NUCLEAR WARFARE AND THE TREATMENT OF MASS CASUALTIES*

BY

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The apathy in this country, and perhaps especially among the medical profession, towards Civil Defence and education in protection from nuclear warfare is very evident. One is told either that "it can never happen" or "that nothing can be done about it." Both these statements should be carefully examined.

It is hoped that, in the cause of brevity, some dogmatism will be excused.

Apart from conventional weapons there are three hazards of total warfare—chemical, biological, and nuclear. In the first category, in addition to the well-known blister gases, there is now "G" gas, a colourless, odourless liquid which antagonizes cholinesterase, allowing accumulation of acetylcholine, a few drops causing immediate contraction of the pupil, followed by convulsions and, within four minutes, death. Apart from being under cover or wearing a gas-mask, some protection can be provided by the immediate injection of atropine, 2 mg., and experiments are being made with pyridine aldoxime methiodide (P.A.M.), which may prove more effective.

Biological warfare, which could be so well exploited by saboteurs, has fearful potentialities—incubation periods, mixed infections, and the infection of animals and crops all adding to its danger. Hygiene, knowledge of home nursing, and stockpiling of vaccines and antisera seem the only antidotes.

But it is nuclear warfare that perhaps merits most attention—destruction by blast, burns, and radiation liberated by either fission or fusion of the atom.

Mechanism of Nuclear Bombs

The atom bomb (Fig. 1A) consists of two "sub-critical" masses of uranium-235 that can be pressed

FIG. 1.—A: Atom bomb (fission bomb). B: Hydrogen bomb (fission-fusion bomb). C: Uranium bomb (fission-fusion-fission bomb).

together by a charge of T.N.T., the whole being surrounded by a reflecting tamper. In the "safe" position a shield rests between the two masses of uranium. This is a true fission bomb.

The so-called hydrogen bomb (Fig. 1B), a fission-fusion bomb, is an atom bomb surrounded by hydrogen isotopes which fuse under the influence of the intense heat to form inert helium with release of more energy—a comparatively "clean" bomb if exploded well off the ground.

This bomb can receive yet another coat of uranium-238, which, though less radioactive than the ^{235}U needed for the atom (A) bomb, can be "split" by the large number of neutrons liberated by the hydrogen bomb. The fall-out from this fission-fusion-fission bomb (Fig. 1C) will be radioactive even if no dust is sucked up from the ground and irradiated.

Within minutes of an atom or hydrogen bomb being dropped on the free world, planes would take off with nuclear weapons from hundreds of bases. There would be a few days of holocaust, during which every activity would cease except for attempts to survive, and at the same time to destroy the enemy. After this there would be a long, long period attempting to make the world again a place in which it would be possible to exist.

There are two things that will reduce the risks of such a disaster—being strong, and being prepared for the worst. The latter in particular concerns us, and includes planning for dispersal and the teaching of self-help, first aid, and hygiene. Such preparation, costing nothing, but requiring medical backing, would more than halve the casualty rate—it might in the long run even decimate it. But more of this later.

We have said a word about the mechanism of nuclear bombs, but what of their effect? One "nominal" atomic bomb is equivalent to 20,000 tons of high explosive, more than a quarter of the total tonnage expended on the United Kingdom in five years. One H bomb of 10 megatons is equivalent to 500 times the A bomb or more than 100 times the weight of T.N.T. which fell on this country in the whole war.

Effects

The effect of either the A or the H bomb varies greatly according to the height of the burst, terrain, and weather, but the former would normally be an air burst to obtain maximal blast effect and would then be "clean," with negligible fall-out and with radiation effects only from the flash. The H bomb might well be a ground burst, and, in addition to perhaps some fall-out from an outer casing of ^{235}U , it would draw up in the mushroom cloud behind its fire ball of expanding incandescent gas many tons of dust, in which it would induce radioactivity. The radioactive flash from the H bomb loses its significance, as anything in its area of influence would also be both blasted and burnt to death.

On the burst of a bomb, the sequence would be a fantastic light flash, causing temporary blindness, radiation effects, and intense heat of short duration, igniting material depending on its constitution, colour, and screening. This would be followed by the blast effect many seconds later, allowing time to take cover under a table to seek shelter from glass and rubble. The blast would also fan fires started by the original flash.

