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PREPARATION OF BATTLE CASUALTIES FOR SURGERY

LT. COL. HENRY K. BEECHER, M.C., A.U.S.

CONSULTANT IN ANESTHESIA AND RESUSCITATION

MEDITERRANEAN THEATER OF OPERATIONS

IN CARING for the man wounded in battle we are at first concerned solely with what he needs to make it possible for him to withstand transport to the hospital and then to meet the stress of emergency surgery. All else, even the question of ultimate survival, is secondary. The conditions that are to be overcome, the increasing forces that must be opposed, and the means used are the subject of this report. Conditions within the patient arising directly from the wound as well as adverse external circumstances that influence his condition will be discussed, but the emphasis here is on treatment.

THE WOUNDED PATIENT

The enemy has produced the worst wound he could, and its consequences are cumulative—dehydration increased by unusual fluid loss in sweat and vomitus, continuing hemorrhage or plasma loss, pain making rest impossible, increasing emotional exhaustion, developing infection—these and other factors are set in operation by the initial wound. Their progress in the seriously wounded is to be checked in most cases only by surgery or by death. Resuscitative measures give a temporary stay and make successful surgery possible in the severely wounded; but in most cases true release from the consequences of the wound is effected only by surgery. Surgery is not only the goal but is itself a part of resuscitation in the broad sense. Any other view is likely to lead to unfortunate separation between the activities of the "shock team" and those of the surgical team. Care of the wounded man must be continuous and supervision uninterrupted.

Good preparation of the patient for his initial surgery, as well as for the days to come, requires considerate treatment of his pain as well as of a number of psychologic and emotional problems. While lack of understanding in handling these may at the moment be less important than surgical action, a lack of skill here may leave scars as permanently harmful as poor surgery.

PAIN*

The initial assumption of the writer, in common with most physicians

* This has been considered in detail elsewhere. See Beecher, H. K.: Pain in Men Wounded in Battle. In press, 1944.

treating the wounded, was that bad wounds are generally associated with bad pain. This was early found to be incorrect. Careful observers in battalion aid stations estimated that only about one-fifth of the freshly wounded had bad pain. Random samplings of groups of patients in the rear supported this view; but it was feared that in these cases too much time had elapsed to permit accurate evaluation, and that possibly the patients were amnesic for the early hours following wounding. Accordingly, when it became possible to study wounded men in the most forward hospitals on the Cassino Front, at the Anzio Beachhead and later in France, this was done; 225 freshly and seriously wounded soldiers were considered in five groups: 50 patients with compound fracture of a long bone, 50 with extensive peripheral soft-tissue wounds, 50 with a penetrating wound of the thorax, 50 with a penetrating wound of the abdomen, and 15 with a penetrated cerebrum. None of the men considered here was in shock at the time of the questioning. (If in shock at entry, questioning was delayed until this had been overcome.) As nearly as possible consecutive cases were considered. Ten of these had to be ruled out of consideration because they were not mentally clear. Nine of these ten had penetrating head wounds. Disregarding for the moment the entire group of head wounds, only one patient of the remaining 201 was not clear mentally and alert.

Of all of the various types of wounds considered, patients with penetrated abdomens have by far the most pain. This may be due to the spilling of blood and intestinal contents into the peritoneal cavity. Infection may have a part in producing the severe pain observed. Only one-quarter of all of the patients on being directly questioned soon after entry in a forward hospital said they were having enough pain to want further pain relief therapy. Three-quarters did not wish such relief, notwithstanding the fact that the most recent morphine had been given several hours before (4.8 to 7.2, average for the various groups). In the paper referred to, evidence is presented to show that the difference between the one-quarter of the seriously wounded men that wanted further pain relief therapy and the three-quarters that did not, cannot be explained by differences in dosage or timing of the morphine administered. From the data presented it is clear that morphine is, unfortunately, often administered by rote and not according to need. The use of morphine in the treatment of pain was considered in detail in the other paper and will not be discussed further here.

Thoughtful appraisal of wounded men will show that wound pain is only one cause of suffering. Mental agitation and thirst are factors that may be as important to the patient as pain. The excitement and hyperactivity sometimes encountered in the wounded and ascribed to pain may have their origin not in pain, but occasionally in cerebral anoxia, and more often in mental distress. Repeatedly it was found that a small dose of a barbiturate would provide relief not obtainable by reasonable doses of morphine. Barbiturate sedation offers a real addition to the treatment of the distress of wounded men. Small doses of barbiturates (60 mg. sodium

amytal intravenously) and small doses of morphine will frequently accomplish what large doses of either will fail to do satisfactorily. (See *loc. cit.*)

In men in severe shock thirst causes more suffering than wound pain.

In terms of planning, care for the mental and emotional problems of the patient falls within the sphere of the chaplain and the psychiatrist. In practice they often have to be dealt with by the medical officer in charge of the preoperative ward, or by the surgeon. Since part of the rôle of chaplain or psychiatrist may have to be assumed at times by the ordinary physician, some of the responsibilities to be encountered will be mentioned.

THE PHYSICIAN

His Relationship to the Patient.—In the psychologic preparation of the wounded soldier for operation, one must bear in mind that in a high percentage of cases these men are young and their reactions immature. The usual emotional instability of youth has been exaggerated by harrowing experiences. As a result of these the injured have wounds, pain, fear, anxiety. Paternal authority and guidance have been lost and must be assumed by someone. The wounded man seeks it in the chaplain, in the doctor or in his nurse.

Following the confusion of the early hours after wounding, some patients become euphoric. While this is probably more often to be encountered in the early postoperative period, it is sometimes met in the preoperative ward, and may be based upon the overwhelming realization that come what may, the war is suddenly over for the individual. Later the realization that for a longer or shorter time the independent man has become dependent: self-reliance is no longer enough, and a profound depression may follow the euphoria. Major Douglas Kelling observed this sequence strikingly in his study of men who had amputations.

The surgeon's first approach to his wounded patient is the most important. He should hope to portray the trusted family physician, being cheerful and self-confident but not casual. This confidence in his own ability is transferred to the patient. (The tactful chaplain will further build up the patient's confidence in the surgeon.) Consultations in the view of the patient are to be avoided. He is likely to think he is worse than the facts justify.

What to tell the wounded patient who asks questions is one of the most difficult problems of the preoperative period. In the case of the correctible wounds—even amputations are in a sense correctible—much can be accomplished. If the need for an amputation is probable but not certain, tell the patient it may be necessary, but that everything possible will be done to save his limb. If the patient will unquestionably have to have an amputation, his general condition permitting, he should be told before operation. But do not leave it there. Point out that many others have had this same experience and have gone on to live normal lives, both maritally (there is much anxiety concerning this) and economically normal.

Failure to tell a patient ahead of time that an amputation, for example, will be necessary may lead to lack of confidence in his future care.

