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USE OF WHOLE BLOOD AND BLOOD VOLUME EXPANDERS IN U.S. MILITARY MEDICAL FACILITIES IN VIETNAM 1966-1971

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Washington, D.C.

April 1973

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A B S T R A C T

This report presents information on the actual usage of blood and blood volume expanders in US Military hospitals in Vietnam. It is necessary to have a method of estimating blood and fluid requirements for the resuscitation of combat and disaster casualties based on modern surgical practices and experience. The practical "rule-of-thumb" has been the amounts actually used in the most recent combat situation. The amount of blood and the amount, types, and proportions of fluids given to each patient are influenced by what is available, the training and philosophy of the surgeon responsible for the individual patient, and the extent of current surgical knowledge. Therefore what was given is not necessarily what should be given, but nevertheless is the most practical guide. In the Vietnam conflict, because of the superb, prompt rescue, and immediate resuscitation and transport of the injured, a higher percentage of patients with very severe injuries reached the hospitals alive, with an exceedingly high survival rate. Therefore, the Vietnam experience should serve to update the whole blood and fluid requirements for resuscitation under conditions in which severely injured individuals arrive at the hospital alive. It is recognized that concepts of fluid and colloid therapy are at present in a state of flux, but if some indication of their usage rate in U.S. military medical facilities in Vietnam can be determined, this can be useful for current planning purposes. If the amount of whole blood and amounts and types of fluids used per casualty are known, some prediction for future needs can be made. If the patients can be categorized according to wounding agent, and there is shown to be a significant difference in resulting fluid and blood requirements, these predictions can also be modified according to the predominant types of wounding agents. The Vietnam experience represents a situation in which abundant fresh whole blood was immediately available to all patients. Therefore, especially in the U.S. Army hospitals, it probably represents the maximum ratio of whole blood to blood volume expanders in the management of the types of casualties encountered.

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Use of Whole Blood and Blood Volume Expanders in US Military Medical Facilities in Vietnam 1966-1971

It is necessary to have a method of estimating blood and fluid requirements for the resuscitation of combat and disaster casualties based on modern surgical practices and experience. The practical "rule-of-thumb" has been the amounts actually used in the most recent combat situation. The amount of blood and the amount, types, and proportions of fluids given to each patient are influenced by what is available, the training and philosophy of the surgeon responsible for the individual patient, and the extent of current surgical knowledge. Therefore what was given is not necessarily what should be given, but nevertheless is the most practical guide.

By the end of WW II, the requirement of whole blood per hospitalized casualty (based on the amounts used) was 1.5 units.(1) In the Korean conflict, blood usage was 1½ to 2 units per each hospitalized casualty.(2) The "unit" in U.S. military use during and since WW II has always contained about 500 cc of blood.(3) The amounts and types of anticoagulant solution changed between early WW II and subsequent times. For instance, ACD solution was not used by the U.S. military until April 1945,(4) and never was used in the Mediterranean Theatre in WW II.(5) ACD was initially used in a larger volume (100 cc) than subsequently.(6) In the beginning of WW II, blood was drawn in 1000 cc bottles,(7) but by 1945, 600 cc bottles were used.(8) Containers of 500 cc capacity were used in Korea (bottles) and in Vietnam (plastic bags).

In the Vietnam conflict, because of the superb, prompt rescue, and immediate resuscitation and transport of the injured, a higher percentage of patients with very severe injuries reached the hospitals alive, with an exceedingly high survival rate. Therefore, the Vietnam experience should serve to update the whole blood and fluid requirements for resuscitation under conditions in which severely injured individuals arrive at the hospital alive.

It is recognized that concepts of fluid and colloid therapy are at present in a state of flux, but if some indication of their usage rate in U.S. military medical facilities in Vietnam can be determined, this can be useful for current planning purposes. If the amount of whole blood and amounts and types of fluids used per casualty are known, some prediction for future needs can be made. If the patients can be categorized according to wounding agent, and there is shown to be a significant difference in resulting fluid and blood requirements, these predictions can also be modified according to the predominant types of wounding agents.

