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NAVAL BATTLE CASUALTY STUDY

James G. Garrick

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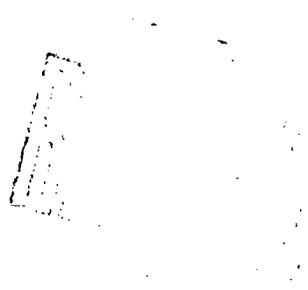
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13. ABSTRACT The Battle Casualty Study was carried out from January to June 1968 at the Naval Support Activity Station Hospital, DaNang, Republic of Vietnam. The purpose of the study was to document the injuries sustained, treatment given, and initial results of treatment occurring to the casualties at the DaNang Hospital. A casualty for the purpose of the study was defined as an individual wounded as a direct result of hostile weaponry who had, prior to his arrival at the Hospital, received no definitive medical care. The study includes 2,021 consecutively treated casualties of the United States Armed Forces; other military and civilian personnel treated were excluded from this analysis. Parameters considered in this report include information regarding prior wounding (in the service of the United States Armed Services), wounding agent, combat experience, location of the patient at the time of wounding, severity of wounding, evacuation time, time from admission to the Hospital to definitive treatment, length of Hospital stay, level of conflict, frequency/distribution of wounds and blood replacement required. The relationships of some combinations of these variables were also investigated, i.e. the relationship of wounding agent to a wound type, severity and extent, as well as the relationship between level of conflict and wounding agents involved. Level of conflict (Tet vs. Non-Tet) and percent of nonsurvival were related to most variables measured in the study. A number of charts and tables are provided for clarity. In addition to this analysis of the information collected, a semipermanent data archive has been established thus permitting continued work for any authorized investigator. Due to the detailed nature of the information available, many avenues of additional analysis remain available.			

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SUMMARY

NAVAL BATTLE CASUALTY STUDY

The material presented here should serve as an example or some of the applications for the information gathered during the U. S. Naval Battle Casualty Study. This work in no way exhausts the amount of information available but rather demonstrates some of the possible parameters of investigation. The data is presently available for further analysis, and if any of this material would suggest other avenues of approach or amplification, we would hope that interested parties contact us.

INDEX OF PUBLICATIONS

1. Garrick, James G.: "Problems Related to the Management of Combat Wounds Caused by Specific Ordnance." *The Journal of Trauma*, 10:1152-1157, 1970.
2. Garrick, James G.: "Initial Surgical Management for the Combat Casualty." *The American Journal of Surgery*, 120:723-725, December 1970.

Initial Surgical Management for the Combat Casualty

JAMES G. GARRICK, MD, Davis, California

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Initial Surgical Management for the Combat Casualty

JAMES G. GARRICK, MD, Davis, California

As in previous armed conflicts, the Vietnam war is resulting in the publication of significant articles dealing with the various aspects of trauma. The introductory remarks in these articles invariably dismiss the more "mundane" aspects of casualty management (such as debridement and delayed primary closure) with a statement akin to the following: "The general principles involved in the surgical management of combat wounds are similar, if not identical, to those employed in civilian practice. Good surgical technique and sound principles are common to both circumstances."

There can be no truer statements than these. However, for the physician-inductee who has not had the opportunity of significant exposure to "good technique" and "sound principles," such statements are meaningless.

Virtually every physician inducted into military service will be dealing with combat casualties. The stateside-based medical officer will provide the casualty with more informed, comprehensive care if he is cognizant of the problems faced by his Vietnam-based colleagues. The effectiveness of the combat zone physician is determined by his familiarity with the management of casualties and their wounds. A portion of this familiarity must exist prior to the appearance of the first casualty.

I hope this paper will provide some of this comprehension and familiarity.

As a rule, combat wounds are grossly contaminated and multiple. The single, isolated, clean gunshot wound is almost a rarity. Because of the unique nature of the wounding agents as well as the wounds themselves, the handling of battle casualties involves problems not encountered in even the busiest civilian hospitals.

The biggest differences between civilian (or stateside) and war trauma are: (1) the open, contaminated nature of war wounds and (2) the frequent involvement of multiple areas and organ systems in battle casualties.

The open character of the wounds often allows direct visualization of damage to special structures (such as nerves, arteries, and bones), but at the same time it introduces the problem of sepsis. The multiplicity of areas involved raises problems, most notably blood and fluid loss, not encountered to this degree in the patient with single, isolated injuries, no matter what their degree or severity.

The following guides are arranged in the order they would be carried out on an actual casualty. Were they arranged in order of importance, the first items on the list would be the principles of adequate debridement and delayed primary closure.

"Adequate debridement," "careful cleansing," and so forth are all somewhat nebulous terms and are interpreted in the framework of the surgeon's experience. "Delayed primary closure," on the other hand, is an absolute rule that can, and must, be followed regardless of surgical experience and expertise.

General Principles

Adherence to Established Surgical Principles of Sterility and Cleanliness. Although circumstances often preclude the performance of surgery under ideal "stateside" conditions, this is no excuse not to utilize every means available to achieve the most nearly aseptic state possible.

The contamination insult to the patient is sufficiently gross without the additional insult of introducing resistant organisms. Recent investigations reveal that these hospital-originated infections constitute the major septic threat to casualties under treatment.

Adequate Debridement: Cutting Away of All Nonviable and Grossly Contaminated Tissue. Debridement must be performed in logical steps. Gross contaminants are first lifted out of the wound. The actual debridement is carried out in layers in a logical progression from the skin to deeper tissues. Adequate exposure is essential at every level. It is impossible to debride that which is not seen.

Skin: Contrary to a sometimes popular belief, skin is not "cheap." At some time the wounds will

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Figure 1. A, debridement resulting in sacrifice of an excess amount of uninjured skin. B, end result yields same exposure as "A" but less uninjured skin sacrificed.

require closure. The practice of excising large amounts of normal skin to obtain surgically attractive ellipses should be discouraged. True, elliptical wounds are most readily closed and do not require additional excisions of tissue for closure as do circular wounds. However, ellipses can be made by just extending the ends of the wound and not removing additional tissue. (Figure 1.)

Skin incisions should often be made in the direction of the wound (most of which are tangential in nature) rather than according to skin lines. This may not facilitate closure but it will frequently obviate the need of the additional incisions

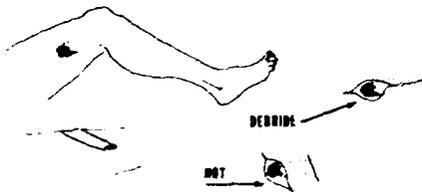


Figure 2. A skin ellipse made in the direction of the missile path is generally preferable to two separate incisions.

necessary to trace missile tracts. (Figure 2.) The latter incisions invariably result in necrotic skin bridges.

Fat: Fat should be trimmed so the walls of the wound are perpendicular to the skin surface. If left in the depths of the wound, it will require later debridement when either it becomes necrosed or its removal becomes necessary for closure. Redundant fat also obstructs drainage.

Fascia: All loose strands of fascia should be excised. Fascia that is allowed to "tent" across dead spaces should be trimmed away or incised so it will be relaxed and retract to an area where at least

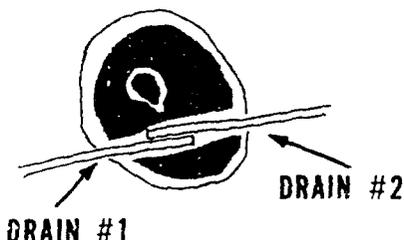


Figure 3. Method of draining a through and through wound.

one of its surfaces rests on healthy tissue. Holes in fascia must be debrided just as other tissues must be debrided. Necrotic fascia forms a nidus of infection, a frequent sequela of inadequate debridement.

Muscle: Determining the viability of muscle is a frequent, important, and often very difficult task. The presence of bleeding or the color of the muscle is sometimes an unreliable guide. Hemorrhagic muscle (as caused by contusion) is often glue-gray and does not bleed readily. It will, however, often survive. Contractility is probably one of the most reliable of the various indications of muscle viability. It is not an infallible indicator. "Doubtful" muscle is better excised than subjected to watchful waiting.

Tendon: Tendons should be minimally but adequately debrided. All loose ends are trimmed flush with the major intact portion of the tendon. Because of the relative avascularity of tendon, loose ragged ends rapidly become infected and partially liquify. If a tendon has been perforated, the hole through it must be debrided. A tendon can be left intact even though the hole through it involves over half the diameter of the tendon. An attempt should be made to keep tendons from bow-stringing across dead spaces. Bow-stringing, however, is not an indication for tendon sacrifice because a surprising number of tendons will survive if kept covered with moist sterile dressings.

