ORGANISATION AND TREATMENT OF AIR-RAID CASUALTIES.*

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Experience of air-raids in London has been that the proportionate incidence and mortality of casualties has been greater from bombs in the daytime than at night, although, of course, more casualties have occurred at night because of the much larger number of bombs. Of 300 casualties received, 220 were admitted on 33 occasions, at night, and 80 on four occasions in the day, a proportion of cases of less than three to one, whereas the corresponding proportion of bombs dropped must have been very much greater. Casualties result in largest number from the bomb in a crowded street, store or factory, hence the large number per bomb in the daytime; and in less number from hits involving smaller shops or houses, hence the more limited casualties per bomb at night, when the largest crowds are collected in the comparatively safe modern ferro-concrete buildings which are used as night shelters.

For similar reasons, a higher proportion of serious casualties is admitted to hospital in the daytime than at night. In 300 admissions, the mortality was 21 in 220 cases at night and 20 in 80 cases in the day, i.e., approximately 10 per cent. for night and 25 per cent. for daytime. The most severe injuries are found among penetrating wounds due to primary missiles, viz., the high velocity bomb fragments, and the larger crush injuries due to falling masonry, whereas the smaller low velocity secondary missiles such as glass produce on the whole less serious wounds. In the case of a bomb explosion in a crowded street—the usual daytime incident—casualties are due mostly to primary missiles and nearly all the cases can be collected readily and brought to hospital. When a building is hit—the common nighttime incident—the smaller structures collapse and the occupants are buried, dead, or seriously injured, the majority never reaching hospital, while the modern ferro-concrete buildings stand up to the explosion and the occupants are hit by smaller secondary missiles, the most common of which is glass.

It follows then that the proportion of severe injuries *admitted to hospital* is higher in a group of casualties resulting from the explosion of a bomb in the street, as in the daytime, than in a building, as at night. In the recent heavy night raids on London, hundreds of casualties were admitted to the hospitals, nearly all due to falling masonry, about 75 per cent. glass, but there were very few major injuries. In one night, among 120 cases admitted to two hospitals, there were only three deaths.

This serves to emphasise the value of shelters and corresponds with the experience in Spain, where, of course, day bombing was a menace, and the establishment of street shelters rapidly lowered the incidence and mortality of casualties. The problem in this country, as it has turned out, is mostly one of night shelters, but the fact that our street shelters, which were erected hurriedly and have come in for criticism, have not been much used, calls for thanks to our air force rather than criticism of our civil defence authorities. Had our defence not been so adequate, we should certainly have been thankful for the street shelters, as they were in Spain.

FIRST-AID.

Casualties are collected by the first-aid parties and in the daytime not infrequently patients are brought in also by private car, taxi or lorry. The work of the first-aid parties and ambulances has been splendid and casualties arrive within a few minutes of the explosion owing to the speed with which they work, often under terrifying conditions. The only serious criticism that can be made of first-aid work is excessive use of the tourniquet. Very few cases of serious primary hæmorrhage occur and a straightforward dressing and bandage are usually sufficient to stop bleeding. The correct application of a tourniquet is not easy, especially when attempted hurriedly, and cases have been admitted with wounds bleeding as the result of inefficient tourniquets, although probably a large number of these have been applied not by first-aid workers, but by patients' friends and others at the scene of the explosion.

* A lecture given to the Bedford Medical Society at Bedford County Hospital on April 29th, 1941.

A tourniquet applied too loosely is inefficient because it causes more bleeding, but a correctly applied tourniquet may even be worse because the diminished blood supply may well be a factor responsible for the establishment of infection in the wounded area, particularly in the presence of muscle injury. The tourniquet should therefore be reserved for the occasional severe primary arterial hæmorrhage.

Directions to the first-aid worker were excellently summed up by Dr. Roe in a letter to the "British Medical Journal" on 15th March, 1941. He gives the following instructions:—

Rapid clearance is the primary concern.

Only absolutely essential first-aid is to be given.

Tourniquets are seldom to be used.

No elaborate bandaging and splinting.

Hot water bottles are supplied in the ambulance.

First-aid exercises in the dark are part of the training.