To be used for this purpose, records have to include all casualties, without selection, rather than to be from a study done on selected cases, especially if the criterion for selection was inconstant. There are three presently available sources of such information for blood, and two for fluids. None of these sources was planned for this purpose, so each has some needed information lacking.

In comparing the blood and fluid usage rates listed in this report with data from other sources, it is important to note that in this report, the term "hospitalized casualty" refers only to trauma cases. Unlike some other sources of military medical statistics, the many admissions for disease although indicated in Table 1, are not included in the computations. It is felt that this more precise definition is more useful for military surgical planning purposes. It is also important to note that ratios of blood or fluid use "per hospitalized casualty" are less clinically meaningful than ratios "per patient transfused or infused." This is because the criteria for hospital admission vary depending on the medical evacuation policies. In Vietnam, often a helicopter would pick up all of the casualties in a given area and take them all directly to the treatment facility required by the most seriously injured. This resulted in "hospital admission" of some of the less seriously injured who in other combat situations would have been treated in battalion aid stations, clearing companies, etc., and would not have been classified as "hospital admissions."

I. Blood Usage as Determined from USARV Central Blood Bank Reports*

The first source is the USARV Central Blood Bank Reports, which were sent to the Department of Defense Military Blood Program Agency.

*The statistics in this section were compiled by CPT Leon P. Eisman, MSC, USN, Deputy Director, Military Blood Program Office.

TABLE I

Use of Whole Blood in US Military Hospitals in Vietnam - 1967-1971

Year	Total Initial Admissions, All Causes, All US Hospitals, RVN	Initial Admissions Casualties				Units of Blood Reported Transfused (All Patients, Including Non-Casualties and Non-US)	Patients Reported Transfused (Including Non-Casualties and Non-US)	Units Per Patient Transfused (f ÷ g)	Units/Hospitalized Casualty* (All casualties including non-US) (f ÷ e)
		NBI	IRHA						
		All	US	All	Total				
	a	b	c	d	e	f	g	h	i
1967	180,175	25,794	33,168	38,785	64,579	99,950	19,996	5.0	1.54
1968	148,587	19,850	40,144	67,046	86,896	169,953	39,154	4.34	1.95
1969	140,595	20,316	34,403	52,146	72,462	158,632	34,499	4.59	2.18
1970	110,634	17,619	16,055	27,791	45,410	112,724	30,307	3.71	2.48
1971	98,019	12,299	4,689	7,746	20,045	36,081	8,650	4.17	1.80
Total	678,010	95,878	128,459	193,514	289,372	577,340	132,606	4.34	1.99

*This calculation "assumes" that all of the blood used was given to casualties, so is a maximum value. Actually some could have been used for non-casualties.

Sources: Column (a) and (b): USARV Surgeon's office, compiled from Morbidity Report (DA Form 8-268)
(c) and (d): Compiled from the following reports:
USAF Biometrics Div (SGHB): Report of patients
USN, BUMED (NMDSC-40): Inpatient Statistical Reporting System
USA, OTSG Biostatistical Analysis Branch: Bed and patient reports (RCS MED-79)
(f) and (g) USARV Central Blood Bank Monthly Reports

These reports include a listing of the number of transfusions given per month as obtained from reports sent from the hospitals to the blood bank. Often all of the reports were not available when the compilation was made. Some of the reports from individual hospitals never were received. However, over a period of time, the errors and omissions can be considered to balance out. The reports sent to the Military Blood Program Agency did not categorize the recipients, who would include all patients receiving the blood for any reason. It can be assumed that most of the transfusions were for trauma cases, because little major elective surgery was done in the U.S. military hospitals, and relatively few of the non-surgical cases required transfusions. The amounts of blood given to non-U.S. casualties would not necessarily be the same as those given to U.S. casualties because of differences in normal blood volume (body size). However, there is considerable overlap, and since more precise categorization of the recipients is not available, all were grouped together in the estimations of amounts of blood used per hospitalized casualty and per patient transfused.