Nerves: Frayed ends of nerves should minimally be debrided. If continuity has been lost, the procedure favored by many surgeons is to tie together loosely the cut ends with a loop of heavy wire. This procedure not only facilitates re-exploration, retrieval, and repair, but also limits retraction. No attempt at primary nerve repair should be undertaken.

Bone: All free cortical bone fragments should be removed. Minute, free cancellous fragments may often be left in the wound if they are clean and lie in a somewhat anatomic position. Periosteum should be saved whenever possible. Frequently, periosteum (if attached) can be salvaged if copiously irrigated to clean away gross contamination. Attempts to cover exposed, attached bone with soft tissue (such as rotated muscle flaps) are often met with septic disaster. Bone with attached periosteum can survive when covered only with a moist dressing.

Irrigation and Cleansing. Sterile normal saline is the most frequent irrigant. Some surgeons use a mixture of saline and hydrogen-peroxide (10:1) because the foaming action of the peroxide often floats bits of clothing, dirt, and necrotic tissue from the depths of the wound. It is thought that

this advantage more than offsets the minimal necrotizing effect of the solution. The use of a hydrogen peroxide solution also aids hemostasis.

More important than the "quality" of the irrigant is the quantity used. Copious amounts, under sufficient pressure to reach the recesses of the wound, must be used. Asepto® bulb syringes are very effective for this purpose.

Drainage. Wounds that penetrate muscle, unless widely and visibly open to their depths *must* be drained. Penrose drains of varying sizes are the type used most frequently. Drains must be long enough to allow them to reach the depths of the wound. They should protrude out of the wound at least 1 inch. The protruding end should be wrapped loosely in a gauze sponge so it does not come in contact with the skin edges. Such contact will cause skin edges to macerate and thus will delay later closure.

Through and through wounds should be drained with two Penrose drains. Separate drains are inserted into entrance and exit wounds. The drains are overlapped in the depths of the wound. (Figure 3.) In this manner, on removal, there is no contaminated exposed end of a drain to be pulled through the wound.

Occasionally continuous suction and irrigation drains are necessary. Hemovac® tubing serves this purpose well.

Gauze packing of wounds, when performed for other than hemostatic purposes, is to be condemned. No matter how loosely the packing is placed, the movement of the patient will compress the gauze, forming it into a relatively impermeable plug. Under these circumstances, adequate drainage is impossible. If wounds are packed, this fact should be noted on the patient's chart as well as written on a piece of adhesive tape stuck to the dressing. It is essential that other physicians who subsequently will be responsible for the patient's care are aware of the presence of packs in wounds.

Application of Massive, Nonconstricting Dressings. In the case of wounds on the proximal portion of an extremity, edema can be curtailed by wrapping the limb distal to the wound with an elastic bandage. The bandage must be applied from distal to proximal. The use of massive dressings is advocated because hemorrhage and exudation will usually stop before the dressing has soaked

through. The dressing is thus prevented from acting like a wick.

Delayed Primary Closure. From a logistic standpoint, there is usually insufficient time to close wounds primarily at the time of the original debridement. There is no reason for primary closure using the rationale that such procedure will return the patient to duty more rapidly. (In the latter case, a four-day decrease in hospitalization time is all that can be achieved. This is hardly significant when weighed against the three to four week delay resulting from a wound that has been closed over an infection.)

Thus, there is no valid reason to close the majority of wounds primarily. Yet, primarily closed wounds are not infrequently seen, even in a combat zone.

Nearly every medical officer who has served in Vietnam has found the "exception" to the "rule" of delayed primary closure. The majority have been "burned" by the experience, especially when attempting primary closures of extremity wounds.

The exceptions to this rule are related to the area of the body rather than the type of wound. Many facial, neck, and abdominal wounds can be closed primarily. There are virtually *no* extremity wounds in this category.

Delayed primary closure should be carried out at four days for most wounds. Prior to this, a complete dressing change is usually carried out at forty-eight hours. After the delayed primary closure the patient's evacuation should be delayed at least forty-eight hours. At that time the wounds should be redressed in order that they can be examined for signs of sepsis. If there is ever any question regarding the presence of sepsis, the wound must be opened.

Summary

Sound surgical principles in the management of trauma are terms frequently used, occasionally described, and rarely formally taught. The single, unique feature of military medicine is the primary treatment of combat casualties. Thus, it behooves the neophyte medical officer to be aware of some of the more common problems that will be treated by "sound surgical principles." This paper has been an attempt to detail these principles.

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PROBLEMS RELATED TO THE MANAGEMENT OF COMBAT WOUNDS CAUSED BY SPECIFIC ORDNANCE

JAMES G. GARRICK, M.D.

From the Bureau of Medicine and Surgery, Navy Department, Research Task No. M4305.05-3015

The type of casualty seen at various combat zone hospitals accurately reflects the tenor of the conflict. Major offensive deployments, whether allied or enemy, yield high proportions of bullet wounds and fragment wounds from artillery and mortars. Search-and-destroy-type missions and patrol operations, on the other hand, produce a higher proportion of mine and booby trap injuries.

Not only is this of general interest, but it also plays an important role in patient care, particularly in regard to times required for triage and operation. For example, mine and booby trap injuries will not only take significantly longer to prepare for operation, but the actual surgical procedures will be more time-consuming as well.

However, more important than the differences in patient handling times are the specific differences of the wounds, even though over 90% of the wounds are lumped into the "missile-caused" category. Each kind of ordnance results in characteristic wounds and problems. The following are some general observations on this topic.

A. WOUNDS CAUSED BY MINES AND BOOBY TRAPS

Although this is considered as a specific category of wounds, the wounding agents

The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

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are anything but specific. They are grouped together because of the nature of contamination, as well as the fact that the explosive force in most cases is from below upward (Fig. 1). The category includes all explosive ordnance which is buried or lying on the ground. Although usually detonated by the patient or a comrade, the device may be activated by a vehicle or, remotely, by the enemy.

Unless the explosive device consists wholly of a specific weapon (e.g., an M-26 grenade), the observed or recovered fragments are of little value in determining the weapon involved. Frequently the device is little more than a box filled with explosive and metal scraps, the latter having been picked up from bomb craters, etc. The resultant wounds vary widely in size and distribution.

The casualties resulting from these devices do, however, have one thing in common: the explosive forces that resulted in the injuries came from below upward. Not only are the fragments from the weapon itself propelled in this direction (primary missiles), but also bits of sand, wood, dirt, gravel, rock, pieces of boot, and even pieces of injured comrades (secondary missiles). As often as not, these secondary fragments cause as much damage as the primary fragments, or more.

Contamination is the grossest imaginable. Frequently handfuls of sand or dirt are blown upward, dissecting between tissue planes, to be found 12 to 18 inches proximal to the wound of entrance. This is particularly true of the adductor region of the thigh and the posterior leg (Fig. 2).

The force of the blast itself is often sufficient to strip the periosteum from the en-



FIG. 1. Result of standing directly above a booby trap at the time of detonation.



FIG. 2. Metallic and other foreign bodies (arrow) are all parts of the boot worn by another man who stepped on the booby trap 5 ft distant from the patient.

tire tibia and at the same time separate all major muscle groups of the leg. However, this may not be evident prior to operation, as the tissues often will have fallen back

into nearly normal relationships. As a result, the initial examination (both physical and radiographic) may reveal a relatively clean amputation at the ankle, but operative exploration will reveal the necessity for a high, below-knee amputation (Fig. 3). However, X-rays often reveal dirt or air, or both, at higher levels than the point of entry.

Initial surgical management of these casualties involves the essential surgical principles of debridement of all nonviable tissue, copious irrigation, adequate drainage, and delayed primary closure. In addition, the following must be kept in mind:

1. Recovery of all but the most minute of the fragments is essential. The body could undoubtedly tolerate many of these metallic foreign bodies, but the depths of the tract cannot be thoroughly cleansed unless they are totally examined. This requires exploration of the area deep to the fragment, because such an examination will often reveal a piece of cloth or boot driven in ahead of the fragment (Fig. 4).

2. Any wound that perforates the dermis must be incised. If the surgeon elects not to debride the skin formally due to the superficial nature of the wound, then the wound must be at least opened more widely.



FIG. 3. Opaque, nonmetallic material proximally to fracture is mud that entered the extremity at the fracture site.

More often than not, "slitting open" the wound will reveal the rock or piece of gravel that caused it, and would cause the subsequent infection.

