MEDICAL PROBLEMS OF RADIATION

11 May 1960

CONTENTS

Page

SPEAKER--Colonel Frederick W. Timmerman, Medical Corps, USA, Student, ICAF 1

ASSISTED BY:

Lieutenant Colonel James B. Hartgering, MC, USA, Army Research Office

Major Michael P. Dacquisto, MC, USA, Chief, Nuclear Medicine Division, WRAIR

GENERAL DISCUSSION 12

NOTICE

This is a transcript of material presented to the resident students at the Industrial College of the Armed Forces. As such it represents the views of the author and not necessarily those of the Industrial College or the Department of Defense. Members of the College may quote it only in student reports or publications for use within the College. Other persons may not quote or extract for publication, reproduce, or otherwise copy this material without specific permission from the author and from the Commandant, ICAF, in each case.

Publication No. L60-178

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Colonel Frederick W. Timmerman, MC, USA, Student, Industrial College of the Armed Forces, was born on 24 August 1915. He attended the University of Vermont where he received his B.S. (1937) and M.D. (1940). Since entering military service he has attended the Army Medical Field Service School 1940-41, Command and General Staff College 1943, Armed Forces Staff College 1953, and Army Medical Service Graduate School 1953-54. He served his internship at Walter Reed Army Hospital, Washington, D.C. He was Company Commander and Battalion Executive, 32d Medical Battalion, Carlisle Barracks, Pennsylvania 1941-43; Medical Liaison Officer, AAA Command, Camp Davis, N.C. 1943-44; Commanding Officer, 30th and 86th Medical Battalions, United States and European Theater of Operations 1944-46; Deputy Surgeon, Fort Lewis, Washington 1950-51; Surgeon, Hq XVI Corps, Far East Command 1951-53; Deputy Commandant and Arctic Consultant to The Surgeon General, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, 1954-56; Assistant Chief, R.& D. Division, Office of the Surgeon General 1956-58; and Executive Officer, U.S. Army Medical R.& D. Command, Washington, D.C. 1958-59. This is his first lecture at the Industrial College.

MEDICAL PROBLEMS OF RADIATION

11 May 1960

COLONEL TIMMERMAN: General Mundy and Gentlemen: The medical problem of ionizing radiation is something like, I think, a stew or a salad. It's made up of increments of a lot of things--some scientific evidence, experimentation, emotion. It's flavored a bit by personal interest and particular personal attitudes. This gets all mixed together; and through the years we've been given small doses from time to time.

After almost each dose of stew or salad, some of you have come to me and said: "Well, what about this, Doc? Is that so?" or "I read such-and-such." This became a little difficult. Me being lazy, I broke the cardinal rule of the military and actually volunteered to come here this morning. I was not asked. I volunteered and you can blame it on me. I got my mouth open when I should have been listening, but I am happy to be here.

What I wanted to try to do for all of us here together, for this last month in the final problem, was to establish some commonsense frame of reference as to the medical problem of ionizing radiation.

Now, knowing all of you and having associated with you for eight or nine months, I felt that the better part of valor was to provide myself with a little reinforcement. So I have brought with me this morning two experts in the field, who will back me up and try to get me out of any holes I may get into. I wished a couple of times they were with me last week in Paris.

First, we have Colonel James Hartgering, who is at present over in the Army Research Office, part of General Trudeau's organization. Colonel Hartgering has been in the field for many years. At one time, in varying jobs and varying posts, he spent seven years with the old Armed Forces Special Weapons Project. Jim was also chief of the Nuclear Medicine Division out at Walter Reed Army Institute of Research. We also have the present Chief of the Nuclear Medicine Division at WRAIR, Major Michael P. Dacquisto.

These two gentlemen have been around in the nuclear field since about 1951, and have been involved in almost all of the testing. So I

think they can field the questions. I know that some of you here come close to being nuclear physicists or experts and I wanted help. I have it.

I'm going to divide the time very nearly half and half into what I have to say and then into answering your questions; and I'm sure you will argue with me.

Our problem is the problem of manpower survival. We are interested, of course, in the short-term range, primarily from the military standpoint. But we have to be interested also in the long-range problem.

I must say now that Herman Kahn said that those who did not take carbon 14 into consideration didn't know what they were talking about. Well, we've taken carbon 14 into consideration; so I think we're qualified to be here.

Now, we'll break the problem of manpower survival into three areas--general considerations; the problem of immediate radiation; and the problem of chronic exposure, that is, repetitive exposure or fallout, and go at it from that direction. We will not argue about exact figures. I'm not going to try to go back to the basic physics that the people from Sandia gave us last fall. I'm going to talk just about radiation and in general figures. You can argue a hundred units of radiation one way and the other and we will not answer you at all.

We are going to make statements quite flatly here that you may not agree with. This is all right. We have the background and can provide the thinking and the scientific proof behind those statements if you desire it.