It might be added that while *elaborate* bandaging and splinting are inadvisable, efficient splinting of a fractured long bone is important as a means of diminishing pain and thereby shock.

FIRST-AID POSTS.

Disposal of cases should be direct to the hospital without delay at a first-aid post, or alternatively all first-aid posts should be attached to hospitals, as emphasised by Trueta, so that transfer of cases between hospital and first-aid post is simple.

Organisation for air-raids having been based largely on principles developed in the last war, first-aid posts were established in positions corresponding to the advanced dressing stations of the battlefield, but, as has been pointed out, aerial bombardment of a city is more comparable to siege warfare, in the casualty organisation of which the hospitals are in the actual fighting zone, so that intermediate casualty posts are time-wasting and therefore harmful. Rapid admission to hospital where shock can be adequately treated and wounds can be excised is the essential point. "Apart from the tourniquet for excessive bleeding, the only useful form of first-aid is immediate surgery" (Trueta).

RECEPTION ROOM.

Casualties are examined and classified in the reception room by a responsible person, usually the senior surgeon on duty, since this is a most important undertaking. All clothing is removed so that no wounds may be missed. In the more seriously shocked cases, resuscitation treatment is commenced immediately and the patient is left on the stretcher to save unnecessary shifting.

Short notes are made on a single typewritten sheet hung on a board at the foot of the bed. Each bed has a prominent number for easy recognition of cases for the theatre.

Cases are conveniently classified into two groups according to the need for operation.

1. Cases not requiring operation.

(i) *Cases without serious external injury—*

Shock and blast injuries.

Concussion.

Abrasions and contusions.

Simple fractures.

(ii) *Penetrating injuries in which operation is inadvisable—*

Foreign body in the brain.

Through and through wounds of chest.

(iii) *Hopeless cases*—

Eviscerated abdomen.

Large compound fractures of skull and laceration of brain.

2. Cases requiring operation.(i) *Immediately*—

Primary hæmorrhage.

Perforating wound of abdomen.

(ii) *When convenient*—

The majority of lacerations, penetrating wounds and compound fractures without shock.

Simple fractures.

(iii) *After resuscitation*—

Lacerations, penetrating wounds and compound fractures with shock.

Burns.

The preoperative disposal of these cases must now be decided, the alternatives being to transfer them to the wards for preparation and resuscitation, or to carry on these in the reception room without shifting the patients. We have found it more convenient to use the reception room for resuscitation and preoperative treatment, for several reasons :—

(i) It saves moving the patients twice.

(ii) It saves time and energy to have the patients in one or two rooms as they need frequent observation, and intravenous infusions can be supervised more easily.

(iii) It is easier to arrange and revise the operation list.

(iv) Our operating theatres are situated close to the reception room and between it and the wards.

We have found this method of combined reception and resuscitation rooms satisfactory and would recommend it.

OPERATION LIST.

The cases for operation having been listed, it is most important for *one* individual to supervise the transfer of cases to the operating theatres. This duty is an essential one and time may be wasted if it is not running smoothly ; it is conveniently carried out by a resident medical officer or registrar.

CAUSE OF INJURY.**(i) High Explosive.**

The pathological results peculiar to high velocity missiles are of course dependent on the momentum acquired by these small projectiles travelling at speeds of 3,000 to 5,000 feet per second. In a penetrating injury due to an object of small momentum, as in civil practice, the area of damage is limited to the immediate vicinity of the wound track, whereas with a rapidly-moving object there is a large area of hæmorrhagic devitalised tissue extending for several cubic inches around the actual track of the missile. There is an effect like an internal explosion, this destructive effect being due to the momentum imparted to the tissues around the track by the high velocity missile. (Zuckerman.) It is particularly the contusion and devitalisation of a large mass of muscle which is so dangerous and which calls for immediate and adequate excision.

(ii) Blast.

Contrary to expectation, morbidity due to blast has been slight. In over 300 admissions we have seen no case in which we could diagnose blast injury with certainty, and few in which there were any suggestive signs. It will be remembered that, in his address on this subject

to the Royal Society of Medicine, Zuckerman pointed out that, except for large bombs, blast is not experienced further than 20 feet from the explosion. The wave of blast pressure drops very rapidly as shown in the curve.