Far more difficult problems are the "uncorrectible" lesions—great facial disfiguration, total blindness, loss of genitalia, spinal cord transection. The extent of these wounds is usually not certain before operation and positive statements concerning them usually must await operation. The only help such a patient can be given is confidence that he will get good care and that everything possible will be done; definite answers to his questions cannot be given until later. The proper psychologic handling of this group of patients needs study.

Relationship of the Physician to the Chaplain.—The commanding officer or the physician in charge of the patient is often inclined to appraise the value of the chaplain in terms of his (the officer's) personal need for religious support rather than according to the need of the newly wounded man: "There is nothing the chaplain can do that the good physician cannot accomplish." Nonetheless, a fair minority of the seriously wounded are not mentally at ease until they receive spiritual attention. They are lacking and suffer without it. The physician who assumes that he is good at handling such matters often is very bad.*

The physician too infrequently recognizes that a man's spiritual life is a private matter and is too often reluctant to grant that opportunity for private discussion desired by the patient. (Chaplain M. I. English: This can be compressed to two minutes.)

Dividing the army into two classes, the following generalizations can be made: (a) The enlisted men (in the combat zone at least) are far more religious than expected; where they have grown away from the church, it is usually through carelessness, a passive process. The enlisted man has confidence in the help the chaplain can bring. He wants religious help in a crisis. (b) The officer class presents more education. Members of this group often actively reject religion through an intellectual process. Others are indifferent or "superior" on a "logical" basis. Still others, and many of the best officers are in this group, on recognizing intelligence in the chaplain equal to their own, will act on the assumption that the chaplain knows what he is up to. Since he is not stupid and really believes he has something to offer, the chaplain is permitted to go ahead, although many of these same officers would be hard put to it to give a rational description of what the chaplain could do.

The physician must beware of projecting pastoral care upon the wounded man too abruptly. "Am I that bad, Doc?" The chaplain can stroll in and approach the patients casually, not as though he were arranging a volley ball match and time was short.

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* The writer is particularly indebted for good advice on these matters to Captain M. I. English, a chaplain of wide experience in dealing with the freshly wounded, and to Major Douglas Kelling, Psychiatrist for the 45th Division, also widely experienced with such problems.

THE CHAPLAIN

The successful chaplain, if he is to care well for the wounded, must grasp the fact that the soldier has been torn from his familiar life and thrown into a strange milieu where old standards of conduct are ignored or escaped deliberately. The patient's animal spirits have led to adventures that he knows to be wrong, according to his earlier training. He is wounded and suddenly, unlike the pious old lady who has contemplated death for years, new thoughts of death are thrust upon him with insistence. "As soon as I got wounded I thought: 'Damn it, I would have to die without the priest.'" He is confused, but mostly he is frightened, and the chaplain as an expert in straightening out misadventures is heartily welcomed. Major Kelling confirms Chaplain English's statement that feelings of guilt are common in the wounded and that discussion of these with the chaplain is helpful to the patient's effort to acquire serenity.*

The presence of the chaplain is especially important to those whose religions embody a ritual of death, chiefly Catholic. "Am I to die?" Priest: "Some do; you might." Contrary to widespread assumption the administration of extreme unction need not alarm. While the point of view is difficult for the writer to accept, both experienced chaplains and experienced psychiatrists insist that it is sometimes desirable to tell a man he is going to die, that such knowledge correctly imparted does good. "My religion is supposed to help me now," and anguished hope gives way to tranquility is the idea. Maybe so, but certainly with the improvements in medicine of recent years, more caution than ever before is necessary if such statements are ever justified.

ADVERSE EXTERNAL CIRCUMSTANCES

In a study by Beecher and Burnett** it was shown that about 2.5 per cent (of 2853) wounded men arrived at an Evacuation Hospital† in need of particular care in resuscitation, with surgical shock either seriously impending or present. Conditions and processes within the patient in part responsible for the poor condition of these patients were referred to above. External circumstances that tend to increase the number of patients arriving at the hospital in poor condition are chiefly these:

* In the experience of the writer, apathy is uncommon in the preoperative ward; sometimes it will be encountered, particularly in those with head wounds, occasionally in men in shock. Anxiety and pain may have led to the need for and use of sedatives and narcotics. Later, memory of this period is often found to be lacking. During convalescence the wise chaplain may be obliged to go over the same ground in discussion several times.

** Beecher, H. K., and Burnett, C. H.: Report to the Surgeon, North African Theater of Operations, July, 1944. Field Experience in the Use of Blood and Blood Substitutes (Plasma, Albumin) in the Treatment of Seriously Wounded Men. The Medical Bulletin of the North African Theater of Operations, **2**, No. 1, 2, July, 1944.

† Most of these (2296) were at Anzio, where the hospital bore the same relationship to the front as a field hospital.

Exposure.—This theater has provided a rich variety of geographic and climatic conditions, desert heat and mountain snow storm, dry country and marshes, high elevation and low. Whether exposure may lead to heat exhaustion or to freezing, it is usually associated with inadequate food and fluid intake and with poor rest. *Delay* in the field or along the evacuation chain lowers the patient's reserves. *Rough handling* may be unavoidable in litter transport down mountain trails, or in prolonged ambulance hauls over rough roads; but it often precipitates shock. *The forward treatment* received in Battalion Aid Stations, Collecting Companies and Clearing Stations will be considered below under various headings. In passing, it may be mentioned that this occasionally accounts for part of the poor condition of casualties as they arrive in the forward hospital. Common errors: Overmedication (morphine), too much plasma or too little, failure to recognize and close an open pneumothorax, failure to check serious hemorrhage, transport of patients with head and pharyngeal wounds on back instead of prone as they should be, failure to protect the patient properly during transport. This ranges all the way from poor splinting of broken bones to inadequate blankets, especially underneath the patient in cold weather.

Chart I shows, for the several types of installations, size, position, representative distance apart, duration of the patient's stay in, and the usual means of his transport along the line of evacuation. In the *Battalion Aid, Collecting* and *Clearing Stations* only the simplest procedures are undertaken, and these with the single aim of making the wounded man transportable—splints and tourniquets are applied, hemorrhage staunched, bandages placed, sucking chest wounds closed, plasma and morphine administered if needed. Nothing is done here that will make the man non-transportable.

At the Clearing Station the patient's condition is appraised and a decision reached as to whether he must be taken at once next door, to the Field Hospital, for initial emergency surgery, or whether it is probable that he can withstand the further journey of several miles to the Evacuation Hospital where surgery will be carried out. Minor as well as major wounds are treated in the Evacuation Hospital.

Many factors in addition to the patient's immediate condition must influence the decision in the Clearing Station of where to send him: whether the road connecting with the Evacuation Hospital is good or bad, long or short, difficult for blackout driving or not. Also pertinent is the fact that conditions in the Field Hospital are likely to be, because of the very nature of the installation, less satisfactory than in the larger, more completely staffed Evacuation Hospital farther in the rear. This is no commentary on the staff of either installation. For that matter, the mobile auxiliary surgical teams are important in both. With their smaller staff resuscitation may be slower in the Field than in the Evacuation Hospital. Conditions for postoperative care may be poor in the former. For example, the Field Hospital is often far forward, near, and sometimes in front of, the heavy

artillery positions. The cannonading makes it difficult for the postoperative patient to get the rest he needs. But the well-placed Field Hospital significantly shortens, in comparison with the Evacuation Hospital, the time between wounding and definitive surgery. In cases where time or poor condition contraindicate farther transport, the Field Hospital is invaluable.