I'd like to show you that in the period of time since nuclear weapons have come along, a great deal of work has been done. It's difficult to get exact answers in this field. We've known radiation, the experts have, since 1895. In fact, the day that I opened my mouth and volunteered to do this, I cut the obituary out of the paper here in town of Dr. Grubb, who was one of the earliest people in X-ray. He was burnt severely in the days when people didn't know what ionizing radiation was. He went through some 95 operations for cancer that came about because of his X-ray burns in the early days; but he lived to be 85. This period from 1895 to the present time covers the entire span of our work in radiation.

But little was done except for diagnosis of disease, or treatment of cancer or certain other conditions, until the nuclear weapons came along. Then interest, of course, was generated and built up very, very quickly. We went into the field, to varying elements of the Army, Navy, and Air Force, and to the Atomic Energy Commission, and tried to get answers. They have not been easy to get.

I'll break in to say that this is one field, gentlemen, that really is just as joint as, or more joint than, this school, because we have all worked together. The color of the uniform hasn't made a bit of difference. When we have gotten together to discuss the problems, there have been just as many blue suits or dark blue, or this color suits, as anything else and there were our civilian friends from the AEC. So the things we state here today reflect the opinion of the Government agencies--not necessarily those of some people who are trying to sharpen an axe on the outside. We did go into the field many times, but it was most difficult.

Finally, in 1957, with "Plumb Bob," a large experiment was mounted out in the Nevada desert. I want to show you about a minute of a film (moving picture film being played as speaker continues), just to show you how much trouble we went to.

This is an aerial view of the setup out in the desert. Some of you have seen some of these pictures before. A hospital was set up. The animals used were swine, because they were somewhat near the same size as the human, and of the same body thickness. At the weight of a hundred pounds we could get a standard pig, and cut down a little bit on the variation between different animals. So we went out there and, with the support of the Armed Forces Special Weapons Project, mounted a big experiment.

The animals had dosimeters placed inside. You see a surgeon working. It was very carefully done. Neutron dosimeters, gamma dosimeters, so that we could try to find out how much radiation did what.

In this experiment, divided into several aspects, we wanted to study radiation first. You see, some of you who are interested in armor, we put animals in tanks. They were very carefully instrumented. We put animals in an array out in the field, protected from blast and thermal, because we wanted just radiation at this time.

I want to point out that here the entire array only covers 150 yards. I'll come to this again in a moment. But it is interesting that from the farthest point to the point right here was only 150 yards from supralethal injury from radiation to almost no injury at all, showing you that on the ground with nuclear weapons, the cutoff is exceedingly sharp. And, as some of our previous distinguished speakers have said, the best thing, for immediate radiation, is not to be there. But I show you this, again, as a frame of reference to indicate that we have gone into the field and that we have gone into the laboratory, jointly, all services together, to try to get answers.

Some of the answers which are in published form, which have been referred to here, are out of date. They are out of date because it takes years to get things approved and published. So again we will say that many of the answers we will give are not supported in the published literature or that which you will be able to get, simply because of the time interval. This was in 1957, and the findings of that test are still not included in the published data.

Let's establish right at the outset some general figures for the effect of radiation on people. You will be a little surprised.

Just recently it has been agreed that 200 REM, or R--name it as you will--cause no appreciable effect. We don't have to worry about this--an immediate dose. Normally, 650 R can be expected to kill half of the people exposed, without treatment--650. These are just landmarks for what we're going to say. Everyone exposed without protection or without treatment to 1,000 R can be expected to die, eventually.

Exposure somewhere in the order of 10,000 R will produce almost immediate incapacitation; at between 5,000 and 10,000, an individual will feel quite bad for a few minutes. He will bounce back and actually recover most of his ability for minutes to hours; and then he will go down hill very rapidly. This interval shortens as the dose goes up. But you do get incapacitation quite quickly at 5,000 to 10,000 R.

This is of interest to some of the Air Force people here, because it has been stated officially that 5,000 knocks you out right now. This is not necessarily true. It takes over 100,000 units of radiation to produce immediate death. And this is only of academic interest. You've got to be sitting in the fireball in order to get that range of exposure. So, radiation will not produce immediate death.

From the chronic side, again to give you the frame of reference, it has been agreed very recently that 300 R distributed more or less over a week, has no effect; that you can tolerate 500 R over a month; and that you can tolerate 1,000 R over a year. These figures are completely different from those we have been talking about previously. But this is the ball park we're talking about and the standard frame from which we start.

In comparison to those figures, what do you get from ordinary examinations that you're all acquainted with? It is true that these are not quite comparable to the X-ray or the radiation you get in a nuclear explosion; but it gives you a feel for the figures. That's the sort of thing you hit normally.

Now, let's go again and strike out first immediate radiation. What are the effects and what can we expect, and how can we prevent it? As I said, we are interested in manpower survival. The effects can be prevented by distance and shielding; and the effects can be treated to some extent.