3. When dirt has been blown up into tissue planes, first one must remove the largest amounts of dirt or sand, irrigate, and finally, sharply debride the dirty exposed tract. If the tract is debrided initially, removal of the bolus of mud from the depths at the close of the procedure will recontaminate the tract, and it will require re-debridement.

4. As the debridement and irrigation of each wound are completed, drains should be inserted prior to going on to another area. Placement of drains at the conclusion of the entire procedure will often result in neglecting to drain areas debrided earlier in the procedure.

5. As is true with virtually all combat wounds, primary closure is mentioned only to be condemned.

B. WOUNDS CAUSED BY GRENADES

From the standpoint of wound-causing capabilities, there are two general types of hand grenades currently in use in Vietnam. The first is the small fragment type, manu-

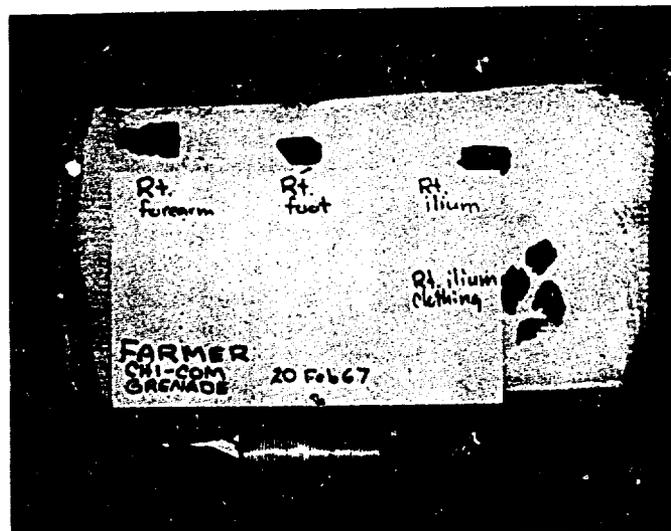


FIG. 4. The four clothing fragments were all found deep to the metallic fragment labeled "Rt. ilium." This is the result of detonation of a booby trapped grenade.

factured by the United States. Some of these have fallen into enemy hands, and thus they are used with equal effectiveness by both sides. The larger fragment grenades have less well-defined origins, and are used primarily by the enemy.

When hand grenades are actually thrown, they account for less than 10% of battle casualties. Grenades are often used as booby traps or as detonating devices for mines, and thus account for many more injuries.

Of the small fragment grenades, the only one in general use has fragments measuring approximately $2 \times 3 \times 7$ mm. The wounds are multiple, and although the skin perforations are small and reasonably clean, because of the high initial velocity present in close proximity to the detonation, the destruction occurring to deeper tissues is considerable. Fractures are most often of the "punch-out" or perforating type, but one fragment is capable of severely comminuting a tibia.

The wounds, while often massive, are frequently cleaner than those caused by "large fragment grenades." Pieces of clothing are usually not pushed in ahead of the fragment, because the fragment tears rather than "punches out." However, even though clean, the wounds often require extensive debridement due to the massive tissue destruction. The fragments can often be left embedded in deeper tissues possessing a good blood supply.

The grenades yielding large ($1.5 \times 1.5 \times 0.5$ cm) fragments are generally of enemy origin, and are at best crudely made. Their fragmentation pattern is inconsistent, and it is not uncommon to recover three or four connected fragments that have failed to break apart on detonation. The fragments from these weapons travel at a lesser velocity, but this seeming disadvantage in effectiveness is more than compensated for by: 1) the fact that they come in contact with (and thus contaminate) more tissue; and 2) that they punch out

fragments of clothing and push them ahead into deeper tissues (Fig. 4).

Thus it is essential that large fragments be removed. Removal is prerequisite to retrieving the fragmented clothing deep to the metallic fragment. The wound tracts also require thorough debridement because of their high degree of contamination.

C. WOUNDS CAUSED BY ARTILLERY (ROCKETS, MORTARS, ETC.)

Fragment size and shape in this category are generally inconsistent, with a few exceptions. Fragments greater than 6 inches in diameter have been recovered from patients, but this is the exception rather than the rule. Often this ordnance will explode in the air or upon impact, in the latter case yielding secondary fragments from dirt, rocks, etc. Upper extremity, trunk, and head wounds are more common with artillery than with mines and booby traps.

The position of the patient at the time of explosion is of more than academic interest in this category. If the patient is sitting at the time of an explosion occurring in



FIG. 5. Low-velocity bullet wound.

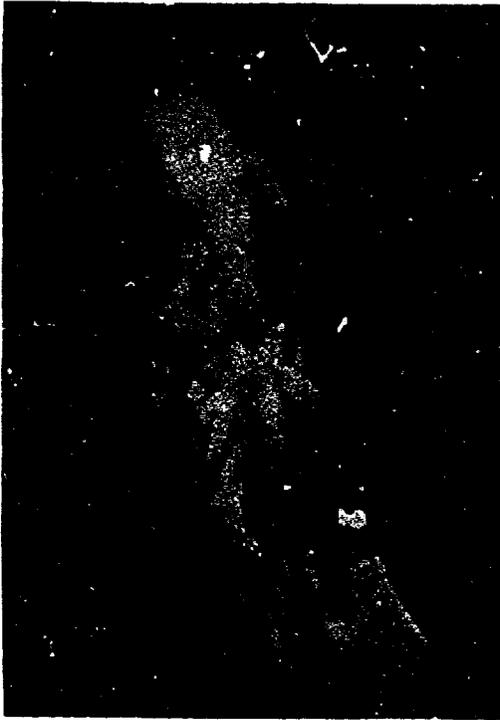


FIG. 6. High-velocity bullet wound.

front of him, he may have intra-abdominal fragments that entered through his thighs. Thus appropriate diagnostic measures (e.g., X-rays) can be carried out only with a

knowledge of the mechanism and position of injury.

The larger artillery fragments are also capable of driving clothing in ahead of them, and should be dealt with as with the large grenade fragments.

D. BULLET WOUNDS

Bullet wounds of the extremities often are the cleanest and most easily handled of all battle casualties. There are, however, problems involving bullet wounds that are rarely seen in casualties from other ordnance.

Low-velocity bullets often cause comminuted fractures, but the degree of comminution does not approach that seen with high-velocity bullets (Figs. 5, 6). "Re-fragmentation" or lead splatter is also commonly seen after a bullet sheds its copper jacket. "Exit wounds" may have allowed egress of only bone fragments, and the bullet may remain in the patient. Unless the bullet is in an area where it is likely to cause mechanical problems, or can be easily recovered, it may usually be allowed to remain. Heroic efforts to "recover the bullet" are usually ill-advised. Clothing

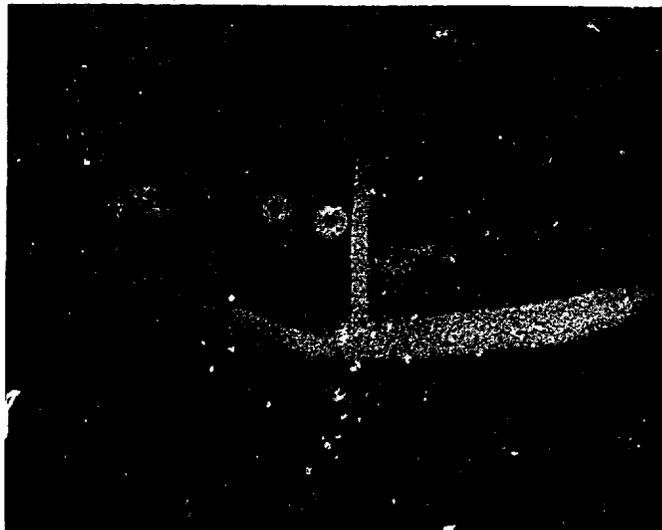


FIG. 7. Metallic punji stake injury in spite of steel plate in sole of boot. Stake penetrated web space between fourth and fifth toes.

is rarely carried into the wound ahead of the bullet.

It must be remembered that with many bullet wounds (as well as with any high-velocity missiles), tissue destruction is not limited to the missile tract per se. The tract is enveloped in a cylindrical zone of variable diameter, and the degree of tissue destruction is caused by the energy expended by the missile passing through the tissues. Therefore, before the surgeon elects not to debride the tract formally, he should examine it thoroughly. It must also be remembered that the path of the missile (bullet) may have but a cursory relationship to a straight line drawn between entrance and exit wounds. The varying densities of the tissues through which the missile passes all have the capability of changing the trajectory of the missile.