CURVE OF BLAST PRESSURE.

(From A.R.P. Handbook No. 5. With acknowledgments to the Controller of H.M. Stationery Office).

It will be seen that at 14 feet distance the pressure is 110 lbs. per square inch, whereas at 30 feet it is only 15 lbs. The margin between being killed and being uninjured is therefore small, which may help to explain the small clinical incidence of blast. Whatever the reason, general experience has been that the number of cases of lung lesion in which blast may have been a factor is very small.

Furthermore, even in cases of recognised lung injury without external wound, it has to be borne in mind that pulmonary hæmorrhages due to blast are no different in appearance from those due to direct injury of the chest apart from blast. This has been pointed out by Robb-Smith and by Zuckerman, who states: "The conditions which in air-raids predispose to internal injuries without penetrating wounds are so numerous that care should be exercised before it is decided that any instance of lung hæmorrhage is either partly or wholly due to the direct effects of a blast wave."

(iii) Falling Masonry.

Injuries due to secondary missiles may be large, involving the crushing of a considerable amount of tissue by a heavy piece of detached masonry, or small, due to penetration by a small missile, of which the most common is glass. The latter are much the more numerous among cases admitted, because a large number of the serious crush injuries never reach hospital. Casualties due to glass are considerable, constituting about 75 per cent. of the cases due to secondary missiles.

In the presence of an open wound, the important distinction between large and small injuries is the amount of muscle damage.

(iv) Burns call for no special comment.

CAUSES OF MORBIDITY.

Morbidity in casualties may result in one or more of three ways :—

1. Immediate danger to life, e.g., shock, hæmorrhage or injuries to vital organs.
2. Sepsis, e.g., infected lacerations, compound fractures or burns.
3. Deformities, e.g., fractures, burns or nerve injuries.

Apart from trivial injuries, therefore, such as abrasions, or contusions in non-vital organs, the three indications for treatment are : to save life, to prevent sepsis, and to prevent or correct deformities, and every case should be treated with reference to these three considerations.

Treatment may be conservative, as in the treatment of shock or prevention of sepsis by drugs and sera, or operative as in the control of hæmorrhage, excision of wounds or manipulation of fractures.

Indications for Operation.

We may summarise the indications for operation as—

1. *To save life.*

Experience of air-raid casualties shows that the number of operations performed to save life directly is extremely small. Presumably the majority of patients with such injuries do not survive to reach hospital. The causes of death being coma, syncope or asphyxia, operation to save life may be called for in

Cerebral hæmorrhage with compression.
Primary hæmorrhage and cardiac injuries.
Open pneumothorax.

2. *To prevent sepsis.*

This is the most important indication for operation. It is the most common, gives gratifying results, and is the most useful economically as on its success depends the rapid restoration of man-power. In this group are—

Lacerations and penetrating wounds.
Compound fractures.
Burns.

3. *To avoid deformities.*

This is important from its frequency and economic value, since it includes cases of—

Fractures.
Nerve and tendon injuries.
Burns of extremities.

We may now consider the treatment of some of the commoner conditions with special reference to these three indications.

BURNS.

The immediate danger to life is shock associated with so-called burn-toxæmia ; whether this is due to loss of proteins or absorption of toxins, it is undoubtedly best treated by coagulation. Hence if the burn is one which threatens life by shock as in the trunk coagulation treatment is indicated.

The prevention of sepsis is attempted by preliminary excision. Sepsis may occur during the course of treatment by any means because it depends mostly on the presence of sloughing, which is itself dependent on the original extent of the burn. Hence no method should necessarily be criticised on the grounds of the development of pus ; for the same reason however, the better treatment should be the one which does not intensify the amount of necrosis of tissue and which tends to promote separation of the sloughs. On these grounds, open treatment, e.g., by saline and sulphonamides is preferable to any closed coagulant treatment particularly if associated with tissue destroying agents such as silver nitrate.