About shielding and distance. I pointed out on the first film that the breakoff on the ground is very sharp. There's a rule of seven. With a fractional-kiloton weapon, the area of danger is seven-tenths of a square mile. When you go up into the kiloton weapon, let us say, like the Hiroshima or Nagasaki bomb, it goes up to about seven square miles. When you go up to a 5- or 10-megaton weapon, it goes up to about 700 square miles--its immediate effect. But thermal and blast effects go out farther than radiation. So with megaton weapons, immediate radiation is not of primary interest. With the smaller weapons, the smaller you get, the more interested we are in radiation.

You can get protection, 50 percent cut-down in dose, by about an inch and a half of steel, 5 inches of concrete, or 7 inches of earth. Sure; it makes a difference as to the type of bomb, or the type of weapon--the mix between neutron and gamma. Steel isn't as good for neutrons, as you know, when you get into other problems. Earth and concrete are about the same. From our tests we have found that the effects on people from neutron and gamma radiation are essentially the same. So they can be lumped together. But by shielding you can get protection from immediate radiation. You can get the best protection by being lucky enough to be outside of that sharp cutoff area.

We will get a little later in my presentation to some of our hopes toward giving you some other kinds of protection, but right now this is where we stand.

At this stage I'm going to leave the immediate effects right there. Those of you who are in the limited war committees may consider some of them. But actually, more interest is in the chronic exposure area.

To talk about it, let's put it this way: We're interested again in manpower survival. We want our people. I will speak about the current management of human cases of radiation exposure, the experimental findings of the present and what we can expect in the future.

Now, as far as the current situation today is concerned, I have given you ball park figures. In the area of a dose which you can expect to kill half the people, something can be done--treatment. If you can support the individuals who have been exposed for a period of time until they can recover, you will reduce the number who die.

Now, one of the reasons for death in the area of 650, in this dose range, is infection, destruction of the blood, and general effects.

Right now you're going to ask, and you're thinking: What actually does radiation do to depress the blood and to cause destruction of the bones? I will admit something right now. In spite of all of the work that has been done, we still don't know what radiation really is. We can see the picture of the results, but the mechanism is not clearly understood. There are theories, and we can give you some, with the formulas. But they are theories. We don't really know.

We do know, however, that certain things happen. And in this area of LD 50 dosage, if a patient is given supportive treatment, that is sufficient fluids to make up for that which he loses with diarrhea, blood to make up for the destruction of the red and white cells, and antibodies to prevent infection, you can indeed cut down the number of people who die at this dose level.

With the given dose, they succumb to infection. However, if they are given a full aureomycin course, and antibiotic course, the number of deaths is cut way down. They are protected. They're not protected; they're treated. Then with a smaller dose of antibiotics, there is not quite as good a result; infection comes along and takes them off.

Now, this is not like treatment after the fact. It also cannot be likened to your five inches of concrete. This is not protection, that is, medicine replacing steel or concrete. This is just supporting the injured individual until such time as his normal bodily functions can resume their work. But something can be done. It's not entirely without hope.

This is the present status of treatment. You may have read about the use of bone marrow and certain other things. At the present stage of the game this is not practical.

At the doses of, say, 1,000 R (the LD 100, which kills everyone), this kind of treatment will not reduce the mortality. At the dose levels that kill 75 percent, you will with proper treatment improve the number of people who live.

Back in about 1949 it was found that certain chemicals, if given before exposure to radiation, would increase the resistance of the animal to radiation. This, perhaps, works the same, let's say, as the five inches of concrete or the inch and a half of steel. That is, these chemicals work in some manner to reduce the effect of radiation.

Some of the earliest work was done in mice. There are similar items in every chemical that was used. You have in one group, at least two C's--carbon and sulphur. Every one of them, in one way or another, is linked in that manner.

Now, all of these did give mice 100 percent protection against LD 100. That is, it just about cuts the effect in half.

With the dosage in this area, then it's double the dose that they would tolerate.

You will note here--and I'll come back to it later--that the doseages that were toxic to the mice were fairly close to the ones that were effective. There's not too much difference between the dose rates.

This work started out in 1949 and a great deal was done through the 1950's, in attempting to find some chemicals that would give protection ahead of the fact. We want to protect people; cut down the effects of the radiation.

Again, the control. Normal saline solution, salt water, is given. A large number of animals are used, because there is a variation between animals, just the same as there is between all of us. In the control the percent of survival in one week is 73. Then it goes way down. And in the untreated only 13 survived with that particular dose.

But, one of those chemicals, 15, given five minutes before, none. One hour before, the control again drops down. You didn't have quite as good protection. Given five minutes after exposure though, nothing. It was no good. This had to be done ahead of time.

We were very much interested in proceeding along this line, but not too much progress was made. So, two years ago, some of our people at Reed came through with an idea, which now seems so self-evident that we wonder why some of our good people like Mike Dacquisto didn't think of it before. But it's one of those things.

These drugs were too toxic in animals like dogs, and presumably in people, to be used. The dose which would protect in the larger animal, not the rodent, was so poisonous that it killed the animal. That's a losing proposition.