With the "nominal" A bomb, the size of that dropped on Hiroshima and Nagasaki, almost total destruction would occur within a radius of $\frac{1}{2}$ mile (0.8 km.), severe blast, burns, and radiation effects for 1 mile (1.6 km.), and houses largely uninhabitable for $2\frac{1}{2}$ miles (4 km.). With the 10-megaton H bomb—on all targets except the large conglomerations of population a 2-megaton bomb might be more realistic—total destruction might be expected over a $3\frac{1}{2}$ -mile (5.6-km.) radius, severe damage up to 10 miles (16 km.), and slight damage up to 20 miles (32 km.). With the 2-megaton bomb there would be only slight damage at 10 miles (16 km.). In spite of the "magnificence" of the H bomb, the A bomb is still likely to be used for military purposes, where ground must later be occupied by the attacker and for some small objectives such as air fields.

Medical Organization

The medical services that must cope with this situation will be civilian augmented by the Services. Broadly speaking, the medical organization will consist of headquarters,

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forward medical aid units, hospitals (acute, auxiliary, and home cover), ambulance-car organization, and medical stores.

The hospital service and mobile units, until called out, will be administered, under the regional senior administrative medical officer, by an area hospital officer, who will be responsible for the direction of casualty admission within his area of some ten thousand beds. The principal medical officer at regional level will advise the Civil Defence Controller.

The first-aid teams, consisting of a medical officer, one S.R.N., and eight or nine auxiliaries, are "mobile"—ready to go to an incident and help to deal with serious emergencies and triage (the sorting of casualties)—or "static," to be situated at each acute hospital and helping to screen it from the less seriously injured cases and, in fact, provide a service for the walking wounded. The mobile first-aid unit is equipped with a car, 10-cwt. (500-kg.) truck, and motor-cycle. Both types of first-aid units are an integral part of the hospital service, but will be assisted as necessary

FIG. 2.—Suggested layout of a forward medical aid unit. SB₁ = Squad for off-loading. SB₂ = Squad for internal movement. SB₃ = Squad for on-loading. Triage by team of one senior medical officer, one clerk, and one nursing orderly.

by a casualty-collecting party from the Civil Defence Service. Until called out, both will work in the hospital to which they are attached, and will continue to be maintained by that hospital, but the mobile unit will be at the disposal of the Civil Defence Controller when required.

The tendency is now to group together some four mobile first-aid units to form forward medical aid units of much greater value and potentialities. With these larger units some serious attempt at sorting casualties may be made, and a suggested layout is here given (Fig. 2). On arrival patients would be "frisked," if necessary, with a geiger counter in the ambulance to see whether they need pass through decontamination, to be stripped of their clothes and washed, before entering triage. One or two medical officers of considerable experience should do the actual sorting, each accompanied by one or possibly two clerks and a nursing orderly. One medical officer might superintend both the first-aid section, from which light cases would be passed on to welfare or home, and the holding section for the very sick, though most of the care of the latter would be under the direction of a senior member of the nursing service. Two medical officers will be required in the urgent treatment section, where haemorrhage would be checked and correctable respiratory defects dealt with, and where compound fractures would receive attention. The evacuation section would require only a couple of nursing orderlies. An administrative officer could relieve medical staff of some duties and stretcher-bearers would be in three squads—one

for off-loading, one for on-loading, and one situated in a corner of the triage section for internal transportation. Two stretcher-bearers would stand by a stretcher case from its entrance, until it had been taken to first aid, holding, treatment, or evacuation, and they would then return to their rendezvous. Ambulances, after discharging cases, would proceed to an ambulance park, to be cleansed if necessary, pick up new stretchers and blankets, and then await orders.

Documentation must be of the simplest. A casualty label should be attached to the patient, if this has not already been done, with name, main diagnosis, symbols of M for morphine (with dose and time), T for tourniquet (with time), X for priority, H some haemorrhage, and R, C, XX, and P for contamination with radioactivity, blister, nerve gas, or phosphorus. Immediate disposal must be marked on the label in writing or by tabs, and if time is available the patient's address and where he was found should be added. Tabbing could be of five colours: (1) urgent, acute hospital; (2) urgent treatment and then acute hospital; (3) acute hospital not urgent; (4) hold; (5) first-aid and welfare. For the unit record, all that is required is a nominal roll of name, main diagnosis, and disposal.

An "acute hospital" will be any hospital with operating facilities expanded up to its maximum and possibly augmented by the addition of a tented extension provided by the Army. Nursing will be largely by auxiliaries supervised by S.R.N.s. These hospitals will be supported by auxiliary hospitals with approximately an equal number of beds, set up in stores, factory buildings, and the like, under the charge of a general practitioner and relying almost entirely on auxiliary nurses. They will deal with the less seriously ill cases both before and after admission to the acute hospital. In "target areas" only small "home cover" hospitals of not more than 15% normal capacity will be retained to deal with accidents and emergencies, and they will be staffed on a rota basis from one of the acute hospitals in the periphery.