In the Vietnam situation, it was often difficult to decide whether an injury was the result of hostile action (IRHA) or "non-battle injury" (NBI), and in any combat situation blood may be required for the treatment of NBI resulting from causes such as aircraft and vehicular accidents. Therefore, both IRHA and NBI are included in the analysis of blood utilization.

As seen in Table I, subject to the limitations discussed above, in 1967 through 1971, the average yearly whole blood usage ranged from 3.7 to 5.0 units per patient transfused, and 1.5 to 2.5 units per hospitalized casualty. The total average blood usage for this time was about 2.0 units per hospitalized casualty and 4.3 units per patient transfused. From 1967 through 1971, total trauma admissions (casualties) were 289,392, and the total number of patients reported transfused was 132,606. Assuming that most of the transfusions were for trauma cases, this would indicate that about 46% of hospitalized casualties required transfusion. These records do not include any information on fluids other than blood, with the exception of the following data on plasma:

The use of plasma was first mentioned in the monthly reports of the U.S. Army, Vietnam Central Blood Bank (CBB), in November 1966 when 19 units of "plasma" were reported administered to a burn patient. The December 1966 report indicated that 3 units of "plasma" were administered to a burn patient. No further mention of plasma was made in the CBB monthly reports until October 1968, when 192 units of fresh frozen plasma were recorded as having been available for the month. Fresh frozen plasma was provided initially by the 406th Army Medical Laboratory, Camp Zama, Japan. Fresh frozen plasma was sent to Vietnam from Continental United States between August 1970 and September 1971, and thereafter was again supplied solely by the 406th Medical Laboratory.

The fresh frozen plasma (FFP) was used primarily as a coagulation defect prophylaxis (and treatment) administered to patients who had received very massive transfusions. From October 1968 to December 1972, 5,965 units of fresh frozen plasma were reported to have been administered. During the same time, 1,026,835 units of whole blood were reported transfused, this representing a ratio of 1 unit of FFP per 172 units of blood. Details of the exact indications for its use in given circumstances are not available, and it appears from some reports that administration was at least sometimes empirical. Therefore this proportion probably represents a maximum value for planning purposes. However, because of the paucity of detailed data, it has less value as a "planning factor" figure than the data for whole blood use.

As early as February 1965, group specific blood transfusions were used in multiple casualty situations in Vietnam, from blood drawn locally. According to Kiel[9] prior to April 1965, only "O" blood was sent from Japan to Vietnam. It was soon realized that this permitted utilization of only 45% of the potential donor population, and that all blood was administered in hospitals, where cross-matching was feasible. By the end of 1965, most of the blood used in U.S. military hospitals in Vietnam came from Japan, and comprised all four blood groups.[9]

Supplementary blood supply from Continental United States (CONUS) was started through the Department of Defense Military Blood Program Agency in July 1966. According to the Military Blood Program Agency's records, initially, only Group O blood was requested. In January 1967, Group B blood was also requested and supplied. In September 1967, Groups O, B, and A began to be requested and furnished from CONUS. After May, 1969, all four of the major blood groups were requested and supplied from CONUS, in specified proportions. As seen in Table II, the maximum percentage of universal donor transfusions reported per month was 46% (November 1969). There was a much higher "universal donor" transfusion rate for 1969 than in any other year reported. The data from September 1967 through December 1971 represents information from all hospitals furnished U.S. military blood, which included some non-US, Allied facilities. In 1972, when for the first time the reports enabled separate listing of US military hospitals, only 1.3% of the reported transfusions in U.S. hospitals were listed as "universal donor" type. From September 1967 to December 1971, 528,858 units were reported transfused, and 103,372 units (19.5%) were reported used as "universal" transfusions. However, only in 1969 did the reported monthly "universal donor" transfusion rate exceed 18%.

According to various laboratory officers (personal discussion), at least after 1967, in the major Army and Navy medical facilities in Vietnam, the initial stages of the cross-match were completed about 10 to 20 minutes after the sample was drawn, permitting group specific transfusion to be started if the patient required it immediately.