CHART I

THE EVACUATION CHAIN

Representative Distances
and Usual Type of Transport

LINE OF COMBAT

(The casualty remains here from minutes to days following wounding)

500 yards
(litter carry or walk)

BATTALION AID STATION — BATTALION AID STATION — BATTALION AID STATION

(minutes to hours here)

1 mile
(litter carry or walk)

COLLECTING STATION — COLLECTING STATION — COLLECTING STATION

(minutes to hours here)

5 miles
(ambulance)

FIELD HOSPITAL — Adjacent litter carry — DIVISION CLEARING STATION (100 beds)

PLATOON (100 beds)

(1-12 days here)

(minutes to hours here)

5 to 15 miles
(ambulance)

EVACUATION HOSPITAL (400-750 beds)

(1-12 days here)

Up to hundreds of miles
(railroad, motor, water
or air transportation)

FIXED HOSPITALS

Station (250-400 beds)
General (1000-2000 beds)

Eventually, the patients operated upon in the forward area are moved to the rear. As many as possible are returned to duty wherever this is possible along the evacuation chain. If this is out of the question the patient is moved as soon as possible to the fixed installations, the Station and General Hospitals. Here reparative surgery designed to return the patient to duty, to speed healing, to prevent irreparable damage or deformity is carried out. (Since these units serve garrison troops emergency surgery is also undertaken in them.)

MANAGEMENT OF THE PREOPERATIVE AND SHOCK WARDS

During the Tunisian, Sicilian, and Italian campaigns many arrangements for handling preoperative patients were tried out. Many of these plans ended in acute dissatisfaction on all sides. While details of arrangements will (and should) vary from one installation to another, experience has shown that the most satisfactory plans all embody the following:

Personnel for Field Hospitals.—The continuous service of one man in charge is important for a period of weeks at least. This individual will be chosen from the internists or the junior surgeons. Indefinite assignment of a surgeon to this post usually leads to discontent and eventually poor care. Twelve-hour stretches of duty are satisfactory, even during heavy drives; but longer periods of work will in two or three days lead to inadequate performance during rush periods. One man must be in charge; but another physician should be trained to cover half of the 24-hour day. At least one nurse or corps man (preferably both) should be on duty at all times to assist the officer in charge.

Personnel for Evacuation Hospitals.—Here, again, one man should be in charge, but unlike the Field Hospitals where all admissions deserve "shock" treatment, the majority of patients in the Evacuation Hospitals do not need detailed resuscitative measures (about 2.5 per cent do). In the Evacuation Hospitals, because of the large volume of patients during drives, two officers should be on duty at a time. One man directs the flow of patients through the preoperative ward to surgery and separates out the patients who are in poor condition. These will be given into the care of an officer who will attend the severely wounded men in poor general condition. At least two corps men and two nurses on duty will be needed at all times.

Relationship of the Surgeon to the Preoperative Ward.—A common and serious mistake occurs whenever this ward is used as a kind of valve to regulate the flow of patients to surgery. The optimum time for surgery will be discussed below. There is no known relationship of it to the number of casualties awaiting treatment, presupposed in the flow-meter point of view. The preoperative ward functions satisfactorily only when the surgical chief of service makes frequent visits to it, for he, in collaboration with the officer in charge of the ward, is best qualified to establish priority of operating time. As early as possible cases awaiting operation will be assigned to specific surgical teams. The surgeon, whose patient a given case is, will then, insofar

as it is possible, share in decisions regarding preparation for operation. It is difficult to overemphasize the error of any system which permits one group, as that in the preoperative ward, to carry a patient so far and no farther, then to have his care assumed by a new group, the surgical team, completely unfamiliar with the patient. Good care necessitates continuity of attention.

Routine Procedures in the Preoperative Ward.—The care of the badly wounded patient will be described below; but, in general, all clothing is removed at once on admission of the patient. Many flagrant oversights have their origin in failure to observe this simple direction.* The litter is checked for adequate blankets under as well as over the patient. A complete physical examination is made, and his care planned. If in poor condition, he is sent to the part of the tent set aside for such patients, under the care of the "shock team."

THE PREPARATION OF THE BADLY WOUNDED MAN FOR SURGERY

Surgery imposes a strain; how severe it may be is suggested by the following figures, on the duration of typical operations in the combat zone:

TABLE I

DURATION OF 130 TYPICAL MAJOR OPERATIONS†

Operation	Number of Cases	Average Duration (Minutes) (Anesthesia Induction Time Not Included)
Neurosurgery:		
Craniotomy (dura opened)	20	109 ± 11
Laminectomy	10	122 ± 7
Celiotomy	20	117 ± 12
Thoracotomy	20	148 ± 14
On Extremities:		
Vascular injury (involving ligation of large vessel)	20	62 ± 5
Compound fracture of femur (includes time to apply spica)	20	83 ± 8
Thigh amputation (guillotine)	20	69 ± 7

Of the wounds considered here, only those of the extremities could be dealt with surgically in one hour; those of the head, chest or abdomen required two hours. In World War I, operations upon the extremities constituted a higher percentage of the total number than now. The belief that major surgery in war time rarely exceeds one hour may have arisen from that earlier experience, no longer typical.

These data on duration of operation are from the Cassino Front and the Anzio Beachhead, chiefly the latter, where the single large hospital area was near, and, unfortunately, often in the scene of action. Many of the wounded at Anzio were injured on the spot, some in the actual hospital

* Consider the patient who accidentally discharged his rifle; the bullet passed between his scalp and the inside of the helmet. It followed the curve of the helmet, reversed its direction, and wounded the man in the buttocks.

† These data were collected from the cases of many surgeons, all able and experienced. Actual operating time (not including anesthesia induction time) is shown. This material is of interest only as it shows order of magnitude. Consecutive cases were chosen without selection. Standard errors of the means are given to show variation.

area, others on the adjacent road, "Purple Heart Highway." One value of Anzio has been to show that even in the midst of military action, surgical technics of accepted peace-time standards need not be sacrificed. (These are jeopardized chiefly by overwork during heavy action.)

The operating times indicated here are typical of practice throughout the forward areas in this theater, as such their implications are rather great. Little different as they are from those of civil life, they symbolize the revolution that has occurred in surgery since the time of the last war. Important factors which make possible such prolonged operating will be discussed later. It is clear, from a consideration of these figures, that the patient must be prepared in the preoperative tent to withstand prolonged surgical stress.

So far in this discussion, the wounded patient and his passage along the evacuation chain have been described. Some indication has been given of the surgical and other stresses the patient must be prepared to meet. Hazards of faulty therapy, chiefly of pain, have been considered in some detail. Most of the matters that have arisen so far have concerned all patients, the lightly as well as the critically injured man. The man who has a slight wound requires little special preparation for surgery. The preparation accorded the badly wounded individual may make the difference between survival and death. What then are the important elements in this preparation?