So the gentlemen out at Reed postulated that perhaps these chemicals worked each a little differently and that perhaps they could take a mix of two of them in a dose range that by itself was not effective in preventing injury but also wouldn't be toxic, and that the toxicity of two different chemicals would not add, but that the protection would add. This does seem simple now, doesn't it, in hindsight?

They tried it. Let me show you a little movie. (Movie film.)

The first experiment shows Blackie and Whitey. These two dogs were exposed to, I believe, 775 units, which is invariably lethal to animals. Blackie was protected within 30 minutes before by an injection of a combined chemical. Whitey was not protected. You can see quite obviously the difference.

Dr. Jacobus is having quite a bit of trouble with our protected Blackie, as you can see. Here's Whitey--bleeding into the mouth with very pale tongue and pale membranes in the mouth because of blood destruction. This dog is exceedingly sick, and, I'm sorry to say, died the day these pictures were taken. It's the control animal.

We love dogs, all of us; but if we can learn something to protect you and our families, we're willing to sacrifice them. Here is Blackie--nice red tongue; a happy, healthy dog. That was two years ago, and Blackie is still happy and healthy out at Walter Reed--as is every other dog which had been used in this experiment and which received the protective chemical ahead of radiation exposure.

I'd like to say this again: We have never lost a dog in this order of dosage that survived the medicine itself. This is not an answer right now, because it still rides on the edge of toxicity. We lost about one or two dogs out of seven or eight that are given the medicine, because they've been skating right on the edge.

But this success did generate sufficient interest so that we obtained some extra support. Again, the work has been coordinated closely between AEC and the other services. About a million dollars a year have been put into this research in the last two years, and some progress is being made.

We hope that we can get chemicals which are less toxic and which will be effective for a longer period of time. Our pipe dream of the future is to develop a pill like we had in the last war against malaria, that you could take once a day to protect you. We don't have that now; so don't get your hopes up. But it is evident that something can be done in the future.

Again, don't ask me exactly how these chemicals work, because since we really don't know what radiation injury is, we're not foolish enough to try to tell you that we know how this mitigates radiation injury. We have only theories. But we know it does help.

At the present time, in the coordinated effort, chemicals are being patterned. There is an attempt at synthesis of specific chemicals, built to order so that we can cut down toxicity and increase the length of active protection. We're talking now about protecting ahead of time.

Just to show you another aspect of this thing. Some of you are interested in high-dose levels. What if you are as unfortunate as Ed Wooten who is flying that B-52 and gets a nuclear antiaircraft warhead up there and is exposed to 10,000 R. We say this is almost immediate incapacitation. We were curious whether these chemicals work up in the higher levels. So some were tried. Let's have that little bit of film on the dogs that had 10,000 R.

(Film) That is an awful slug, gentlemen. There's the answer. The beagle got the protective medication. The other poor animal did not. The beagle did pretty well for three days. He did then drop off. The other dog obviously was not an effective animal. The beagle was a little afraid of the cameras and the lights, but he's a pretty happy animal for 10,000 R. And if Ed had been so unfortunate to have that B-52 up there, if he'd had this medication perhaps he would have been able at least to bring the beast home again and carry out his mission. It's really very interesting.

Don't, again, jump to conclusions--this is not now. It is, however, a hope. Radiation isn't as overwhelming a thing as has been pictured. There's no need of going into all of the details, but this is the white count, the white blood cells, which are very necessary in combating infection, as all of you know. This is the control. See how the white count drops down and the animal goes on out. In the dog protected by the combination of chemicals you see the white count stays right up there in good order.

What's the practical value right now? We don't have the answer, but we hope to be close.

Some of our people wanted to know--getting back to this final problem--if we had something like this, even though it's pretty toxic, which people could take, those who are not in the area of immediate effect, but who are in areas for which conelrad predicts fallout. If today, without adequate shelter, they could take this, what would be the effect?

The Damage Assessment Center, using the same figures that we are using in our final problem, was asked: "Without changing any other parameter of the problem, if the people outside the immediate area of the hit could have a dose of this to take, what effect would it have?" You can see the effect. Over 10 million people would be affected. This is manpower, and manpower we need. This is a practical effect that we hope is not too far off in the future.

Now, you may have gotten the impression that I'm talking only about immediate effects and how to protect people against immediate effects. Actually, the same thing applies for fallout. Now, fallout is short. It's primarily gamma radiation. You can get protection. Protection from fallout is much easier than it is from immediate effects. It doesn't have as much energy.

The only effect you get is that from fallout which comes down within 100 feet of where you are. What is beyond that is unimportant. If you are in a big building, and can stay in the middle of a big building so that no fallout is within 100 feet of you, you would get essentially nothing. It is said that in the basement of an ordinary brick house out in the suburbs, you get a factor of 1 to 100. As to the 1,000 fallout on the roof, you only get 10 in the basement. A very simple shelter gives you a tremendous factor. It cuts this problem way, way down.

