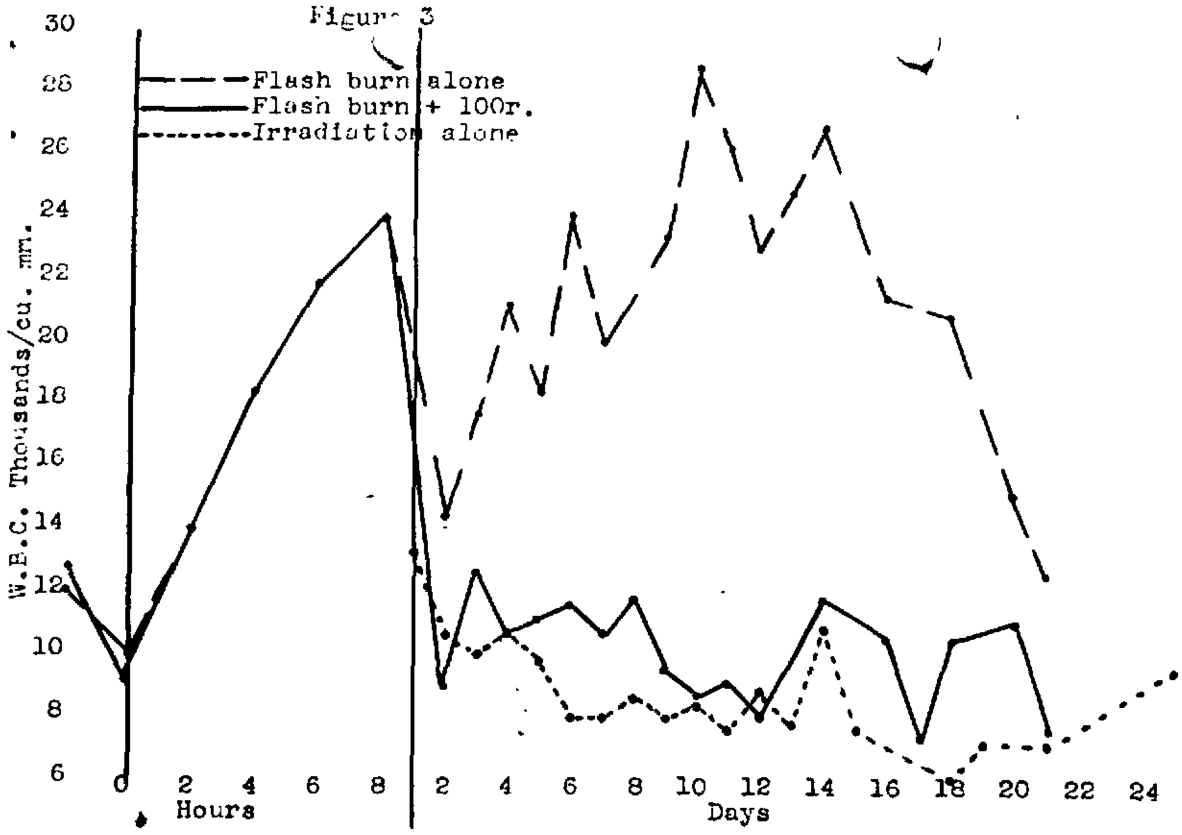
Figure 3



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