Table II

Use of "Universal Donor" blood in Vietnam. (Source: USARV Central Blood Bank Report)

Year	Total Units reported transfused	Total Units reported as "Universal donor"	% Universal donor transfusions
1967*	37,000	1,918	5.18
1968	178,632	25,434	14.23
1969	163,170	54,152	33.18
1970	110,865	19,227	17.34
1971	39,191	2,641	6.73
1972	3,727	48	1.30+

*September through December 1967 only.
+U.S. hospitals only. Reports 1967 through 1971 include some reports from blood sent to non-U.S. military hospitals.

Complete compatability testing was done on most of the blood used in U.S. military hospitals in Vietnam, particularly in the larger medical facilities to which most of the seriously injured were flown directly. It is of interest to note that even in World War II, according to Beecher "except in serious emergencies, all blood given to wounded men was grouped and cross-matched ... Although this was not always easy under combat conditions, it was seldom impossible."(10) The use of group O positive "universal donor" (low anti-A and anti-B titer) blood was found to occasionally cause hemolytic transfusion reactions upon subsequent transfusions of group specific blood.(11)

II. Information from Walter Reed Army Institute of Research (WRAIR) "Wound Checklist" Data*

The Division of Biometrics and Medical Information Processing of the Department of Data Processing, WRAIR, has data collected for another purpose (General Hardaway's wound checklist) on 17,726 casualties treated in U.S. Army hospitals throughout South Vietnam from late 1967 through part of 1969. The data are from information sheets intended to be completed on "every injury case admitted to the hospital whether or not it was a combat casualty." (The completeness of this coverage actually achieved is not included in the available data; however, initial admissions of U.S. Army personnel

*The assistance of LTC Michael Hannegan, MC, Deputy Director, Division of Biometrics and Medical Information Processing, Walter Reed Army Institute of Research and his staff is gratefully acknowledged.

with "battle injuries" totalled 18,779 in 1967, 26,575 in 1968, and 22,442 in 1969 (Beds and Patients Report, OTSG-A). Although the form used was changed sometime during the study, the last one was WRAMC Form 883 dated 1 January 1966 (issue discontinued in 1970). A copy of this form (Figure 1) indicates some of the limitations in the data. Wounds sources included only "small arms," "mortar fragment," "mine," "classified," "burn," and "other." This would require decisions concerning how to list items such as grenade injuries, including the commonly encountered rifle propelled grenade, which might be grouped with "small arms" or "other," and shell fragments from rockets, which might have been placed under "mortar" or "other." The data as received from Walter Reed Army Institute of Research now includes the categories "punji stick," "other native weapon," and "not indicated." It is not known whether this represents "write-ins" or use of a different form.

Another problem is that the maximum amount of blood given is listed as "51 or more units," and the plasma volume expanders as "11 or more units." Therefore, the actual maximum amounts of blood or fluids given are unknown.

There is no provision for listing the amount of fluid if more than one type was given. A notation after "quantity" states "if more than one, only major will be recorded." There are two sources of confusion in this statement. First, it may be construed to apply also to the listing of types of "blood substitutes" which immediately precedes the "quantity" notation, and only one of these may be checked off even though more than one kind was given. Secondly, the definition

FIG 1

HOSPITAL & REGISTRY NUMBER	1	1-7
NAME		8-27
AGE		28-29
RACE		30
SEX		31
RANK		32-34
SERIAL NUMBER		35-44

CARD CODE 1

WOUND SOURCE			
SMALL ARMS		45	
MORTAR FRAGMENT		46	
MINE		47	
CLASSIFIED		48	
BURN		49	
OTHER		50	
WOUND LOCATION		51	
HEAD & NECK		52	
THORAX		53	
ABDOMEN		54	
UPPER EXTREMITIES		55	
LOWER EXTREMITIES		56	
OTHER (FLANK, BACK, GENITALIA, UNSPECIFIED)		57	
WOUND CAUSE	X	58	
FRAG		59	
NBI		60	
ASSOCIATED INJURIES	X		
BONE		61	
ARTERY		62	
VEIN		63	
SHOCK	X		
PRESENT		64	
BP LESS THAN 90		65	
DURATION: 1-2 HR		66	
2-4 HR		67	
MORE THAN 4 HR		68	
VASOCONSTRICTION PRESENT		69	
SHOCK CAUSE	X		
HEMORRHAGE		70	
TRAUMA		71	
INFECTION		72	
OTHER		73	