There's another factor that gets into this, and that's the sharp drop-off. I don't want to argue details right now, but the initial drop-off is very rapid. If people can stay in even a simple shelter until they are told to come out, we can have a great deal more survival of our essential manpower.

This is not an impossible problem. We can do something about treatment right now. We hope we can do something about protection by a chemical. And very definitely in the fallout area, shelters are the answer. A combination of shelter and a practical chemical, for which we hope, would give us a chance for survival in the event of attack on this country. We don't have either one now.

Let's go back again. These figures are quite different. Radiation isn't as bad as it's been painted. You can take 200; 650 will kill about half the people who are not protected and not treated; 1,000 at the present time is the dose which kills everyone. Chronic effects, fallout, as I told you, 300 in a week, 500 in a month, 1,000 in a year. This gets you into manageable areas.

Some of you immediately are thinking about the figures given by Mr. Kahn last month and by another distinguished speaker only yesterday. We have no argument with those figures. In fact, quite a few of them were stimulated by our two friends here.

In studying life shortening, we don't have the real answers. But there are enough data to make us think that for each exposure your life may be shortened about six-tenths of a day. Right now we're all young enough so we're not worrying about four or five or six days. But this is a manageable figure.

How about cancer and so on? We don't know all the answers, but we do know enough to think that a 50 R dose isn't going to do anything. A 100 R dose about doubles the rate.

Let's use leukemia. We know something about this. That's cancer of the blood. Normally in the United States the rate is 6 per 100,000 of the population per year.

Now, in the period since Hiroshima there have been about 70 cases in 100,000 population exposed to pretty high doses. The rate was at the highest peak about five years after Hiroshima. But, even so, the total from 15 years is only 70. This still is in the same ball park as the figures we now have in the United States under ordinary peacetime conditions.

So that's a good answer. You throw your hands out. We don't know the real answer, but we doubt that the problem is as great as some of our emotional friends would indicate.

Genetics. I think Secretary Acheson said it very well yesterday. And Herman Kahn said it. Probably the genetic results are in the manageable area. Probably some increase in genetic effect. The fruit flies say so. But we haven't lived long enough to really know.

To conclude this talk: We believe that radiation is bad; but that it is manageable. The tolerance figures are a lot higher than we thought. You can get a tremendous amount of protection from shelter, from luck, and possibly in the near future from the results of some of the medical research work going on right now. This does give us some hope and does give us a set of figures that you can use during this last month.

I suggest we take a short break and then come back and let you hit us, all three of us, and we'll try to field your questions.

COLONEL HARVEY: Dr. Timmerman is ready for your questions.

QUESTION: Tim, if the Russians were able to achieve this pill-a-day capability before we do, it would be a pretty dangerous situation. I'm sure they're working on it. Do you have any idea what progress they are making?

COLONEL TIMMERMAN: I think you are guessing right. Obviously, as has been stated from this platform and upstairs, possibly the Russians are already in a bit better position than we are, because being on the first strike end, they can disperse their population and so on; and if they have this, it would really put them in a better position.

Two years ago, there was an International Medical Congress in Burlington, Vermont. As a matter of fact, there were Russian representatives present. I think that at that time the knowledge was pretty much across the board, open for everyone; and there was a pretty good exchange. The United States representatives who were present at the time told me that the Russians became quite enthused. At that time, two years ago, we were just about on a par.

Where they have gone since then I can't answer. Can either of you?

MAJOR DACQUISTO: In 1958 there was a meeting in Geneva on the peaceful uses of atomic energy. At that time a laboratory from Czechoslovakia had a group of three or four people who reported on some papers making derivatives of the identical compounds that we are making--nitrogen separated by two carbons from a sulphur--because it's been obvious in the literature for many years that these are the most effective ones. And they reported approximately 20 derivatives that they had made.

At that time it was a little frustrating to us, because our program was still classified and we could not talk about it. Shortly thereafter this classification was lifted, so that we could talk about it. So we're certain not only that they are interested in the problem, but that they think, as we do, that this is an area that should have been explored years ago; and we are both doing it as Johnny-come-latelys. Where they are as of right now I don't know.

QUESTION: Will you give us a little history of the development of these chemicals and how they first came to our attention?

COLONEL TIMMERMAN: I think that actually the whole history is a fairly recent one, and that I was correct in saying that the first really good work was done in about 1949 in mice. Wasn't it, Jim?

COLONEL HARTGERING: Yes.

COLONEL TIMMERMAN: By the Belgians. But you have the picture pretty well, so you had better tell about it.

COLONEL HARTGERING: That was done by a fellow named Bacq, working in Belgium. The first work in this country was done by Harvey Pat, at the Argonne National Laboratory, using fission and

mice. There has been a flood of papers from all over the world since then. But up until two years ago, no one had succeeded in protecting anything except rodents, as Tim indicated--mice and rats.