All ambulances and commandeered vehicles for movement of casualties will come under the ambulance and collecting section of the Civil Defence organization. It seems likely that a key point, where a senior ambulance officer should be situated, may be the forward medical aid unit. Here, obtaining reports from ambulances arriving and keeping in the closest contact with the Area Civil Defence Controller, he will be in an excellent position to co-ordinate and control the forward "hauls" and those back to the hospital area.

Medical stores will be stock-piled at strategic points, and it is presumed that they will be under the control of the regional board.

The Army will keep in close liaison with the Civil Defence Authority, and field ambulances, when available, will make ideal forward medical aid units, while military hospitals can open hospital extensions of 200 beds within four hours, if suitably situated.

It is estimated that about 40% of casualties are likely to be due to blast—many caused by flying glass—and that about 60–70% will have suffered some burning. In the later stages radiation casualties will become a problem—perhaps 15 to 30%—but most of these will have to be treated at home.

Sorting

Triage is, of course, of the very first importance. Let us first consider the ideas of forward sorting of casualties and the experience of a large-scale exercise carried out in America in 1956, and then the ideas arising from the United Services Symposium held at the Royal Society of Medicine in June and at the Mayo Clinic in September, 1957 (*Proc. Mayo Clin.*, 1958).

A mobile team with one triage, three resuscitation, and one holding and four surgical sections dealt with 250 "casualties," 90 miles (145 km.) from their base. The "make-up" of the casualties was: major lacerations, 35%; uncomplicated burns, 29%; wounds to the ex-

tremities, 13% ; head and nervous system injuries, 8% ; chest and abdominal cases, each 5% ; faciomaxillary, 3% ; and ophthalmic, 2%. Of the total, 55% had some burning. The planning took 23 days, but as the result of this the units started work full blast within five hours of the alert.

Many lessons were learnt, but in particular the importance of the sorting section, which was staffed by four physicians of great experience. This section was hardly big enough, and it was felt that, with overpowering numbers, many of the hospital sections would have to drop their work and take over sorting and resuscitation. The whole advance station was organized into (1) triage, (2) resuscitation, (3) holding, and (4) evacuation of sections. The motto "The greatest good for the greatest number" had always to be kept in mind. Every effort had to be made not to overload the "acute hospital" section—even with relief teams the number of cases that can be operated on in the first 24 hours is very limited, and General Drummond suggests that a surgeon can operate on only 12 serious cases per day for any prolonged period. Only cases of really top priority must be thus labelled. Head cases did not as a rule merit urgent treatment. All cases were graded into (1) emergency surgery, mainly to check haemorrhage and remove devitalized tissue, (2) resuscitation, and (3) holding (non-urgent, slight injuries, and moribund).

About 50% of cases were sent to the acute hospital, 25% to distant hospitals for less urgent treatment, and 25% kept in the holding unit.

The main lessons learnt from the "exercise" were the importance and magnitude of triage and the need for a very large supply of tracheotomy tubes and blood and blood substitutes. It seemed likely that tracheotomy might very often be required in multiple injuries with C.N.S. involvement and especially when there was the complication of burns.

The Filter Unit

In the recent symposium on the treatment of mass casualties, Colonel Ahern (1957) dealt with triage and the possible use of a filter unit. He envisaged a 10-megaton bomb on a city with a million inhabitants. There might be 210,000 immediate casualties, excluding the dead. Of these, 60,000 would be light cases and 150,000 seriously hurt. Of the latter, 100,000 would be trapped and some be released, dead or alive, within a few days. There would thus be 50,000 untrapped serious casualties to be evacuated to hospitals as soon as possible. This was the debit side of the ledger. On the credit side there were over 50,000 hospital beds at distances of from 5 to 15 miles (8 to 24 km.) from the edge of the devastated area—just enough to care for the untrapped serious cases, but not enough for the trapped cases to follow. A filter unit might consist of 10 doctors, 120 nursing personnel, and 160 stretcher-bearers and "police"—that is, one field ambulance plus a company of infantry. It could filter 6,000 cases in 24 hours (allowing two minutes per patient for sorting and nine minutes for emergency surgery). It is estimated that 40% would be minor injuries, 20% urgent cases, 20% requiring delayed expert treatment, and 20% "write-offs"—labelled expectant treatment.

The unit would first turn away, after first aid, all walking wounded to a Civil Defence Welfare Centre. The remainder, after being monitored, and if necessary cleansed, would pass to the sorting department, and would then be divided into almost equal groups for immediate treatment, evacuation, and holding. This unit should therefore divert from the neighbouring acute hospitals approximately two-thirds of the cases that found their way to the sorting department.