CARD CODE 2

SURGICAL MANAGEMENT			
SOFT TISSUE		8	
DEBRIDEMENT		9	
DELAYED PRIMARY CLOSURE		10	
SECONDARY CLOSURE		11	
SKIN GRAFT OR FLAP		12	
AMPUTATION		13	
WOUND CLOSURE	X		
SUTURE WIRE		14	
GUT		15	
SILK		16	
OTHER		17	
STAY SUTURE		18	
TIME: PRIMARY		19	
2-5 DAYS		20	
6-12 DAYS		21	
OVER 12 DAYS		22	
BODY CAVITY	X		
HEAD		23	
ABDOMEN		24	
WITH NEGATIVE FINDINGS		25	
GASTRIC INJURY		26	
SMALL BOWEL INJURY		27	
REPAIR		28	
RESECTION		29	
PANCREAS		30	
LARGE BOWEL INJURY		31	
EXTERIORIZED		32	
PROXIMAL COLOSTOMY		33	
SPLEEN		34	
LIVER		35	
KIDNEY		36	
URETER		37	
BLADDER		38	
URETHRA		39	
CHEST		40	
CARDIAC REPAIR		41	
BRONCHUS REPAIR		42	
RESECT LUNG		43	
LIGATE VESSEL		44	

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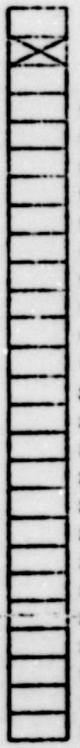
CARD CODE 2 (cont'd)

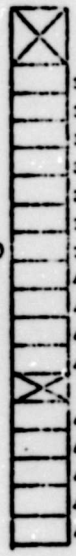
VASCULAR REPAIR
- END-TO-END SUTURE — 44
- GRAFT, AUTOGENOUS VEIN — 45
- PROSTHESIS — 47
- AORTIC — 48
- INNOMINATE — 49
- SUBCLAVIAN — 50
- AXILLARY — 51
- CAROTID — 52
- BRACHIAL — 53
- ILIAC — 54
- FEMORAL — 55
- POPLITEAL — 56

ANCILLARY TREATMENT
- BLOOD — 57
  - 1 UNIT
  - 2-5 UNITS — 59
  - 6-10 UNITS — 60
  - 11-25 UNITS — 61
  - 26-50 UNITS — 62
  - 51 OR MORE UNITS — 63
- BLOOD SUBSTITUTES — 64
  - DEXTRAN — 65
  - PLASMINATE — 66
  - HUMAN SERUM ALBUMIN — 67
  - SALINE — 68
  - OTHER — 69
- QUANTITY (If more than one, only major will be recorded)
  - 1 UNIT — 70
  - 2-5 UNITS — 71
  - 6-10 UNITS — 72
  - 11 OR MORE UNITS — 73

CARD CODE 3



ANTIBIOTICS — 8
- ROUTE
  - INTRAMUSCULAR — 9
  - INTRAVENOUS — 10
  - LOCAL — 11
  - ORAL — 12
- PENICILLIN — 13
  - 5 MILLION UNITS/DAY — 14
  - MORE THAN 5 MILLION UNITS/DAY — 15
- STREPTOMYCIN — 16
  - 1 GM/DAY — 17
  - MORE THAN 1 GM/DAY — 18
- CHLOROMYCETIN — 19
- TETRACYCLINE — 20
- CHLORTETRACYCLINE — 21
- OXYTETRACYCLINE — 22
- ERYTHROMYCIN — 23
- NEOMYCIN — 24
- POLYMYXIN — 25
- STAPHCILLIN — 26
- NYSTATIN — 27
- NOVOBIOCIN — 28
- COLYMYCIN — 29
- DEMETHYLEHLORTETRACYCLIN — 30
- SULFA DRUG — 31
- OTHER — 32