At Walter Reed, Dr. Jacobus, whom you saw in the movie, was the first man to show that you could in fact protect large animals. The work mainly revolved around trying to find out why these things worked. We have done some studies on why they work. But we don't really worry too much about this, because we use lots of drugs and medicines--as a physician if you come to me, I may give you several drugs. I don't know why they work but they work and I don't care how they work. This is the approach. We know that these things work, and from a military standpoint we say, let's get on with the job and get something that's a little more practical.

One thing that Tim didn't point out that I think is encouraging with these drugs is that they protect, essentially, as far as we know today, across the board. They protect against any radiation effect, whether it be life shortening, whether it be cancer, whether it be genetic effect, whether it be the things he talked about. They are not just good against the acute effects. They protect against all radiation effects, because they essentially act like a piece of steel inside you. You just don't get that much radiation.

So these are really amazing compounds, amazing discoveries. How they work we don't know. I'd like to know; but let's get on with the job and find some that are less toxic.

One other thing I think is a little more hopeful than even Tim pointed out. We're not nearly as far away from the civil defense problem as we are from the problem of the soldier or the sailor or the airman in combat. If you have a nuclear strike on this country, then you're perfectly willing to accept a reasonable percent of toxicity in your people. As Mike always says when he talks about this, "If they're a little sick to their stomach and so forth, which is what these compounds do, this assures that they stay in the basement and don't come out, where they shouldn't ought to be." So we're not nearly as far away from protecting the housewives and the civilian population as we are from protecting the combat soldier, because, obviously, he can't stand the toxicity or he couldn't complete his mission. We're much farther away from this one.

QUESTION: Tim is there any validity to the statement that certain foods, such as cabbage, give the human certain protection against radition?

COLONEL TIMMERMAN: You know, Joe, I kind of figured you'd do this. This is not planted, gentlemen.

The Quartermaster Corps did do some work a while ago with cabbage and broccoli in guinea pigs. If you would eat enough cabbage and enough broccoli, you would get some protection. There are a lot of things that enter into it. I didn't take the time to discuss individual variations. Sure, it varies. There are so many factors when you are testing the effectiveness of something in this field, then it's most difficult.

In the laboratory when Jim was at Walter Reed, they had a strain of mice which had been standardized so that it was known exactly how many units of radiation caused half of them to die. We built a new mouse house, and the new mouse house was better than the old one and the mice were a little healthier and they grew a little fatter and so on. It was the same strain of mice. Darned if they didn't change in LD 50 by 100 R. So there are an awful lot of things that enter into this.

On the famous guinea pig studies. You could wobble a statistic to show that if the pigs ate enough cabbage or broccoli, maybe there was a decrease in mortality. But there were so many factors involved, that honestly, I just never did believe that it amounted to anything. Of course it could be said that if you translated this to the human, you would have to eat impossibly much broccoli and cabbage, you never could do it, plus the fact that the bad effects of certain of the chemicals in the cabbage or broccoli would do you more harm than good.

But, nonetheless, the Quartermaster Corps got a lot of fine mileage out of this and a superb press; more power to them. I'm not being unkind.

QUESTION: Tim, we've read many papers about the clean and dirty bombs. Have your studies shown any real significance between the two?

COLONEL TIMMERMAN: I had figured also that this would be a question. The clean and dirty bomb had to do with the configuration of the weapon--how much fission there is versus fusion and so on and so forth. Do you want to get into any of the technicalities and bail me out a bit? It really doesn't make a whole lot of difference as far as I know. Mike, am I wrong?

MAJOR DACQUISTO: No.

The only way that we know now to get fusion is by fission. It's the only way that we can mechanically or artificially generate enough heat. As you know, the English and ourselves and apparently the Russians are trying to get fusion by means of particle acceleration and by building up temperature in pieces of apparatus to develop fusion. Every now and then there have been reports that they thought they could do it. But this has not held up.

So that to get fusion--and this is a megaton weapon--you have to have fission. The trick is to get these big things together and have the heat generated by fission cause subsequent fusion. There is no way that we know now to get fusion without fission. When you have fission it's a "dirty bomb."

Obviously, if you can do this with 10 kilotons of fission in contrast to a hundred, you can cut down the dirty element by 90 percent; and if you say it this way, it sounds good. But you still have to have fission.

If there are any nuclear physicists in the audience who wish to question this or make comments, I'd be glad to hear them. I'm merely a physician.

COLONEL TIMMERMAN: I think, from a practical standpoint, the question has been blown out of all proportions. In the immediate area of the hit it probably is more important how high the thing is blown. Down low you get a lot more dirt up in the air and secondary products to fall on the ground. The height of the fireball is a little more important to us than the configuration. Would you agree to that?

MAJOR DACQUISTO: Yes.

You could go into the ingredients problem rather than the mechanism problem. In other words, cobalt or other ingredients do make a difference as far as the composition, rather than the mechanism.