E. PUNJI STAKES

The use of sharpened bamboo stakes, metal spear-like devices, etc., has recently decreased in certain areas of Vietnam with the increased sophistication of enemy

weaponry. Holes or "punji pits," in which the stakes are often placed, are frequently booby-trapped to detonate when the stakes are touched, resulting in fragmentation injuries rather than impalement.

When the isolated punji stake injury is seen, it is best handled by cutting of the barb and pulling the device back through the wound (Fig. 7). The wound is then treated like any grossly contaminated, through-and-through wound.

SUMMARY AND CONCLUSION

The weaponry used in the Vietnam conflict is probably as effective and destructive as any weaponry in history. In spite of this, the treatment of the resulting casualties is founded on basic surgical principles: those of adequate debridement, thorough irrigation, and delayed primary closure.

Acknowledgment

The author gratefully acknowledges the assistance of Capt. Charles Brodine, Cdr. Clifford Herman, Cdr. Erwin Hirsch, and Lt. Cdr. Herbert Proctor in preparation of this paper.

NAVAL BATTLE CASUALTY STUDY

Under the auspices of the Naval Medical Research Institute and with the cooperation of the senior medical officer of the Station Hospital, Naval Support Activity, Danang, Republic of Vietnam, the authors attempted to study a portion of the Navy combat casualty handling experience in the I Corps area.

SCOPE

The study was carried out from January to June 1968 at the Naval Support Activity Station Hospital located five miles southwest of Danang, R.V.N. The hospital, during the period of study, had a total bed capacity of from 400-500 with 200-300 of these beds designated for postoperative surgical patients. The hospital maintained a helicopter pad for the evacuation of casualties directly from the field.

The primary triage area in the hospital was capable of handling eight patients simultaneously for examination and initial resuscitative care. A secondary triage area holding 20 patients and a tertiary triage area holding 30 patients, both covered and protected from the elements, were utilized as the primary facilities were filled. In addition, a resuscitation area (holding area) with a patient capacity of ten was available for those patients requiring additional resuscitative care prior to operative procedures.

The x-ray facilities at the hospital contained one hospital-type permanent x-ray unit as well as one 90-second dry film processor. Operating rooms included two major rooms each having a capacity of more than four surgeons and accompanying technicians operating simultaneously, and three minor rooms,

each with a capacity of one to two surgeons operating simultaneously. The latter group included one expandable MUST unit.

In addition to the above facilities, debridement facilities were present in various clinics for treatment of minor cases. These were capable of handling six patients simultaneously. The major postsurgical recovery unit (intensive care unit) held 12 patients.

The staff of the hospital included 3 anesthesiologists, 2 nurse anesthetists, 3 general surgeons, 4 orthopaedists, 2 neurosurgeons, 1 urologist, 1 ophthalmologist, 1 otolaryngologist, 1 oral surgeon and 3 surgical general medical officers.

As the patients entered the receiving area of the hospital, their serial numbers were recorded, and it was determined whether or not they had received prior definitive care. If they had not, they were interviewed by a member of a team of six Navy corpsmen assigned to the casualty study. Information gathered at this time included an appraisal of the wounds, activities at the time of wounding, information regarding wounding agent, etc. The patients were then followed through their entire hospital stay where the remainder of the data presented in this report was gathered. Patients who were admitted and subsequently discharged for their primary definitive care were not included in this study.

A casualty for the purpose of this study was defined as an individual wounded as a direct result of hostile weaponry who had, prior to his arrival at the hospital, received no definitive medical care. (The administration of intravenous fluids and other resuscitative measures en route to the hospital were not considered as definitive treatment.)

This study includes 2,021 consecutively treated casualties of the United States Armed Forces. A similar study was carried out in a parallel fashion dealing with casualties of the Army of the Republic of Vietnam but is not included in this report.

RESULTS

Fifty-nine of the 2,021 casualties died during their course of treatment at the Naval Support Activity Hospital; seventeen of these 59 patients were considered inoperable at the time of admission. Thus, the overall death rate was 59 of 2,021 (2.92%), and the death rate in those patients considered salvageable at the time of admission as 2.08% (42 of 2,021).

Information regarding prior wounding while in the service of the United States Armed Services was obtained in 1,855 patients. Two hundred and thirty-two of these patients (12.5%) previously received one or more purple hearts. Table I indicates frequency of previous wounding. Data was obtainable regarding previous wounding on only 17 of the 59 fatalities in the study. Thus, differences seen in frequency of previous wounding in the living and the group that ultimately died in the hospital are not particularly meaningful due to the absence of previous wounding information on 71% (41 of 59) of the fatalities.

Identification of the wounding agent was determined in greater than 95% of the casualties. Conventional artillery, mortars and rockets accounted for the largest group of casualties (38.3%). Second in frequency were gunshot wounds and third were mines and booby trap devices--see Table II.

An attempt was made to compare combat experience as indicated by time in R.V.N. to the likelihood of sustaining injuries from specific devices.

Because of attrition from wounding and rotation for other reasons prior to the completion of a 12 to 13-month tour of duty in the country, one would predict smaller absolute number of casualties among those remaining in the country for longer periods of time. Unfortunately, at the time of the study, control data was not available regarding the average length of stay in the combat area of those individuals from whom our patient population was drawn. It would appear, however, that between the 1st and 2nd month a significant decrease in the likelihood of being wounded by mines and booby traps occurred. This was a pattern not seen in the case of gunshot wounds or wounds caused by artillery. After the third month in the country, there seemed to be no appreciable difference among the three primary wounding agents in regard to the likelihood of wounding.

Table III indicates the location of the patient at the time of wounding. The vast majority of wounding occurred while the casualty was on foot. Riding in vehicles was the second most common category.

The casualties were divided into two groups depending upon the severity of their wounds. Casualties were considered "major" if they required a formal operating room environment for primary, definitive surgical care. If primary definitive procedures were carried out in a clinic or debridement facility, they were considered "minor." Essentially, only those individuals suffering superficial extremity or trunk wounds not involving major long bones, body cavities, the neck, or major nerves or vessels were treated in the debridement or clinic facilities.

Evacuation time (time from wounding to arrival at the hospital) was then computed for the major and minor categories, and it was determined

that there was no significant difference in the evacuation time for these two groups. This would indirectly indicate that severity of wound did not seem to be a major factor in the determination of the urgency of the need for evacuation from the field.

As each casualty arrived and was studied, determination of the number of other casualties present in the admission facility was made. It was determined that 59% of the casualties arrived at times that would not constitute mass casualty situations. A "mass casualty" situation was defined as one which involved the presence of more than five casualties in the admission facility simultaneously, as the operating room capacity was set at five. Approximately 20% of the casualties arrived while 6 to 10 other casualties were present in the admission area, and another 10% arrived with 11 to 20 casualties present in the admission area. Less than 10% of the casualties were handled at a time when more than 20 patients were present in the admission and resuscitation area waiting definitive care.

Of the casualties 60.1% required surgical procedures necessitating formal operating room facilities, 37.3% required "minor" debridements in the clinic or debridement facilities, and the remaining 2.6% of the casualties required no surgical procedures. Of this last group of 52 persons, 17 were considered inoperable at the time of admission and subsequently died.

Table IV indicates the type of anesthesia utilized during the operative procedures. Only local anesthesia was used in the clinic and debridement facilities. Slightly more than one-third (35.4%) of the anesthetics given were general anesthetics, a situation necessitated by the multiple anatomic

sites of wounding. Wherever possible, spinal or other regional anesthetics were used as these anesthetics allowed more effective utilization of the anesthesia staff.

Graph I indicates the length of hospital stay. Two-thirds of the patients in the entire study were transferred or otherwise released from the hospital facility within three days of their time of admission. Table V shows the disposition of these casualties. Only 7.9% of the entire casualty load was released to return directly to duty. The remainder of those living casualties were transferred to other medical facilities.

Tet and Non-Tet

During the period studied, two differing combat experiences were encountered. The first, the non-Tet period involving 1,679 of the casualties, would seem to exemplify the general experience in the I Corps area in Vietnam conflict in the period of 1967, 1968 and 1969. The Tet offensive involving 342 casualties and lasting 11 days produced a significantly different casualty handling situation, detailed in this portion of the report.

Table VI compares wounding agents during the Tet offensive and during the non-Tet. The most significant difference is the decreased frequency of mine and booby trap injuries during the Tet offensive (16.5% to 6.4%) and the increased frequency (37.3% to 54.1%) of wounds resulting from artillery including rockets and mortars. The proportion of gunshot wounds was almost identical for the Tet and non-Tet periods.