APPRAISAL OF THE PATIENT'S CONDITION

As already pointed out, under the condition of the Cassino Front and the Anzio Beachhead for example, one could expect that about 2.5 per cent of those wounded would fall into the group that is in bad enough condition to require special resuscitative care. Attention will be directed to the very badly wounded men, since patients in less serious condition require to a lesser extent the same treatment.

Recognition of the man already in poor condition presents few problems. The main difficulty comes in early identification of the patient whose condition is deteriorating, recognition of this early enough to check the destroying forces. Early recognition here means economy of care, more rapid preparation for surgery (indispensable if congestion in the preoperative ward is to be avoided) and in the end more lives saved.

The estimate of which patients will bear watching is usually made on the basis of their immediate appearance: Cool extremities and pale skin, with abnormal delay in filling of skin vessels blanched by pressure. The blood pressure may or may not be below normal. If it is, resuscitative care is obviously urgent. The pulse is usually rapid and of rather small volume. The appearance of the wound, its extent, the presence of signs of considerable blood loss either internal or external as in blood-soaked clothing, a history of delay in hospital admission, of exposure, of exhaustion, are all points of value. Excepting patients with head wounds, the badly injured are nearly

always clear mentally* and can give an accurate account of events since their wounding (although later there may be considerable amnesia for this early period). Great thirst is almost always present and causes much suffering. These conditions give a useful hint of difficulties to come. But most important of all for field use is information concerning the *trend* of the pulse and the *trend* of the blood pressure. The way these swing is of great help in evaluating the patient's condition. A rising pulse rate, a falling blood pressure nearly always forecast immediate trouble, especially if associated with a cool skin, in a man who has been at a comfortable room temperature.

With the fairly general acceptance of the view that the cause of deterioration of the wounded patient's general condition is reduced circulating blood volume, problems of therapy become considerably simplified. This simplification is extended with the further acceptance of the evidence that, excepting the processes that lead to dehydration, fluid lost from the circulation is to be explained by loss at the injury site *alone* (except perhaps shortly before death, when some general increase in capillary permeability may occur as a result of profound anoxia). Therapy falls into three main channels: Treatment of the reduced blood volume; treatment of the local wound; and treatment of pain and mental distress. (See above.)

TREATMENT OF THE LOCAL WOUND AS A PART OF RESUSCITATIVE PROCEDURE

Control of hemorrhage may be accomplished by tying a bleeding vessel, by a pressure-pack or by tourniquet. Tourniquets are useful chiefly as a last resort in the control of hemorrhage, usually in the presence of amputations or near amputations. Since they introduce hazards of ischemia and tissue damage, their use is to be as infrequent as possible. "If a tourniquet is necessary, it is applied as low as possible on a limb. It is not removed until a transfusion of blood or blood substitute is already running into a vein; yet, when it is possible that the limb can be saved, the tourniquet is loosened for a few moments at hourly intervals to avoid tissue damage. In hot surroundings the loosening should be carried out more often. With a hopelessly mangled limb, a tourniquet is applied just below the site of election for amputation. When amputation is performed, the tourniquet is not removed until the extremity has been severed."**

Splinting provides a means of preventing further tissue damage, further blood loss and helps to prevent pain. Often Thomas splints are applied with the laced shoe in place. Swelling distal to the wound soon produces needless and great pain. (The shoe should be unlaced and slit if it is considered advisable to leave it on.)

* By actual count only one out of 201 badly wounded patients (not in shock) was not clear mentally on arrival in a forward hospital.

** General Recommendation Concerning Shock, prepared at the request of the National Research Council. Submitted July 16, 1942, by Beecher, H. K., Blalock, A., Cope, O., Loeb, R. F., and Warren, S.

Surgery as an indispensable element in resuscitation will be considered below in the discussion of the optimum time for operation. It is clear that at times there can be no resuscitation without surgery, for example, when uncontrollable internal bleeding occurs, sometimes when great fecal contamination of the peritoneum exists, when leakage into and possibly absorption from, large areas of devitalized tissue is taking place. Resuscitation can and should continue during surgery.

FACTORS OTHER THAN FLUID REPLACEMENT FOR CONSIDERATION IN TREATING THE DEFICIENT CIRCULATING BLOOD VOLUME

Just as the available evidence points to reduction in the volume of circulating blood as the chief cause of poor general condition in wounded men, so will correction of this factor go far to restore the patient to good condition. The more rapidly blood is provided (within reasonable limits, to be discussed below), the more rapidly restoration of a condition suitable for operation will be achieved. The considerable change that has occurred in practice, even during the Italian campaign, is suggested by the following figures: In the Field and Evacuation Hospitals below Venafro and Mignano (Cassino Front) in November and December, 1943, resuscitation of the seriously wounded to the point of operability often required six to eight hours. This contrasts with the more recent experience of Beecher and Burnett (loc. cit.) where very bad-risk patients were prepared for operation and went to surgery in an average of two hours and 20 minutes. The ready availability of whole blood marked an important difference between the two periods. Men who have lost whole blood need blood replacement. Before a detailed discussion of fluid therapy in the wounded is undertaken, a few other matters related to the circulation will be mentioned:

Position of the Patient.—Probably the wounded patient's general condition is at the worst it has been at the moment of arrival at the forward hospital; the delay, the handling, the ambulance haul have all contrived to make it so. About a quarter of the poor-risk patients arrive with no measurable blood pressure. Rest and elevation of the foot of the litter (about 12 inches) with the head and heart low, usually are followed by return of perceptible blood pressure, even before fluid therapy can be started. All badly wounded patients should be placed in this position at once upon arrival, excepting some patients with head wounds (chiefly those with adequate blood pressure), some patients with chest wounds (chiefly those whose oxygenation is mechanically impaired by the position), and also excepting patients with pulmonary edema.

Unless the head-down position gives rise to obvious signs of distress, labored respiration or cyanosis, it should be utilized even in patients with chest wounds and with head wounds, as long as the systolic blood pressure is below 8 Mm.Hg. When the blood pressure has risen to this level, gradual, slow elevation of the head should be started. As much as 20 to 30

minutes may be needed to get these patients with head and chest wounds up into the semirecumbent position.

Gastric Distention.—Ideally, all wounded patients should have their stomachs emptied* before being anesthetized in order to avoid the chance of aspiration of gastric contents. A further reason for this practice is to be found in the observation that distention of the stomach is great enough in some wounded men to interfere with the circulation, decided circulatory improvement occurring on evacuation of the stomach contents. The mechanism of this is not clear, possibly the greatly distended stomach interferes with cardiac filling. Vagal reflexes are possibly involved.