COLONEL TIMMERMAN: Did you all get this? What was pointed out was that it makes a difference what the case is made of and so forth as to what ingredients, radioisotopes you get out of the thing after the explosion. You can put in certain ingredients that will maximize the production of radioisotopes; or you can build it with a minimum. There is a difference in degree and in type of the isotopes that you get out of the weapon. But for practical purposes, from what we have had to say here today, it really doesn't make such a whole lot of difference.

QUESTION: Tim, somebody volunteered me as an economist on this kind of problem, and I have to raise a question. How much more money could you use for research and development in this field? Be reasonable.

COLONEL TIMMERMAN: You know, it isn't all money, though there is more money needed. Almost everybody wants more money, and I think we could use an increment of twofold or threefold.

But there's more to it than that. It takes people. You have heard really good speakers from this platform point out that in many of these specialized fields we simply don't have the people, the qualified institutions and people, to do the work.

I might point out that in the program now going at Reed, a fair amount of the work on synthesis of new chemicals that we're trying to design for this particular purpose is being done in universities and chemical companies. We have gone out and invited them to come in and give us proposals. It really has been pretty difficult to get good ones.

What was the percentage? Of all the proposals you have gone into and so on and so forth, would you think that 35 percent of them were decent work that you'd like to support, or 50 percent--something in this order?

MAJOR DACQUISTO: About 25 percent.

COLONEL TIMMERMAN: I'm off base. So if you doubled or trebled the amount of money in his particular program, if you went much over, I would say, two and a half or three million a year, I think a good deal of it would be going down the proverbial drain.

Isn't this a fair answer? Of course you'd like $10 million I know that.

MAJOR DACQUISTO: What Colonel Timmerman has said is a fair enough comment in terms of developing the chemistry. As a matter of fact, we have about come to the end of the line in terms of competent organic chemists who can work with this kind of compound.

Those of you who have had chemistry, or who remember your chemistry, will notice that these are relatively simple compounds, but they have two active particles of nitrogen and sulphur. Chemists who are familiar with this kind of compound and this kind of chemistry are rare in this country. We have over 75 percent of the knowledgeable ones in the country working for us now. There just aren't that many more. If we would go to other people, they would have to take this on as a new activity, and spend several years learning what's going on while we supported them. So that the money couldn't be used. We couldn't use much more money in the chemistry.

I am sure we could use more money in terms of how the compounds work and why they work. In this sense, perhaps we could be a little more intelligent in what kinds of compounds we have made. But people are the biggest problem.

STUDENT: I might say this: This gets to be a matter of how you optimize the use of neutrons. Even with the fusion weapons you get neutrons. If you put around this weapon materials which will absorb the neutrons, they become poisonously radioactive, like cobalt. Then you can optimize the dirty effect of the bomb by quite a little bit.

QUESTION: It sounds as though we can take a lot of encouragement on behalf of the canine and rodent population. I'm kind of curious about how and when you expect to apply this to humans.

COLONEL TIMMERMAN: Of course again the answer is that these things are still fairly toxic, as I told you. The last that I knew--and I've been here with you for nine months and I may be a little off--was that Major Dacquisto was going to try to use some of these chemicals locally on people being treated with radiation, to see if the damage could be cut down. When cancer of the face is treated with radiation, using a big dose, skin burns result. I think Mikes' people, as a first step, rather than trying to give the stuff internally, were going to apply it in a local area, to see how it did work in that area when a person

with cancer was treated with X-rays. This is a first step on people. Did you do this?

MAJOR DACQUISTO: Yes. We did this. Let me first say a few things about the toxicity.

What Colonel Timmerman said is true. But if you use equations, this is not quite true. By "poisonous" we ordinarily think of something where a pinch of it or a little tablet and you've had the course. The facts of the matter are that for these compounds the dose to take by mouth for a man, if you were to replace it with aspirin, when you take an ordinary dose of aspirin, two tablets, this is five milligrams per kilogram on the average for a man--the dose of that particular compound was 160 by injection and probably 300 by mouth. So this means that if a man were to take--5 into 300 is 60--this is 120 tablets of aspirin for this kind of medication. This is a lot of material; and when you call this a poison--it's poison if you take it to this extent, but it's not poison in the classical sense.

Now, we have tried this, as Colonel Timmerman indicated, as local application on the jaw, to prevent the tissue reaction in the mouth when the roentgenologist was treating a cancer of the bone, such as the jawbone. In this particular case the limiting feature in how much radiation the radiologist can give is the reaction inside the mouth. If he gives too much, he winds up with an ulcer that never heals, and a patient who isn't grateful, and a disease which you haven't cured.

So by applying this locally, you are able to protect the tissue within the mouth and in this sense perhaps give a little more radiation to the cancer. You can try to prolong life a little more, and conceivably if you can give twice as much radiation, you can perhaps cure a number of cancers by radiation that we cannot cure now. It is in this area that we in this country hope to progress with applying this and trying this on people. We are a long way from any volunteer point to try this.