The prevention of deformity is undoubtedly better attempted by open treatment than by coagulation. Hence, wherever the dangers of deformity are so vital, as in the hands and face, coagulation should not be used, provided life is not thereby endangered.

Hence we can conclude that the factor to decide in choosing treatment for a burn is the *situation* of the lesion. Burns of the trunk, covering a large area, are a danger to life and therefore the best means of diminishing burn-toxæmia should be used, this being treatment by coagulation. Burns of the hands or face do not threaten life by toxæmia; the most important indication is to avoid deformity which is best attained by non-coagulation methods. In the later stages of coagulation treatment, when the immediate danger is past and sepsis develops due to sloughing in a deep burn, it is best to proceed to open treatment by saline or hypochlorites to hasten the removal of dead tissue and skin graft after preliminary sulphonamide therapy.

INJURIES OF THE HEAD AND TRUNK.

On the whole, the necessity for operation directly to save life is usually fairly clear, as for example in primary hæmorrhage or in open pneumothorax.

The need for operative interference in the prevention of sepsis is often however more difficult to determine. Among the more important considerations are: the tissue involved—little can be done for damage to the brain, whereas a mass of damaged bowel can be excised; the nature and size of the wound—a laceration requires excision, while a through-and-through wound may be treated conservatively; and the presence of a foreign body and its size and position—if small in the liver for example it may be left alone, while if large and in the periphery of the lung it might be removed.

HEAD INJURIES.

Our experience of these wounds conforms to the usual standards, viz., that the treatment of the brain injury is conservative and that of the parietes operative. Thus, cerebral lacerations associated with the larger compound fractures usually die, and the smaller penetrating injuries with deep foreign bodies are sent for observation to the head centre; an occasional cerebral hæmorrhage with compression is the only life-saving operation called for. Operative treatment is indicated in open wounds of the parietes to prevent sepsis in lacerations of the scalp and the smaller compound fractures.

ABDOMINAL INJURIES.

The prognosis of abdominal injuries is serious; all our cases of penetrating wounds of the abdomen have died. Most large abdominal wounds with evisceration die within the first few hours and although in the few cases of this type that we have had immediate operation was performed, we have no doubt that with further experience of them we should probably reach the same conclusions as Trueta, who advised leaving them alone unless there were no other casualties to be dealt with, since they seldom repaid operation.

The small penetrating injuries are again very serious, but of course require laparotomy.

CHEST INJURIES.

We have seen very few chest injuries; no doubt the more severe such as crush injuries never reach hospital. Operation to save life is called for most commonly for hæmorrhage and open pneumothorax, and to prevent sepsis in the case of retained foreign bodies with laceration of lung tissue.

In comparison with abdominal injuries, the prognosis is less serious. The larger injuries of the chest, with hæmorrhage and considerable laceration of lung, frequently repay thoracotomy so that they should be operated upon as a general rule. In the smaller wounds, such as penetrating injuries with retention of foreign body, it is often difficult to decide the right line of treatment. In the absence of need for urgent operation, such as hæmorrhage or open pneumothorax, the risks of operation have to be balanced against the chances of development of sepsis, either in the immediate, or the remote, future. Important points in making this decision are therefore: accessibility of the foreign body—the more peripheral it is the less the operative risks; the size of the foreign body—the larger it is the larger the amount of lacerated lung and the more likely the onset of sepsis; and the general condition of the patient.

INJURIES OF THE LIMBS.

The main indication for treatment is, of course, the prevention of sepsis, in the execution of which early and adequate excision of the wound are essential. More recently the sulphonamides have been established as a valuable adjunct in treatment, but not to the exclusion of surgery. Points to be stressed are, firstly, the importance of the time factor in the excision of wounds, and secondly, that the urgency of operation varies directly with the amount of muscle damage. The larger the extent of devitalised muscle, the more important is the need for early excision. Hence the limb wounds that should be treated earliest are those caused by penetration of high velocity projectiles and the larger crush injuries, while the majority of smaller penetrating wounds and lacerations due to secondary missiles (mostly glass) are less urgent.

Following excision, small wounds may be closed by primary suture, but the larger wounds involving muscle are best left without skin suture, and there is no doubt that the ideal treatment for these is by immobilisation in plaster of paris.