Graph II indicates the cumulative evacuation time for the Tet offensive casualties as compared to the entire casualty load. A significantly smaller

proportion of casualties were evacuated to a definitive treatment facility during the first one and a half hours during the Tet offensive. Part of the reason for this was the extensive use of holding facilities at the various collecting areas in the I Corps area. During this period patients would be taken directly from the field and staged for short periods of time until an entire aircraft load of casualties could be simultaneously evacuated to a treatment facility.

Due to increasing casualty loads, the elapsed time from admission to definitive treatment also lengthened during the Tet offensive. It is interesting to note (Graph III) that those patients requiring truly emergent surgical care (operative intervention within the first hour) appeared to receive this care regardless of the tempo of the combat situation.

Length of hospital stay also varied significantly during the Tet and non-Tet periods. Nearly 30% of the casualties were released or transferred by the third day during the period of the Tet offensive compared to the slightly more than two-thirds of the casualty load released in this period of time during the non-Tet situation.

Wounding Agents

More significant as a determinant of the care and facility requirements than the tempo of the conflict was the wounding agents present, as can be seen in Graph IV, although it has been previously shown that the tempo of the conflict does indeed influence the pattern of wounding agents. The only type of wounding agent utilizing single projectiles or missiles (gunshot wounds) predictably accounted for a higher proportion of wounds involving

only a single extremity. Indeed of 526 gunshot wounds nearly 50% involved only a single extremity. Head, thoracic and abdominal wounds occurred with almost equal frequency when the result of bullets. As one might expect with the multiple projectiles involved in artillery, rocket and mortar fire, wounds involving multiple extremities were more frequent than those involving a single extremity. Head and abdominal wounds resulting from artillery occurred with almost equal frequency, but thoracic wounds occurred with only half the frequency of the other two major trunk areas. This may be a reflection of the protective influence offered by armor vests, although it cannot be ascertained from our information.

Multiple extremity wounds as well as wounds involving the abdomen with or without multiple extremity wounds were most common in the case of mines and booby traps. Head and thoracic wounds occurred with somewhat less frequency with this particular type of ordinance, all of which might well be a result of the fact that the projectiles and missiles from mines and booby traps generally came from below, upward. One would expect a decreased frequency of injury to those parts further removed from the explosive device (head, thorax and upper extremities).

As a result of the variation seen in the distribution of wounds from various types of ordinance, the type of surgical facility required for definitive treatment also varied. Gunshot wounds with their reasonably high proportion of head, thoracic and abdominal wound sites as well as an increased severity in extremity wounds, particularly when long bones were struck, required the formal operating room facilities more frequently than

did the other wounding categories. Wounds resulting from artillery had a moderate frequency of multiple extremity involvement as well as an intermediate frequency of abdomen, chest and head involvement; these wounds required formal operating room facilities in the least number of cases. Wounds resulting from mines and booby traps required major operating room facilities more often than those resulting from artillery but less often than gunshot wounds. Burns represented only 1% of the casualty load, and nearly one-quarter of these casualties did not require either major or minor operating facilities, and indeed only 11.8% required the major facilities for debridement and primary definitive treatment.

The anesthetic utilized for the primary surgical care of casualties falling into the various wounding agent categories also differed significantly. Gunshot wounds, with their frequent single extremity involvement, required general anesthetics with less frequency (33%) than either of the other major wounding agents. Wounds sustained as a result of mines and booby traps required general anesthetics more frequently (44%) than the other two categories.

Blood replacement requirements also varied appreciably with the type of wounding agent. Over three-quarters of those casualties suffering gunshot wounds and wounds from various types of artillery required no blood replacement during the period of time from their admission to the completion of their initial definitive surgical procedure. Wounds from mines and booby traps, on the other hand, required blood replacement during this period in more than one-third of the cases. Indeed in this latter category 10% of the casualties required 5-10 units of blood, and another 9% required more than 10 units before completion of their initial surgical intervention.

Because of the distribution of the wounds, length of hospital stay also appears to be influenced by wounding agent. Nearly 50% of those individuals suffering extremity wounds without additional wounds of the head, chest or abdomen were discharged or transferred within the first two days after admission. Less than a third of those patients suffering penetrating wounds of the head, chest or abdomen were transferred within the first three days.

Graph V details the frequency with which various anatomic parts were involved. Of the three major midline wounding categories (penetrating head, thoracic or abdominal wounds), those involving the head were seen most frequently without wounds of other body parts. Indeed 58% of those patients sustaining head wounds had head wounds alone without any extremities involved. Forty-four per cent of the penetrating thoracic wounds had no other areas involved while less than 30% of the abdominal wounds had no other areas involved. The likelihood of multiple involvement of the extremities in addition to a major midline wound was thus greatest in the case of abdominal wounds. This involvement was substantial in that over 40% of these patients had 3 or 4 extremities involved in addition to the abdomen. This was significantly higher than in the case of penetrating head or thoracic wounds.

Table VII indicates the frequency of involvement of the various abdominal visceral contents. Two hundred one of 2,021 casualties were found to have penetrating wounds of the abdomen (peritoneal penetration). Of those 201 casualties undergoing exploratory laparatomies, 60 explorations yielded no wounding to the intraperitoneal contents.

One hundred ninety-nine patients required completion of already partial amputations or primary amputations at the time of operative intervention.

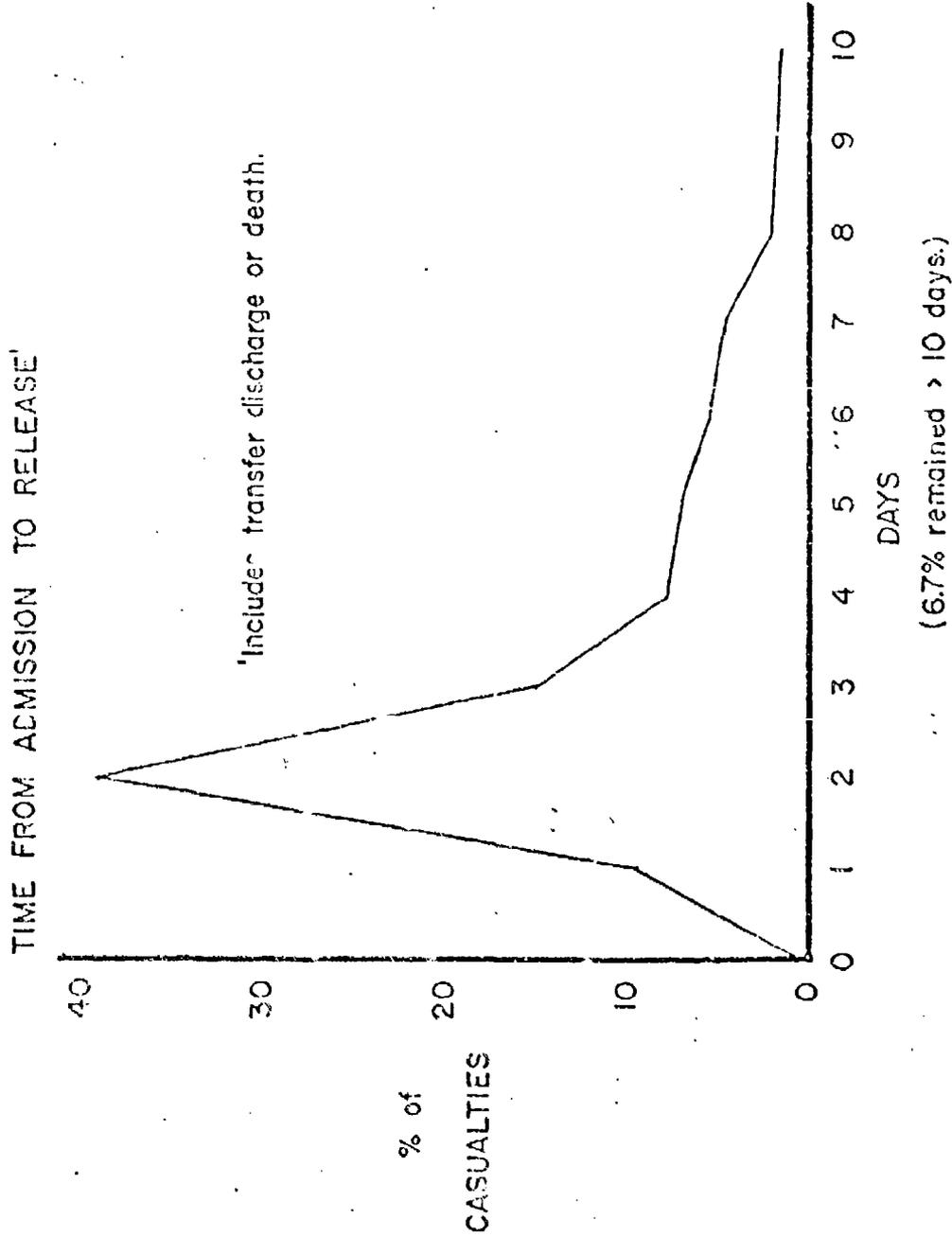
Thirty per cent of these amputations involved fingers or toes. The remainder involved major amputations in the upper or lower extremity with high below-knee amputations being the most common and disarticulations at the knee the second most common. 50.3% of all amputations were at or above the below-knee level in the lower extremities.