Heat.—Exposure to cold is not desirable in a wounded man and will affect his condition adversely; so, also, will warming if rapidly carried out. Fluid loss through sweat, increased metabolic needs and dilatation of constricted vascular beds are all possible consequences of the use of heat. The body heat of an injured man should be conserved, rather than heat added. Gradual warming of the chilled man is usually best accomplished by placing him in bed, with plenty of blankets, in a tent at normal room temperature. During even such a gradual warming as this, blood replacement therapy should be in progress. Although the ground was frozen hard and covered with snow in the mountains around Cassino, no occasions were encountered where the addition of heat other than that described above was indicated.†

Vasoconstrictor and "Stimulating" Agents.—These are usually of no value in treating the wounded man. In large dose they are contraindicated.

Oxygen Therapy.—Whether oxygen therapy is actually of life-saving value in treating wounded men is as unproved as it is in treating pneumonia. It will produce definite signs of improvement (lowered pulse rate, better blood color) and, therefore, appears to be justified on a logical basis.

Much is often made of the fact that cyanosis will not appear when the hemoglobin concentration is about one-third of normal, a rare circumstance, at least in the freshly wounded. In 37 of the worst wounded patients filtered from 2853 wounded men, Beecher and Burnett (loc. cit.) found on examining them four and one-half hours after wounding (not yet adequate time for complete blood dilution) the hemoglobin averaged 12.3 Gm. The hematocrit

* This is urgent when food or fluids had been taken as recently as two hours or so prior to the wounding or at any time following the wound. The largest tube that will slip down easily should be used. A little judicious moving of this as it goes down will produce vomiting, much to be desired, since only thus can it be certain that the stomach is emptied. Actual washing of the stomach is to be avoided when thoracic or abdominal wounds suggest that perforation of the esophagus or stomach may have occurred.

† One patient was brought in in May, at Anzio, during warm weather, apparently suffering from blast injury with intracranial damage (? hypothalamic area). His rectal temperature was 84° F., and remained at about this level for many hours. Heat was added here; hot water bottles were used; but it was not until the day following injury that his temperature returned to normal.

spread was as follows:* 5 were in the 20's; 16 were in the 30's; 8 were in the 40's (only one above 44) and 1 was 50. More important than low hemoglobin in the failure to detect anoxia is failure to look for the signs of oxygen shortage. Moderate cyanosis is too often overlooked as a result of hasty examination and poor light in the preoperative tent.

In the patient whose condition is deteriorating, circulatory changes occur characterized by falling cardiac output and decreasing blood volume. After a time the circulating blood volume reaches a fairly fixed level where it remains; but the cardiac output continues to fall.† These factors lead finally to tissue anoxia, with resulting metabolic change and organic damage and eventually to an irreversible state known as death.

Unquestionably, increase in the oxygen tension in the inspired air is desirable in conditions like these; but how much can be expected of it is open to considerable question. At least until the practical aspect of this question can be better clarified, use of oxygen in field resuscitation should continue. Excepting cases of respiratory obstruction or depression, increase in the volume of the blood and the total quantity of circulating hemoglobin is the chief need. (See below.)

Oxygen is most conveniently administered by nasal tube. (Four or five patients can easily be serviced from a single oxygen tank.) The oxygen is humidified by bubbling through a water column. The well lubricated (12–14 French) catheter should be inserted into the nasopharynx until the patient is observed to swallow a bolus of air, and then the tube withdrawn one-half inch and firmly anchored with adhesive tape to the face. The correct distance for insertion will usually be equal to the distance from the ala of the nose to the ear lobe, less half an inch. Most patients will tolerate a gas flow of four to five liters per minute. Gastric distention is to be avoided. This must be watched for in the unconscious man.

If signs of oxygen shortage are not relieved by the intranasal administration, one can give higher oxygen concentrations. For this a closed system with carbon dioxide absorption, as an anesthesia apparatus can be utilized.

Oxygen therapy should be continued as long as necessary to hold the gains it has effected. (Probably 70 to 100 per cent oxygen should not be administered for more than 12 hours, rarely necessary. If high concentrations continue to be necessary the periods when they are employed should be alternated with 12-hour periods of 50 to 60 per cent oxygen.)

* Hemoglobin, hematocrit (and plasma protein) were determined by the "Copper Sulfate Method of Measuring the Specific Gravities of Whole Blood and Plasma," by Phillips, R. A., Van Slyke, D. D., Dole, V. P., Emerson, K., Jr., Hamilton, P. B., and Archibald, R. M., for the Committee on Medical Research of the National Research Council, 1943.

† General Recommendations Concerning Shock, 1943 (Revision of Report No. 1 of July 16, 1942), submitted by Bard, P., Blalock, A., Cannon, W. B., Gregersen, M. I., Harkins, H. N., Loeb, R., Long, C. N. H., Richards, D. W., Jr., and Wearn, J. T., for the Committee on Medical Research, National Research Council.

FLUID REPLACEMENT THERAPY

Administration by Mouth vs. Parenterally.—Discussions of this subject usually begin with a kindly admonition to give fluids by mouth, if the wounded man will tolerate them. The opposite is more nearly in line with good practice: preoperative fluids by mouth are in most cases contraindicated after the patient has reached the hospital where his initial surgery will be carried out. Certainly they are if anesthesia and operation are anticipated in a matter of hours, and almost always this is the case. Gastric emptying time is exceedingly long in the newly wounded man. One can see food and drink regurgitated that were consumed ten hours, or more, previously. It becomes increasingly clear that one of the commonest if not the commonest serious preventable accident to occur on surgical services is aspiration of gastric contents. This may be due to vomiting during anesthesia. Or it may be due to expulsion of gastric contents into the pharynx as a result of surgical manipulation in the upper abdomen, and then followed by quiet aspiration by the deeply anesthetized patient. The accident may be a fatal one. (See preceding section on "Gastric Distention.") Naturally, dehydration is to be avoided, or corrected if present. This is done by parenteral injection, chiefly intravenously. A final point: fluids by mouth very often precipitate vomiting, especially in patients with nausea from morphine, so that the net-result of administration of fluids by mouth may actually be a loss of fluid rather than a gain. Patients get considerable comfort but little fluid from a wet sponge to suck and to moisten their dry lips.

Salt and Glucose Solutions.—These agents are primarily useful for the correction of dehydration. As "blood substitutes" they are not very effective, and are dangerous. The elevation they produce in blood volume and blood pressure is so transient as to be of little value. The fluid leaks out of the blood stream. In the presence of head injuries the intracranial pressure may be seriously increased by these agents if they are used in large enough volume to produce a significant blood-pressure effect. In the presence of pulmonary damage, or if the heart is working under adverse conditions, they may precipitate pulmonary edema or increase it if it is already present.

During periods of heavy action, when scores, even hundreds, of patients may be awaiting surgery in a single hospital,* the maintenance of an adequate fluid intake in these men becomes a difficult problem. Under such circumstances patients who cannot go to surgery until the next day may be given fluids by mouth. The others may be given normal saline subcutaneously or normal saline and 5 per cent glucose, usually intravenously, but never more than one liter at a time, and in quantities just adequate to keep down definite dehydration.