On arrival at hospital, General Drummond (1957) suggests direct admission to the ward of cases filtered elsewhere—in this way 100 patients can be bedded down in 60 minutes. He stresses the hopelessness of overloading a hospital beyond the capabilities of its staff, and recommends the "locking of the gates" when it is full. One medical company can, however, open and admit an additional 100 patients within two hours of arriving at a hospital to which it may be

attached. If, however, casualties have not been already sorted, this must be carried out in as large a hall as possible at, or adjacent to, the hospital. In the first instance, with minimal documentation, casualties must be sorted by experts into (1) fit to go home at once or after first aid, (2) for transfer to an auxiliary hospital, (3) cases requiring admission and treatment "at leisure," (4) cases requiring urgent treatment and resuscitation, and (5) moribund.

The serious but treatable cases to be admitted to an acute hospital fall into two categories: the very urgent—easily accessible haemorrhage, correctable respiratory distress, crush injuries of limbs, and open fractures—and the less urgent—15 to 40% surface burns, major closed fractures, and damage to the central nervous system.

Types of Casualty

All who dealt with casualties in the last war will be familiar with the danger of flying glass. Much can be done in prevention by screening and sandbagging windows and taking cover. Only the most severely injured would be able to be admitted to acute hospitals. There would be no scope for professional individualism.

Burns would be on an unprecedented scale, and again only for those where expert treatment is necessary to save life and where life can probably be saved will transfusions and infusions be available—they would largely be reserved for 15 to 40% surface burns, perhaps one-third of the cases. For the remainder, sedation—sodium phenobarbitone, 3 gr. (0.2 g.)—analgesics, copious saline by the mouth, and possibly oral antibiotics and a clean covering for the wounds, will be all that is likely to be possible. Exposure to air with the burnt part raised is, however, perhaps best if practicable. The value of early amputation of a badly burnt limb must not be forgotten. Treatment for anaemia later must also be remembered.

An interesting "help yourself canteen" for the treatment of the less serious burns cases is envisaged by Hunt (1957). Instead of a bun, the customer would collect the appropriate burns dressing; for a drink there would be saline and bicarbonate of soda; and at the cash desk would be some simple printed instructions.

For abdominal casualties, treatment of shock and minimal disturbance before urgent surgery are indicated. Intravenous infusion, gastric suction, antibiotics, and sedation will probably, however, be required. Chest cases may need closure of sucking wounds, release of tension pneumothorax, aspiration from the pleural cavity, maintenance of airway, fixation of a floating chest, and, of course, infusions, oxygen administration, and antibiotics. Lower-limb fractures may indicate skeletal traction by insertion of a Steinmann pin under local analgesia through the tibial tuberosity or os calcis. For the upper limb temporary splintage is all that is required, with no attempt to reduce displacement until later. Waterson (1957) outlines the principle of treatment of fractures by the application of standard plasters, none of which surround the limb or can obstruct the circulation, and which can be put on immediately by pairs of trained orderlies as soon as the medical officer has made the diagnosis.

Radiation Treatment

In the treatment of radiation casualties a selection will have to be made of those most deserving of expert help. Prognosis is therefore the first essential. Some guide to the amount of radiation a person has absorbed can be obtained from calculation of the intensity of radiation, duration of exposure, distance from radioactive particles, and screening factors. Screening and distance factors are illustrated by the fact that 6 in. (15 cm.) of concrete quarters the dose, occupation of the centre ground-floor room of a two-storied house reduces the dosage factor by 40, and staying in a cellar by as much as 300. Intensity of radiation from fall-out at first decreases rapidly, so that an area showing a reading of 1,000 r per hour, one hour after an explosion, will have that reading reduced to 100 r per hour

in 8 hours, to 10 r per hour in 48 hours, and to 1 r per hour in three months. It must be noted that the drop in radiation is much slower in the later stages because this latter radiation is due to isotopes with much longer half-lives. 50 r in 48 hours is considered a permissible dose for rescue workers in an emergency. 100 r will produce some morbidity, 200 r 50% casualties but little if any mortality, and 400 r 50% mortality.

Prognosis on these physical factors is, however, both difficult and uncertain, as some people can absorb nearly twice as much radiation as others without serious harm. The very old and very young are the most susceptible. Pathological examinations would not only be largely impracticable but of little use. We come eventually to old-fashioned clinical medicine and observation, and particularly to timing of onset of symptoms after exposure, for our real guide. If there are no symptoms for 24 hours after exposure and then they consist only of slight vomiting and nausea, the prognosis is good. If persistent vomiting occurs within two hours (a victim may be sick because of shock or other causes), fever before seven days, or purpura or loss of hair before three weeks, the prognosis is probably hopeless. Treatment consists of rest and sedation and a bland nourishing diet with plenty of fluids. In the more severe cases intravenous fluids and antibiotics of the erythromycin wide-spectrum type, to be started after the fifth day, when the leucopenia becomes manifest, may be helpful if available.