COURSE
- DAYS HOSPITALIZED IN VIETNAM
  - 1-5 DAYS — 33
  - 6-15 DAYS — 34
  - 16-30 DAYS — 35
  - 31-45 DAYS — 36
- COMPLICATIONS — 37
  - WOUND INFECTION — 38
  - DEHISCENCE OF ABDOMINAL WOUND — 39
  - RESPIRATORY — 40
  - CARDIAC — 41
  - GASTROINTESTINAL — 42
  - RENAL INSUFFICIENCY — 43
- DISPOSITION
  - DUTY — 44
  - EVACUATED — 45
    - PROGNOSIS GOOD — 46
    - PROGNOSIS POOR — 47
  - DEATH — 48

of "major" is not given. Is it the one with the greatest physiological effect, or is it the one administered in greatest volume? If just one unit of two different plasma expanders was given, which would be listed? In most instances, more non-colloid fluids (e.g., Lactated Ringer's solution) are given than the colloids, even when colloids are employed. Therefore, it is possible that these data will omit at least some instances in which dextran, Plasmanate, or human serum albumin were used. Lactated Ringer's is not listed by name, although there is a space for "saline" and for "other."

According to instructions issued by the USARV surgical consultant (LTC G. W. Fisher) in March 1966,[12] the "checklist" was to be "filled out at the time of final USARV disposition of the patient, i.e., duty, transfer out of country or death" and were not to be filled out for transfers in-country, to avoid duplication. Therefore although in most cases the fluids and blood given represent the initial resuscitation and surgery, theoretically post-operative fluids and blood would also be included.

a. Use of Whole Blood

Of the 17,726 casualties, 2774 (15.7%) received some whole blood. The quantities were grouped rather than recorded individually, so the actual amount per casualty is not known. The distribution of the amounts (units) of blood received by the 2774 casualties who were transfused was as follows:

Number of Units	Number of Casualties
1	224
2-5	1597
6-10	569
11-25	278
26-50	81
51+	25
Total	2774

The actual maximum given to a patient in this series is not recorded. If the amount given is assumed to be the upper limit of each range, and 1 and 51 is accepted as the amount for their respective groups, maximum average utilization of 1.5 units per hospitalized casualty, and 9.43 units per patient transfused can be estimated. Similarly using the lower limits of each range, a minimum of .75 units per hospitalized casualty and 4.78 units per patient transfused is estimated.

An average utilization can be estimated by assuming the amount given to be the mid-point of each group, with 1 and 51 accepted as the amount for their respective groups. This indicates an estimated total of 19,721 units of whole blood administered to 2774 patients. This would be 1.11 units per hospitalized casualty, or 7.11 units per patient transfused.

b. Use of Plasma Expanders

Of the 17,726 casualties, 4311 (24.3%) received some plasma expander (including Ringer's lactate and saline). The distribution of amounts (units) of plasma expanders received by the patients infused was as follows:

Number of Units	Number of Casualties
1	1050
2-5	2427
6-10	357
11 or more	176
Quantity not Indicated	301
Total	4311

The "unit" is a different volume depending on the expander used; for instance, a "unit" of Ringer's lactate is 1000 ml, whereas a "unit" of 25% human serum albumin is 100 ml. In the tabulation of plasma expanders, the concentration of serum albumin (25% or 5%) was not given. However, supply records indicate that little if any 5% serum albumin was sent to Vietnam for US military use.

Using calculations similar to those employed for the whole blood, the maximum total amount of plasma expander used is estimated as 18,992 units if the 301 "not indicated" are considered one unit each. There was a maximum of about 3.93 units of colloid or fluid used per patient receiving fluid if the 301 with "amount not stated" are omitted. If the "amount not stated" is arbitrarily listed as "1" the "maximum" would be estimated as an average of 3.99 units per patient receiving fluid. In calculations involving plasma expanders (including saline and lactate), since the maximum number of units listed was 11, this is used as the upper limit per patient.