Major arterial injuries constituted 3.3% of all casualties and are detailed in Table VIII.

Frequency with which blood transfusions were utilized was not only a reflection of the wounding agent but also a reflection of the multiplicity in wound sites. Five hundred fourteen or 25.4% of the 2,021 casualties required transfusion of whole blood in addition to other intravenous solutions. 9.5% of the casualties required greater than 15 units of blood between the time of admission and conclusion of the primary definitive operative procedure. Of those casualties requiring whole blood replacement, slightly more than one-third required only 1 or 2 units of blood.

Table IX indicates the blood requirements based on wound site. The increased frequency in need for blood replacement in patients with abdominal wounds is a reflection not only of the severity of that particular trunk wound, but also, is a reflection of the increased frequency with which multiple extremity wounds were found in combination with abdominal wounds. This is true to a lesser degree with penetrating thoracic wounds. Head injuries, because they were more often than not associated with an absence of extremity wounds or wounds to the trunk, required the least amount of blood when one considers only those patients requiring blood replacement.

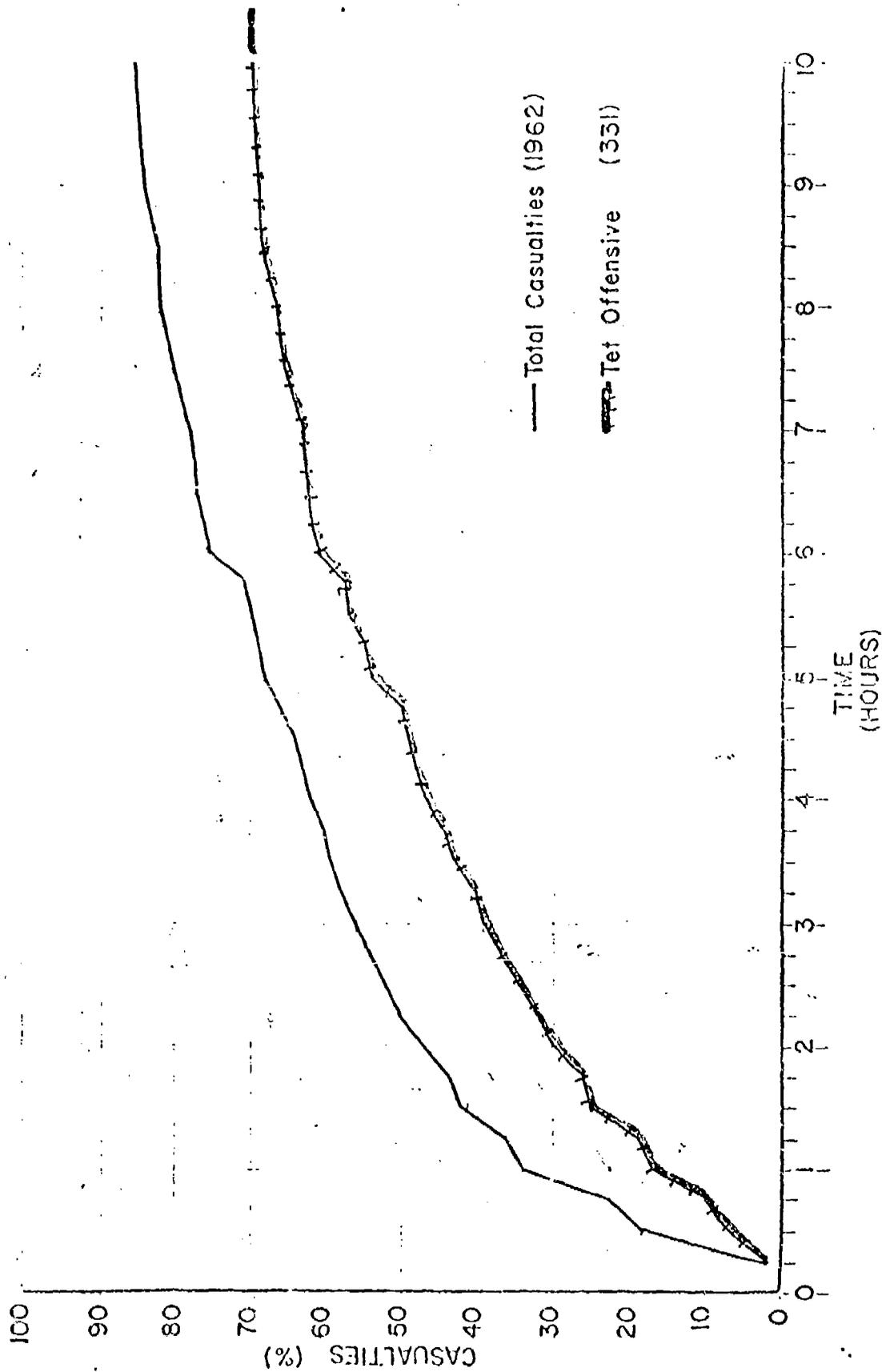
GRAPH 1



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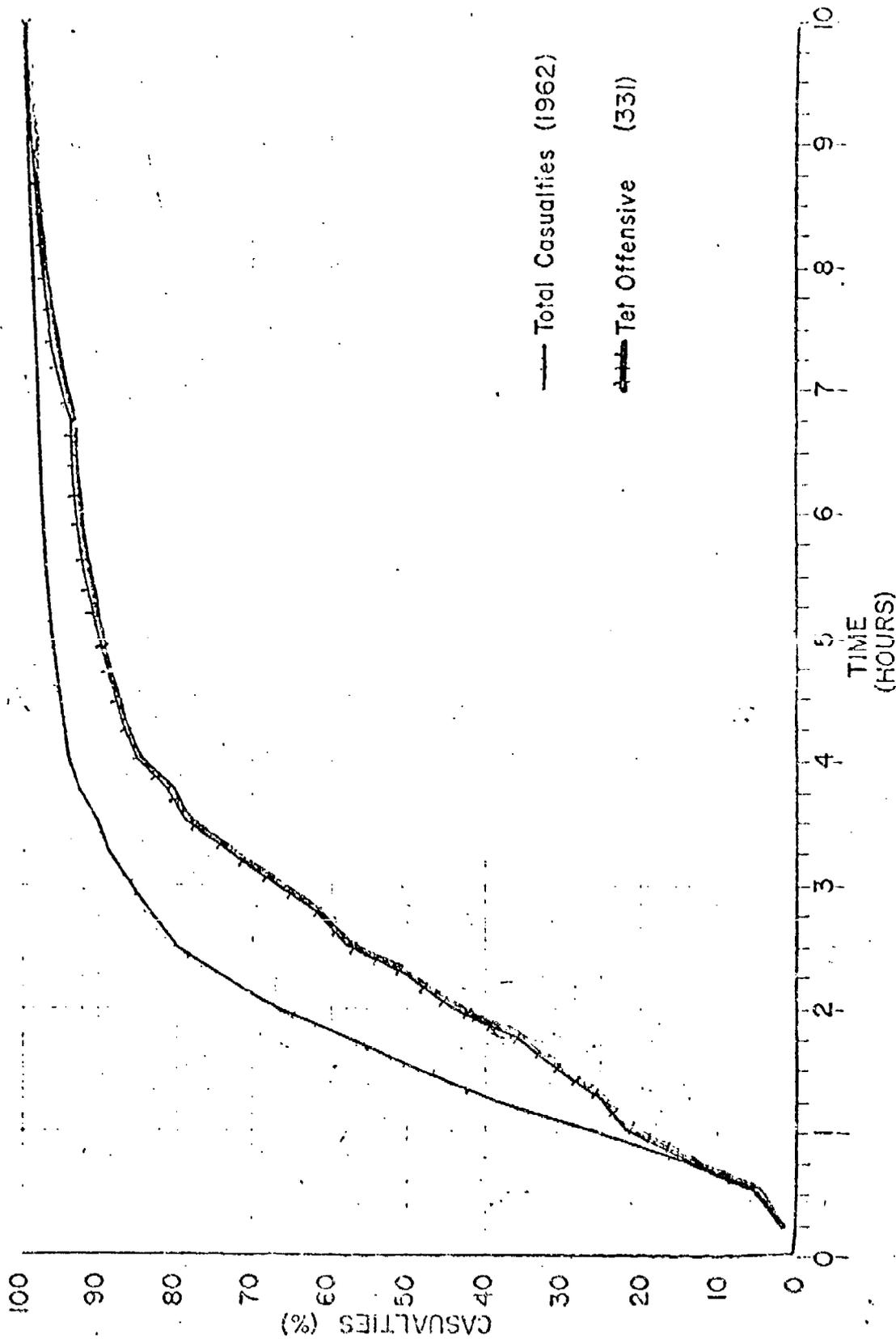
GRAPH II