The post-operative treatment of large lacerations and compound fractures has been revolutionised by the large scale adoption of fixation in plaster of paris. This technique has proved its place so quickly and smoothly that it is difficult to believe that its value was ever in doubt, but actually it is only during the last few months that it has been accepted as a standard technique in this country.

At present plaster is the routine, and reasons have to be found for not using it rather than the converse. A great debt is owed to Trueta for his work in the popularisation of the plaster technique and also for his recommendations on numerous other points in connection with organisation and treatment of air-raid casualties, nearly all of which have proved their accuracy.

The advantages of plaster are considerable, the more important being : optimum progress of wounds, with exclusion of infection ; avoidance of dressings ; comfort to the patient ; ease of transport.

Treatment of Foreign Bodies in the Limbs.

In general, the presence of a foreign body in the tissues does not of itself call for treatment, but only in so far as it is responsible for causing sepsis. In this respect metallic fragments and glass are much less important than pieces of clothing and dirt from house or street, although the amount of associated tissue damage is greater with the larger solid foreign bodies, and this it is most important to excise.

It will be found that quite a number of small foreign bodies, such as bomb fragments and glass, will not be located at operation, but provided adequate excision is performed they do not often interfere with healing.

Radiography of Limb Wounds.

Routine radiographs in limb wounds have not been taken ; in the excision of wounds only the larger and accessible foreign bodies are removed, so that the previous localisation of all foreign bodies is not essential, and, in any case, cloth, grit, etc., do not, of course, show. Fractures, joint lesions or doubtful cases should be radiographed.

Sulphonamides.

We have used the sulphonamides in the standard prophylactic doses as recommended and have found no ill-effects. Experimental work by D. Stephenson and H. E. Ross (1940) and others is strongly in support of its use, especially by local application to wounds, and as early as possible. F. Hawking (1941) has demonstrated particularly the importance of immediate treatment in experimental gas gangrene, a delay of only two hours considerably reducing its value, and six hours rendering it useless.

SUMMARY.

Bomb for bomb, casualties admitted to hospital are more numerous and severe in daytime than at night. The reasons are essentially the greater destructive power of primary than secondary missiles, and the greater ease of collection of street than of " building " casualties, in which the more serious may never reach hospital.

The essentials of first-aid are: rapid collection, adequate splinting and avoidance of unnecessary tourniquets.

Classification of cases is made conveniently into two groups according to the need for operation.

It is recommended that reception and resuscitation rooms should be combined.

The causes of injury may be: primary missiles from the bomb, blast, secondary missiles from falling masonry, and burns. Clinical cases of blast are infrequent.

The indications for treatment are three: to save life, to prevent sepsis and to avoid deformity.

Treatment of burns should be directed to three indications, viz.: shock associated with burn-toxaemia, sepsis, and deformity resulting from delayed healing, their relative importance and treatment being decided by the situation of the lesion. Coagulation treatment is indicated in trunk burns, to mitigate toxæmia, but not in the extremities, where prevention of deformity is important.

In head injuries treatment of the brain is conservative and that of the parietes operative. The larger wounds are usually fatal; smaller injuries, such as lacerations and compound fractures, are excised and do well.

The prognosis in abdominal injuries is serious. The larger wounds seldom survive operation; the smaller wounds may recover after laparotomy.

The prognosis is better in chest than in abdominal injuries. As a general statement, the indications for operation are the converse of those for abdominal wounds, i.e., the larger injuries usually need thoracotomy, whereas the smaller wounds may often be treated conservatively.

The main indication for treatment in wounds of the limbs is the prevention of sepsis in which early and adequate excision is the essential, urgency of operation being in proportion to the amount of muscle damage.

Post-operative immobilisation in plaster is the best treatment for larger wounds.

Foreign bodies in the limbs are of importance only in so far as they are responsible for introducing sepsis and of themselves do not interfere with healing provided adequate excision of devitalised tissue has been performed.

Routine radiography of limb injuries is not regarded as essential.

Prophylactic sulphonamide therapy is now standard, and its local application is probably the most effective route.

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