* At one period during the great Anzio drive more than 300 patients were awaiting operation at one time in the 94th Evacuation Hospital. The situation was the same in the other hospitals of the Beachhead. It was immediately relieved by a shuttle of air evacuation planes to the large hospital base at Naples—40 minutes away by air.

Plasma.—The use of plasma as one of the best of the "blood substitutes" is well established. Its use is greatest in the forward installations (Battalion Aid, Collecting and Clearing Stations) where blood transfusion is impossible or its attempt inadvisable, and in the treatment of burns.

Excepting the hemolytic problem in burns, plasma represents the chief need there, for it is the part of the blood lost. Its replacement is indicated. Plasma is a part of definitive therapy. Various rules can be made as to quantity to be used. A common one: Two units of plasma in the first 24 hours for each 10 per cent of the body surface burned, or until important hemoconcentration has been relieved. If laboratory facilities are at hand, give 100 cc. of plasma for each point the hematocrit is above a normal of 45. If the plasma proteins are low, 25 per cent should be added to the calculated quantity of plasma needed for every gram the proteins are below six per 100 cc. Better economy is effected in treating burns if the required plasma administration is spaced over 24 hours than crowded into the early hours, for if more is given than needed at one time it is probably lost from the circulation. Secondary shock from burns may occur many hours following the initial injury. The physician in charge must be alert to recognize and treat the anemia that often develops in these cases.

Curiously enough, a fact that is often not adequately appreciated is that plasma, lacking hemoglobin, cannot be, is not, a satisfactory substitute for blood in the wounded man who is seriously bled-out. This state is common in badly wounded men. The great merit of plasma in these cases is that it temporarily sustains the seriously falling blood volume and decreasing cardiac output; it sustains blood pressure at a level compatible with life for a limited time. *Plasma gives more time to get whole blood into the patient.* It should be considered as a stop-gap and not as definitive therapy in patients who have suffered extensive hemorrhage. It has been repeatedly shown in this Theater that plasma, although it will, in many cases, restore for a time adequate blood volume and pressure, in so doing it often gives a false sense of security to those treating the wounded man. *The patient who has been in poor condition because of blood loss, with low blood volume and possibly low hematocrit, will be often seriously endangered if his blood (and effective vascular) volume is increased by plasma without hemoglobin being added.* Such a patient may superficially appear to be prepared for anesthesia and surgery. The blood volume has been restored and the meager quantity of hemoglobin available diluted. The blood pressure has been restored to the level where the already deficient hemoglobin begins to leak out again. A small further loss of hemoglobin from renewed bleeding or during surgery may be critical and sudden disaster occurs. Unfortunately, this has happened many times. *Plasma alone will not adequately prepare the seriously wounded man for surgery.*

One of the most difficult problems is to determine how much plasma should be given in the forward installations. In the badly wounded, 500 cc. may be given as the initial dose. In general, plasma should be given only to the extent of elevating the systolic blood pressure to about 85 Mm.Hg. The

recumbent patient will not suffer if his skin is warm and of good color when the blood pressure is at this level, and needless loss of hemoglobin will not occur as a consequence of bleeding resulting from pressures that are higher than necessary.

While the total volume of plasma to be employed must depend on therapeutic effect and circumstances not possible to treat in generalizations, it can be said that it is rarely necessary to give more than four units of plasma in the four or five hours that often precede hospital admission of the badly wounded individual.

After a Field or Evacuation Hospital has been entered, *preparation for operation* will utilize about one unit of plasma to three units of whole blood.

Albumin.—This fraction of the blood exerts the greatest osmotic pressure of the plasma proteins; 80 per cent of the colloid osmotic pressure of the normal plasma is accounted for by the albumin present. Beecher and Burnett (*loc. cit.*) have given this agent a field trial and have summarized its advantages and disadvantages as they concern military medicine. On the good side is the fact of its small bulk; 25 Gm. dispensed in 100 cc. solution are said to be roughly equivalent to two units of plasma, when used in the well hydrated patient. This was not demonstrated clinically, but possibly the circumstances of the field testing were not adequate to show this difference. Albumin, as it is dispensed is ready for instantaneous use. No reconstitution is necessary as with plasma. It can be administered in one-third to one-half the time needed for plasma. It is remarkably stable.

Also, to be considered is the following: Albumin is expensive in terms of quantity of blood needed to prepare it. Its molecule being smaller than that of the globulins, presumably leaks out of the blood stream faster than they do. Plasma's natural antibodies have, of course, been eliminated as the albumin is separated out. (How desirable these are may be questioned under the present circumstances.) The use of albumin is undesirable in the presence of dehydration.

Before albumin can be adequately evaluated it needs to be compared in man, with plasma, on the basis of cardiac output and blood volume effects. Oddly enough, this has not yet been done so far as can be found. Certainly the combat zone is not the place to engage in such studies.

In the clinical observations referred to above, albumin was employed in some 200 patients. Blood pressure measurements at about ten-minute intervals were followed in 89 patients who received one unit of albumin and in 61 other patients who received one unit of plasma. The spread of the initial blood pressures was comparable in the two groups, as were age, sex, hydration, wounds and general condition. An average of the data (comparable spreads in both groups) when the initial systolic blood pressure was below 80 Mm.Hg. (See Table II)

Higher initial blood pressure levels were studied with similar results. These data were supplemented by observations of the patient's general condition, peripheral circulation, skin temperature, and pulse rate and quality.

Admittedly, all of these data are based upon relatively crude technics of examination: clinically, they add up to no demonstrable difference between one unit of plasma and one unit of albumin, theoretically much more powerful.

The water administered with the plasma is of course an asset, since the tendency in wounded men is toward dehydration. Concentrated albumin depends for its effect on drawing fluid from the tissues into the blood stream, thus, dehydrating the tissues. In well hydrated patients this is all right; but in dehydrated individuals additional salt and water must be given, usually at the rate of two units of albumin to a liter of normal saline, given intravenously. (Subcutaneous administration of saline or glucose solutions is to be avoided in shock because of the poor rate of absorption as a consequence of the lowered peripheral circulation.)

TABLE II

Factors Considered	Plasma	Albumin
Initial blood pressure (Mm. Hg.)	49/21 (Av. of 19 cases)	47/22 (Av. of 40 cases)
Maximum blood pressure after 1 unit of blood substitute (Mm. Hg.)	88/52 (Av. of 15 cases)	83/53 (Av. of 35 cases)
Time to achieve maximum blood pressure (mins.)	19 (Av. of 16 cases)	22 (Av. of 34 cases)
Time for fall of blood pressure to begin (mins.)	29 (Av. of 9 cases)	33 (Av. of 19 cases)

No significant untoward effects were associated with the use of albumin. In two cases a mild, transient urticaria may have been caused by the agent. Transient moist râles in a patient with a thoracic injury may have been caused by the albumin. (Any sudden increase in blood volume is undesirable in such a case.)