EVACUATION TIME
Injury to Admission Non-fatalities



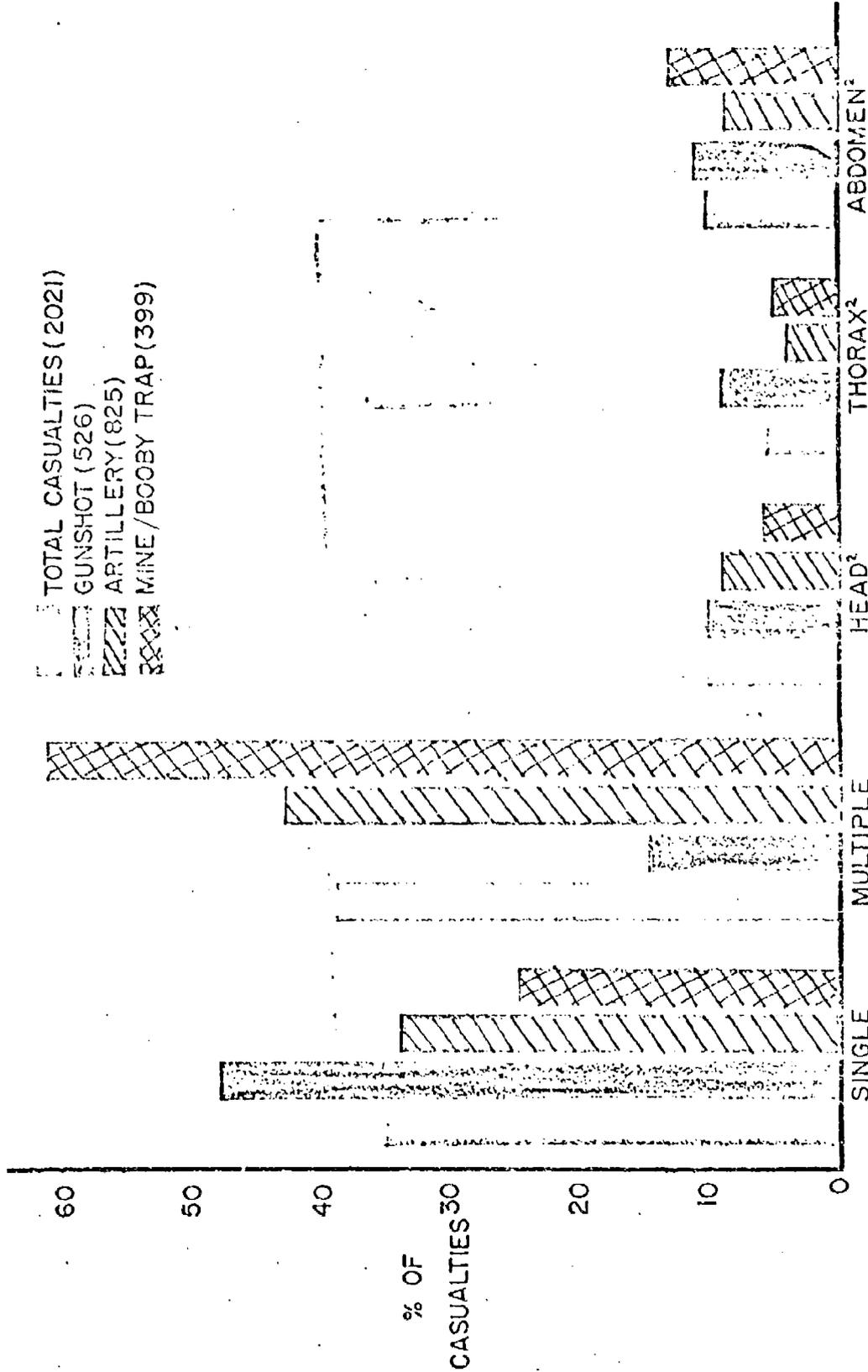
GRAPH III

ELAPSED TIME FROM ADMISSION TO DEFINITIVE R_x
Non-fatalities



GRAPH IV

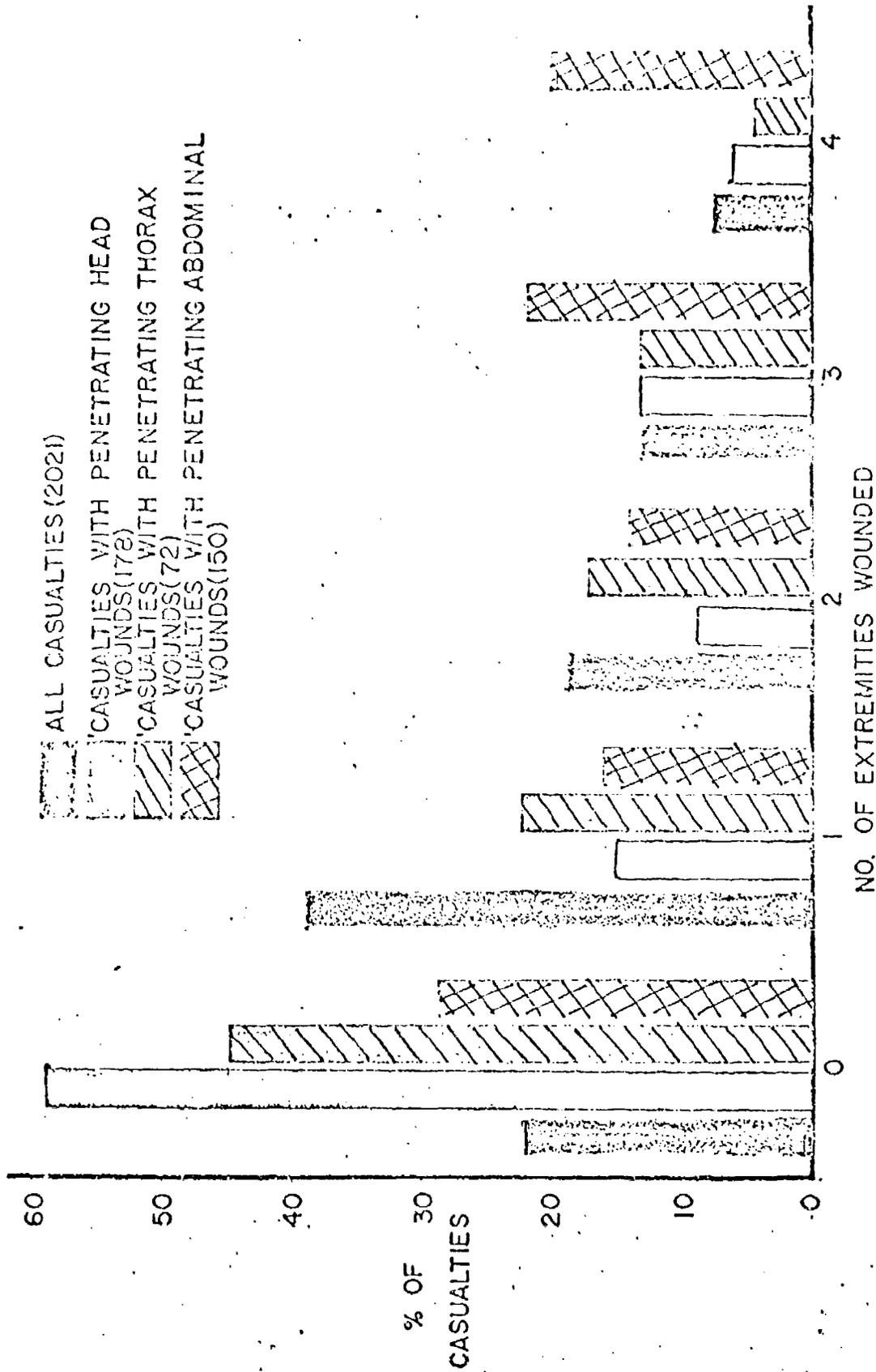
WOUND SITE vs. WOUNDING AGENT



*INCLUDING PENETRATING HEAD/TRUNK WOUNDS
 †INCLUDING MULTIPLE WOUNDS

GRAPH V

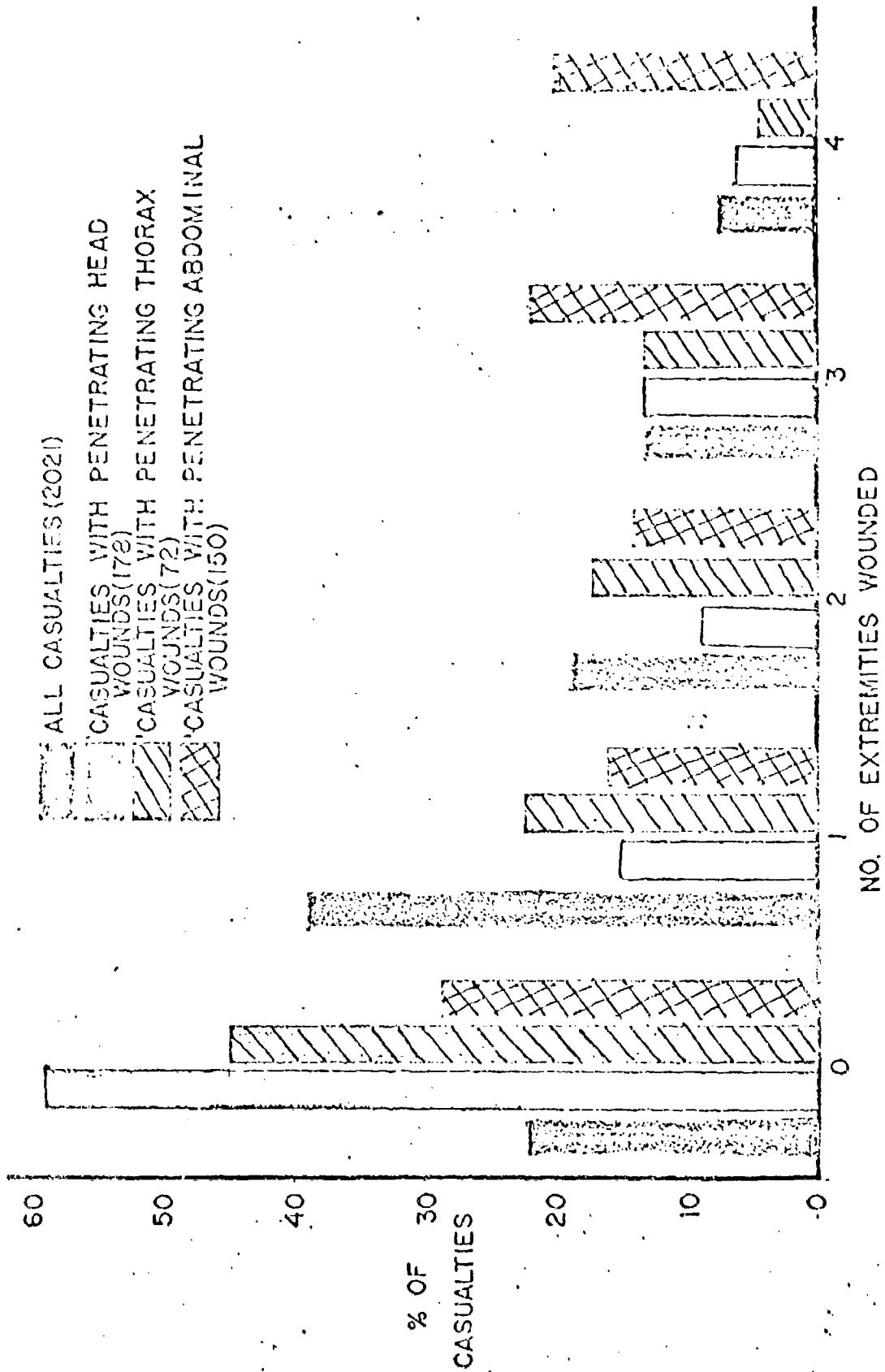
DISTRIBUTION OF EXTREMITY WOUNDS



*EXCLUDES MULTIPLE PENETRATING HEAD/TRUNK WOUNDS.

GRAPH V

DISTRIBUTION OF EXTREMITY WOUNDS



*EXCLUDES MULTIPLE PENETRATING HEAD/TRUNK WOUNDS.

TABLE I

Prior Wounds (Purple Hearts)	No.	%
0	1623	87.5
1	191	10.3
2	38	2.0
3	3	0.2
>3	0	0
No Data	(166)	-
Total	2021	

TABLE II

WOUNDING AGENTS

2021 TOTAL CASUALTIES

Gunshot (526)	24.7%*
Artillery (325)	38.8%
Mines and Booby Traps (399)	18.7%
Other: Grenades, Burns, Multiple, Unknown (378)	17.3%

* %'s based on 2128 total
due to occasional multi-
ple wound causation.

TABLE III

LOCATION OF CASUALTY AT TIME OF INJURY

Location	Number	Percent
Afoot	1677	83.0
Vehicle	114	5.6
Aircraft	52	2.6
Building	63	3.1
Unknown	<u>115</u>	<u>5.7</u>
TOTAL	2021	100.0

TABLE IV

TYPE OF ANESTHETICS GIVEN

	No.	%
General	713	33.4
Spinal	359	16.8
Regional	223	10.4
Local	841	39.4

Total anesthetics given 2136

7% (149 of 2021) casualties
needed no anesthetics

TABLE V

DISPOSITION OF CASUALTIES

Location	Number	Percent
Released Alive	1,962	97.1
To Duty	160	7.9
"In Country"	312	15.4
Hospital Ship	183	9.1
"West-PAC"	1247	61.7
CONUS	49	2.4
Unknown	11	0.5
Died	<u>59</u>	<u>2.9</u>