The distribution of medical and all rescue planning will have to be governed by "fall-out." As stated before, when a nuclear explosion takes place on or near the ground a large quantity of dust is sucked up and irradiated. This will be carried by the prevailing air currents at the levels it traverses and will gradually settle again down-wind. Meteorological observations will give some indication of likely areas of fall-out, but a zone some 50 miles (80 km.) across and perhaps 200 miles (320 km.) long may be expected. Weather conditions will also determine how long a warning there may be before the fall-out settles—in some areas there may be perhaps an hour. The intensity will be at once plotted and zones demarcated on this information. The policy in the whole area must be to "go to ground," and the critical time for moving again is 48 hours. The reason for this is, as mentioned before, that the degree of radioactivity falls off rapidly for about this time and then much more slowly, and that this time is about as long as it is considered feasible to keep the population under cover. After this two-day lapse, in the periphery the population may be allowed out about half the day, a little more central for two hours, and in the centre, where there is still more than 10 r per hour radioactivity, everyone must be evacuated—but again not till 48 hours after the burst.

Conclusions

What do we learn of practical importance from these sketchy remarks?

Firstly, plans must be made in advance for dispersal of population and voluntary partial evacuation by families in target areas. As the warning period is likely to be short, previous planning is essential. As part of this evacuation, about 80% of all patients would be sent home from all hospitals and the hospitals in the target areas would be completely cleared.

Secondly, enrolment, organization, and teaching of auxiliary nurses is of paramount importance, as on these we shall largely have to rely.

Thirdly, more information must be given to the public on the grounds of reducing panic. The unknown is the worst of all, and besides this there is some reassuring information that can be given. For instance, when a nuclear bomb has dropped it is unlikely that there will ever be another in that area; that flash blindness is often temporary though lasting hours; that mild face burns may cause loss of vision due to oedema for 24 to 48 hours only.

Fourthly, the "stay put" policy must be completely accepted; not only will evacuation after an incident increase risk to the individual from fall-out but it will hamper rescue, and also there may be nowhere for the evacuee to go. A badly bombed but just habitable house is better than none at all.

Fifthly, the population as a whole must learn some first-aid, home nursing, and self-help. Not only will there be no medical services available to deal with the minor casualties, but for those in a fall-out area no help can be obtained from outside for the first two days.

Finally, everyone should know something of hygiene. With concentrated populations in "safe" areas, burst water and sewage systems, and reduced resistance, resulting perhaps from both malnutrition and radiation effects, the results of epidemics might be worse even than the immediate bomb burst. As rigid a standard of hygiene as possible would be essential. Here again the Army Medical Services, with their vast experience, will be invaluable.

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ADAPTATION TO STRESS CONFERENCE OF BEHAVIOURAL SCIENTISTS

[FROM A SPECIAL CORRESPONDENT]

The Mental Health Research Fund held a conference on "Research on Stress in Relation to Mental Health and Mental Illness" from July 15 to 18 at Lincoln College, Oxford. Its purpose was to arrive at a synthesis of the concepts used in different branches of the behavioural sciences when discussing stressful situations and stress effects, or at least to clarify the differences between the ways these terms are used. Physiology, endocrinology, biochemistry, ethology, psychology, and psychiatry each had one or more representatives, and the conference brought together some 40 scientists, American, Canadian, and British, under the chairmanship of Sir GEOFFREY VICKERS, V.C., the chairman of the Fund's research committee.

Finding a Common Language

The fare was rich and varied. It was hardly surprising, therefore, that, suffering from indigestion, some participants should have expressed doubts about the feasibility and even the desirability of achieving a useful degree of synthesis. They tended then to argue that each branch of science requires to work out its own conceptual models, and that models worked out in other branches lose their precision and usefulness if they are incautiously extended. However, there were few who were not in sympathy with the thesis, argued cogently by Professor R. W. GERARD, of the Neuropsychiatric Institute, Ann Arbor, in a final summing-up, that the behavioural sciences form a unity, and that the processes of adaptation, whether to the physical, biological, or interpersonal environment, have a great deal in common; the similarities are more impressive than the differences. Several speakers had asserted that psychosocial stressors are very different from biological stressors because their meaning and therefore their effects depend upon past experience, which differs from one individual to another. Professor Gerard countered their arguments by pointing out that biological individuality is no less evident than psychological individuality.