The whole thing boils down to albumin's advantage over plasma being in its small bulk and ready availability. This suggests that it should be useful in Battalion Aid Stations and other difficultly accessible posts especially when transport must be by hand. Conceivably albumin should be of advantage for use with air-borne troops, in ambulance planes, and in submarines, where space and weight are at a premium. Whether in terms of the principles on which army medical supplies are chosen, it is desirable to provide albumin for the exceptional circumstances where it has an advantage over plasma, is beyond the writer's experience.

Blood.—(a) Indications for Its Use: The man who has lost large quantities of blood needs blood replacement. Adequate preparation of the seriously wounded man for surgery and support during surgery are impossible without whole blood. This has been demonstrated in probably every preoperative ward and operating room throughout the Tunisian, Sicilian, Italian and Southern French Campaigns. True resuscitation of the wounded requires whole blood. Such statements in no sense minimize the value of plasma. This agent has superbly filled a great need, discussed above.

The best guides in the field for the use of blood are simple, but of great help: the presence of blood-soaked clothing; the nature and extent and duration of the wound; the rate and quality of the pulse, and its trend;

the level of the blood pressure, and its trend; the peripheral circulation as indicated by temperature of the skin and the speed of the response to blanching by pressure; and the color of the mucous membranes.

Possibly, too much attention has been given to the fact that on many occasions the blood pressure may be normal yet the patient seriously depleted. Although it may be unreasonable, this has led to a tendency to dismiss the blood pressure as a helpful sign even when it is low—a fatal error, on some occasions. More helpful than the level of the blood pressure, is the direction of its swing—a falling blood pressure, a rising pulse rate, are in most cases an urgent indication of the need for blood.

In the early hours after wounding the kinds of laboratory data available in the field are likely to be deceiving: the hemoglobin, hematocrit and plasma proteins are usually only a little below normal, before blood dilution has taken place. (These factors are, of course, of great help in evaluating the needs of the patient postoperatively, after stabilization has occurred.) Plasma volume information would offer real help. At the present time at least its determination is too time-consuming to be justified for routine use. The simple clinical signs referred to above, rightly interpreted, provide the help needed to gauge the quantity of blood to be used in a given case. Indications for the use of blood are inseparably linked-up with questions of speed of administration and volume to be given, discussed in the following two sections.

(b) Speed of Administration: This depends on how critical the state of the wounded man is. Unquestionably, badly wounded patients need prompt care. In the study of Beecher and Burnett (*loc. cit.*) the most seriously wounded patients were found to arrive at the hospital at the Anzio Beachhead (short, good roads) more than four and one-half hours after wounding. This suggests that deliberate appraisal of the case is permissible. It is hardly likely that a few minutes more or less on top of the delay already present, in getting the blood or blood substitute into the patient will make any difference. In fairness, however, it must not be overlooked that the handling and ambulance ride immediately preceding hospital entry may have reduced the patient's condition to its poorest. A quarter of the men in this group arrived with no measurable blood pressure. Often only a few minutes of rest in the head-down position was adequate to permit improvement so that measurement of the blood pressure was possible. Action here is governed by rather arbitrary decision based on experience. If the patient's condition is considered to be desperate (systolic blood pressure usually below 60 Mm.Hg.) he is placed at once in the head-down position (foot of litter elevated about 12 inches) a unit of plasma or albumin started while a transfusion of low titer "O" blood* is obtained. Although patient's blood for later grouping and cross-matching is obtained at the first vena puncture, time is not taken for matching on the occasion of giving the first or at times even the second blood when dealing with the desperately

*Iso-agglutinin titer of 1–64, or less.

wounded. The first transfusion may sometimes be forced in rapidly by using a bulb (from a blood-pressure apparatus) placed on the blood flask's air inlet tube. Rarely this may be necessary for the second transfusion. As soon as the blood pressure has begun to rise, efforts to obtain great speed of administration can be relaxed as long as the improvement continues.

Subsequent transfusions are usually given more slowly: 500 cc. blood in half an hour to an hour. When the systolic blood pressure has risen to 80 Mm.Hg. the latter rate is generally adequate. So, also, is it for the use of blood prophylactically when fall of blood pressure is to be anticipated, but not actually occurring.

For the certain flow of blood in critical periods cannulas should be introduced under direct vision by "cutting down" on the vein. In emergencies two transfusions should run simultaneously.

(c) Volume of Blood to be Used: The young, healthy, organically sound battle casualty will tolerate his wound and the strain of surgery without replacement of all the blood lost. It is unlikely that a 3,000-cc. hemorrhage is often exceeded. Probably a good many lose 1,500 to 2,000 cc. of blood. Accurate observations on this would be interesting. In the study of Beecher and Burnett (*loc. cit.*) of the most seriously wounded (2.5 per cent of 2,853) battle casualties it was found that from the time of hospital entry until definitive surgery was completed one unit of plasma or albumin and 870 cc. blood were needed on the average before surgery. During surgery a further 500 cc. was administered to two-thirds of the patients, while the remaining one-third got an additional 1,000 cc. blood. These patients had come into the hospital (chiefly at Anzio) over fairly short lines of travel from the front (up to ten miles), fairly good roads were available, and the patients arrived as mentioned in four and one-half hours, average, after wounding. Certainly, the quantity of blood administered by no means replaced the quantity lost and yet as evidence that these patients were well prepared for surgery the following can be submitted: In 2,853 patients who were operated upon, none died during surgery. During April and May at the Anzio Beachhead, the hospital death rate in these patients for 1,623 battle casualties was 1.48 per cent. Finally, the surgeons were positive in their statements that they considered these patients well prepared for operation.

(d) Hazards and Reactions: Transfusion of blood, like the transplantation of any tissue, is a complicated process, filled with opportunities for human error. With increasing speed and volume of blood used increased strain is placed on the laboratory and those checking and supplying the blood. It is also possible that the rapid use of large volumes of nontype specific blood may lead to serious, even fatal reactions. Possibly the use of low titer O blood will help to solve this problem. Ideally, type-specific blood should be used in all cases, practically this is often not possible.

Excluding the accidents when clearly mismatched blood has been given, reactions vary all the way from transient and trivial malaise, chills, fevers and urticarias, to fatal urinary suppression. The chills, urticarias, *etc.*, have been

shown attributable in most cases to faulty preparation of the apparatus used, either inadequate cleaning or delay beyond two hours in sterilization after cleaning. These reactions even in the field (94th Evacuation Hospital) can be kept below 3 per cent.

Fatal urinary suppression, with death from uremia, has been found in some cases to be associated apparently with kidney damage arising from free hemoglobin or myoglobin deposited there.

Perhaps when large quantities of blood are used, the red cell destruction to be expected results in the liberation of greater quantities of free hemoglobin in the circulation than the body can cope with. Other suggested explanations of the free hemoglobin-containing kidneys: sulfonamide reactions, also "shock kidney." Exactly what is meant by this last term is not clear, but apparently those who use it refer to a condition in which considerable quantities of hemoglobin or myoglobin are released from traumatized areas. These are absorbed into the blood stream, accumulate in the kidney and appear to impair its function.