TOTAL	2,021	100.0

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TABLE VI

WOUNDING AGENTS
(TET vs. NON-TET)

WOUNDING AGENT	TET (342)		NON-TET (1679)	
	No. of CASUALTIES	% of TET CASUALTIES	No. of CASUALTIES	% of Non-TET CASUALTIES
GUNSHOT	97	28.4	429	25.5
ARTILLERY	185	54.1	627	37.3
GRENADE	25	7.3	146	8.7
MINE/BOOBY TRAP	22	6.43	277	16.5
MULTIPLE	(12)	(3.51)	(50)	(3.0)
UNKNOWN	19	5.6	68	4.1

TABLE VII

SPECIFIC ORGAN INVOLVEMENT
 PENETRATING ABDOMINAL WOUNDS
 (201 CASUALTIES)
 (60 NEGATIVE EXPLORATIONS)

ORGAN	No. of CASUALTIES	% of ABDE EXPLOR
STOMACH	19	9.4
DUODENUM	5	2.5
SMALL BOWEL	67	33.3
COLON	57	28.3
RECTUM	10	5.0
LIVER	39	19.4
SPLEEN	19	9.5
PANCREAS	3	1.5
KIDNEY	17	8.5
BLADDER/URETHRA	13	6.5

*Exclusive of duodenum.

TABLE VIII

MAJOR ARTERIAL INJURIES *
(3.3% of All Casualties)

Artery	Number	Percent
Axillary	2	3.0
Brachial	21	31.3
Femoral	20	29.9
Popliteal	7	10.4
Common carotid	6	8.9
External carotid	4	6.0
Internal carotid	<u>7</u>	<u>10.4</u>
TOTAL	67	99.9

* Exclusive of traumatic or primary amputations.

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TABLE IX

BLOOD REQUIREMENTS¹ VS. WOUND SITE

	Casualties	Blood/ patient	Requiring blood Number	%	Blood/patient requiring blood
EXTREMITIES (No major head or trunk wounds)	1563	0.83	1344	14.0	5.90
HEAD ² (penetrating, all)	196	2.85	122	61.3	4.65
CHEST ² (penetrating, all)	117	4.72	75	64.1	7.36
ABDOMEN ² (penetrating, all)	201	6.09	151	75.1	8.11

¹ Admission to completion of surgical procedure

² Categories overlap