The Europeans--the French and the Belgians and the Italians--have given these medications to people. And people can tolerate now about 25 percent or 30 percent of the dose that we know they need, based on animal studies. That is, they will take this much and not suffer serious side effects. They may have some nausea, vomiting; but it will go away the next day. So that we are not even terribly far away here. No one has pushed us any further than this, for obvious

reasons. Like everyone else, we don't know what has been done behind the Iron Curtain. Whether they have done anything like this, I don't know.

QUESTION: Tim, would you say a few words about the effect of the nuclear test ban on medical research in radiation? Has this delayed it or set it back? Or has the laboratory work gone ahead?

COLONEL TIMMERMAN: I think the answer to this, as to whether the ban has delayed our work, is very mixed. Let me start off by saying that testing in the field is a most difficult thing. I showed you just a little piece of a movie of the terrific setup which we required in Nevada in 1957. This is not cheap, either in people or in money. Oh, it's not millions of dollars, but I think that one ran in the order of half a million, and it took about 300 professional people and many, many weeks.

Then our problem was, quite frankly and honestly, that the powers that be did not feel that they could give us a known weapon just for medical purposes. So we always were working in combinations with other tests, in which they were testing a device. This would be wonderful if our scientific friends would tell us what the thing was going to go at, because it makes a tremendous difference.

You remember, I pointed out that that array on Wilson shot of Operation Plum Bob only covered 150 yards, from supralethal, where it would kill all the pigs, out to where they didn't get enough to mention. That was only 150 yards. So if this device goes more than 5 or 10 percent off prediction, you either kill them all or you don't do enough to study.

It has been a tremendous problem. We went back to the desert in 1958 and ran into the same thing. We were well prepared on one test, and the device failed to function properly, and didn't even blow the cap off the tower. But there was enough radiation so that the animals had been exposed and could not be used again. You have to start months back to get the animals in the desert, at the right size and so forth, so you can handle them. Everything was prepared, and there they went down the drain--in this case several hundred.

So it has been most difficult. We had hoped after the 1958 series, in fact we went in and asked that we be given a known tested device and then all of us together mount a joint medical study where we really could try to get some answers. But then the ban came along.

Now, even if they blow warheads underground, I doubt that we will be able to do very much medically. Shortly there is something else coming along, however--things called pulsed reactors--which can be used now to study neutron effects. There are types of reactors. Right now there's a big hole in the ground out at Walter Reed, where they're putting in a new medical reactor. There are a number of reactors being put in by not necessarily medical people that we can use. I think, putting them all together, we will probably progress faster in this manner than we would otherwise. There are just too many problems in field testing.

I showed you the animals that we used for the field test. You would be amazed at the problems that one gets into. It's cold at night and it's hot in the daytime in the desert. The pigs get sunburned if you leave them out too much in the daytime, and they get pneumonia at night; and they're tougher than most animals. Really and truly, believe me, I don't think that this ban has had too much effect on our work. Would you agree?

MAJOR DACQUISTO: I have only one comment. There is one thing that we would like to see done. We would like to see the Hiroshima shot refired. This is the specific thing we want done. And the reason we want it done is that we don't know the dose of the 100,000 Japanese survivors that were followed. We don't know the dose within any reasonable feel for what the problem is. So this was a real requirement--not to do any of the military-type weapons, but to refire the Hiroshima weapon under controlled conditions, with some animal experiments, so that we could document the dose problem. The only question here was that my friends at Los Alamos said they didn't know whether the thing would ever go off again or not.

QUESTION: Is there any prospect in the way of impregnating clothing or body armor or anything like that in connection with this chemical work that you are doing?

COLONEL TIMMERMAN: Actually we are talking about radiation now--for an overall protective suit or something, the answer is No. Do you remember the figures I gave you--an inch and a half of steel? A half inch of lead would give it to you too. You can't physically carry enough of this around, you see, as far as a protective suit or something like that is concerned. It just is outside the realm of feasibility.

There is one thing that should be said, however. In vehicles, like tanks and that sort of thing, it might be possible to have mounted as a part of the vehicle--I'm just talking now--say, a lead boot. If you're driving with your right foot, you might have a lead boot that you could stick your left foot into--the driver and the assistant driver and the gunner in front. Then if they were exposed to a big dose, they would have one leg that would be essentially protected.

It's surprising what has been done. If you do have one good bone that has not been exposed, this will carry an awful lot, and it will increase the amount that the rest of the body can take, because what we've been talking about is whole-body radiation. It has been known for a long time that you can take a lot more in a part of the body than you can the whole body. What I am saying is that this is an area for exploration. But for general, for the doughfoot or the pilot, you could put a lead sheet in a tank or perhaps even stick an aluminum seat in the airplane to protect the pelvis of the pilot, and make him happier and it might help to preserve his life. But from the practical standpoint, it's a difficult problem.

COLONEL HARVEY: Tim, I didn't hear your first O.P. but your second one was outstanding and most interesting. I would like particularly to express my appreciation to Colonel Hartgering and Major Dacquisto for coming over and being with us today. Thank you very much.

(11 Oct 1961--5,600)B/de:dc