One difficulty in determining how much of the kidney problem is to be accounted for by blood and how much by sulfonamide is due to the fact that most patients who have received blood in large quantity have also been liberally dosed with sulfonamides; thus, it has been difficult to separate these two possible causative agents. With the more general use of penicillin, replacing in some cases sulfonamides, the problem of determining responsibility should be easier in the future than it has been in the past. There is the possibility, of course, that sulfonamides, myoglobin, hemoglobin and so on, produce serious kidney damage only in conjunction with some other factors such as low systemic blood pressure.

Two groups at the Anzio Beachhead received identical types of patients; in one the fatal anuria rate was much higher than in the other; yet the use of sulfonamides was not significantly different in the two places. Moreover, since the same types of injury were received in both places, and since several thousand cases were under consideration, the incidence of "crush syndrome" as well as the incidence and duration of low blood pressure was presumably the same in both groups. The group with the higher anuria death rate used considerably more blood and that more rapidly than the other group. It is impossible to say at this time whether or not this is significant. If some as yet unidentified hazard is present in the occasional transfusion and responsible for the anurias, the more transfusions administered, the more anurias one might expect. There is too little evidence at hand to justify much speculation in this direction at present.

(e) Grouping and Cross-matching of Blood: Except for the great emergencies described above, all patient's blood is to be regrouped *and* cross-matched with the donor's blood. It is often stated that this is not possible in practice. The facts are otherwise. Unless great care is exercised in the transfusion of blood the accidents that occur will nullify the value of the procedure. Perhaps in the future fuller information concerning low

titer O blood will reduce the necessity for grouping and cross-matching in the field. At the present time it can be said that there is too little safety in the use of blood unless *both* grouping and cross-matching are carried out. These safety measures need be dispensed with in relatively few cases.

After 1,000 to 1,500 cc. of nontype specific blood have been administered to bled-out patients a new sample of the recipient's blood should be obtained for subsequent cross-matching. This process should be repeated after every additional liter of blood is administered.

(f) Alkalinization of the Patient: The evidence on which to base decision concerning this is not as full as one would like. It is sufficient, however, to suggest that patients who receive 1,000 cc. of blood or more (as well as those who are on sulfonamides) should be alkalinized.

TIMING OF BLOOD ADMINISTRATION AND OF OPERATION

During periods of heavy military action it must be expected that the blood available may be in short supply, at least its provision will be difficult and economy in its use necessary. The quantities of blood previously mentioned as desirable are half to two-thirds those used and recommended by some experienced officers under the same circumstances. The total quantity of blood needed to see a patient through his operation can be greatly influenced by the timing of its administration. To be specific: When a patient has been extricated from his immediately critical condition and must await operation for a considerable period, elevation of his systolic blood pressure to about 85 Mm.Hg. is all that is necessary *as long as his color is good and his skin warm.* He can be transfused immediately preceding surgery. In all cases some of the limited blood supply should be saved for use during and immediately following surgery.

In other cases an individual's wound may be such that definitive surgery is a necessary part of his resuscitation: when profuse internal bleeding is occurring it is wasteful of time and of blood to attempt to get the patient's blood pressure up to normal. One should consider himself lucky if a systolic pressure of 80 to 85 Mm.Hg. can be achieved and then surgery undertaken. This applies as well to other common conditions where full resuscitation is often impossible until the situation has been corrected surgically, for example, where wide fecal contamination of the peritoneum has occurred, where leakage into, and possibly absorption from, devitalized tissue is in progress.

Acceptance of the view that resuscitation can and should continue during surgery will lead to early operation, to be desired in nearly all cases.

It is a matter of considerable surprise to the writer that there has been as much discussion as has taken place in Italy and France concerning the merits of early against late operation in wounded men. Surely, the wound has set several continuing processes in action: there is bleeding and plasma loss from serous surfaces and into traumatized tissues. Contamination leads to progressing infection. With these and other drains upon him, the seriously

wounded patient must have constant external support by way of blood and plasma. If, as a principle, one can say that the smallest quantity of blood and plasma should be used that is compatible with the patient's well-being (until we know more about the cause of the fatal anuria mentioned above, that is an almost obligatory view), then early operation appears desirable on this basis. Unquestionably, delay in operation necessitates the use of larger quantities of blood and plasma to maintain the patient on an even keel than otherwise is the case. A further point is important in this connection. It has been well established in the cases of peritoneal contamination encountered in perforated peptic ulcer that the mortality rate rises sharply with the passage of time. With the grosser tissue contamination met in warfare this is probably also the case. The passage of time is against the patient's good. That early operation is compatible with successful surgery is borne out in the study of 2,853 battle casualties observed on the Cassino and Anzio Fronts, referred to above.

SUMMARY

The enemy has produced the worst wound he could. The immediate physical consequences of the wound and the inseparable mental and emotional problems that arise from it are discussed in terms of what is needed to prepare the wounded man for surgery. Specifically, the distress of the wounded man was found to come from three sources, pain, mental agitation and thirst. Severe pain is usually best treated with morphine; but much that has passed for a response to pain was found to respond to small doses of barbiturates. Pain great enough to require further treatment with morphine was found to be surprisingly infrequent (present in only one-fourth of the severely wounded as they arrived at the most forward hospital). A great need was found in the newly-wounded man for the use of small doses of sedatives of the barbiturate type.

The relationship of the wounded man to those around him, especially the physician and the chaplain, is discussed, with a view to preparing the man for his future care.

The effect of adverse external circumstances upon the wounded man and his course along the evacuation chain are discussed with attention being given to details of the organization and application of supportive treatment which must precede the initial surgery. One clue to the extent of the resuscitative measures that must at times be carried out is to be found in the fact that even in the most forward hospitals, the field and the evacuation hospitals, the average duration of operation for craniotomy, laminectomy, celiotomy, and thoracotomy was of the order of two hours or more (not including anesthesia induction time). Even operations upon the extremities averaged more than an hour. The deliberation in the surgery carried out compares with that of peacetime medicine.

Experience has shown that about 2.5 per cent of battle casualties (under the conditions of study) will require intensive resuscitative measures. The

needs of this desperately wounded group are discussed from three points of view: (a) Treatment of the local wound. Surgery is an inseparable part of resuscitation in its broad sense. On occasion there can be no resuscitation, even temporarily, without surgery (cf. internal bleeding, great fecal contamination of the peritoneum, *etc.*). In any case resuscitation (blood therapy) should continue during and after surgery. (b) Treatment of the depleted circulating blood volume. Here, position of the patient, gastric distention as it interferes with the circulation, application of heat and oxygen therapy are all discussed. Route of administration of fluids, the rôles in therapy of saline and glucose solutions, of plasma and albumin preparations, and of whole blood are considered in detail. In the case of blood administration, problems and hazards concerned with volume and speed of administration are dealt with. (c) The treatment of pain and emotional disturbances is discussed.

The timing of blood administration and its relationship to the optimum time for surgery are discussed, as, also, is the question of slow against rapid preparation for surgery.