The minimum average amount of plasma expander used per patient infused was 2.10 units if those with the amount not stated are omitted, and 2.16 if those with the amount not stated is arbitrarily listed as 1. To estimate the average amount of plasma expanders used, the amount given is assumed to be the mid-point of the grouping, (with 1 and 11 accepted as the amounts for their respective groups), multiplied by the number of patients in each group. The 301 instances in which quantity was not indicated were distributed among the groups accerding to the proportions of recorded units in the groups. This yields an estimated total of 15,412 units of plasma expander given to 4311 patients. This would be an estimated average of 1.15 units per hospitalized casualty, or 3.57 units per patient receiving the fluids. Distribution of specific fluids is shown in Table III.

(1) Dextran: 83 (0.47%) of the 17,726 casualties hospitalized received some dextran. The amount of dextran received per casualty is not actually listed, and can be derived only by estimations. Using the maximum amounts and assuming that all the plasma expander used was dextran, the amount given would be not more than 6.02 units per casualty receiving dextran, or not more than .03 units per hospitalized casualty. For this estimation, the maximum possible to have been given is assumed to be 11 units. It is surprising that at least 28 of these patients (i.e., more than 25% of them) received more than 5 units of dextran. This may be related to the fact that there were 22 vascular repairs in this group, a much higher proportion than in any of the other groups.

TABLE III

Distribution of Casualties Receiving Plasma Expanders (by Amount and Type)

(WRAIR Study)

Amount (Units)	Number of patients receiving given amounts					
	Dextran	Plasmanate	Human Serum Albumin	Saline	Lactate	Other
1	9	1	0	68	927	35
2-5	40	1C	7	198	2218	85
6-10	17	4	8	52	320	50
11 or more	11	9	1C	64	161	52
Quantity not Indicated	8	3	3	38	264	16
Total	85	??	28	420	3890	238
	(83*)			(417*)	(3879*)	(235*)

*Totals as reported in text, believed to be more accurate than those reported here. Both are from different portions of the same computer study.

(In 91 patients, the type of fluid given was "unknown." These are omitted above).

(2) Plasmanate: 27 (.15%) of the 17,726 casualties received some plasmanate. The maximum average amount per patient receiving plasmanate (based on all expanders given, to a maximum of 11 units/patient) was 7.04 units. This would be .01 units per hospitalized casualty. This group included 13 burn patients, a much higher proportion than any of the other groups.

(3) Albumin: 28 patients (.16% of all hospitalized casualties) received some quantity of albumin. As noted above, the relative amounts of 5% and 25% albumin are not in the data as compiled but it was probably all 25% albumin. Using the same methods for estimation, the maximum average amount per patient receiving a plasma expander would have been 7.68 units, or .01 units per hospitalized casualty. This group included 7 burn patients. It is interesting to note that at least 18 patients received more than 5 units of serum albumin, including at least 10 receiving "11 or more units."

(4) Saline: 417 patients (2.36% of all the hospitalized casualties) received some quantity of saline. This is an estimated maximum average of 5.47 units/patient receiving fluid or .13 units per hospitalized casualty.

(5) Ringer's Lactate: 3879 patients (21.88% of the hospitalized casualties) received some lactated Ringer's solution. This is an estimated maximum average of 4.38 units per patient receiving the fluid, or .96 units per hospitalized casualty.

(6) Other Fluids: Fluids other than those listed above were given to 235 patients (1.33% of the hospitalized casualties). The identification of these "other" fluids is not available. This was an estimated maximum of 6.52 units per patient receiving the fluids, or .09 units per hospitalized casualty. In 91 patients, the type of fluid given was unknown in the original data. This was .51 of those receiving fluids, with an estimated maximum of 5.29 units per patient receiving it (or 0.03 units per hospitalized casualty).

In summary, as seen in Table III, Ringer's lactate was reported used far more often than any of the other volume expanders. In the group listed, 3879 patients received Lactated Ringer's solution, 417 received saline solution, and 140 received some colloid, of which about four times more dextran was used than either Plasmanate or serum albumin. The colloid use therefore was about .03 of the total fluid requirement for initial resuscitation.

c. Blood and fluid use in management of wounds from specific weapons (Table IV and Table V)

The 17,726 individuals had 18,053 etiological agents listed (including 632 with source not indicated) so there was an overlap of 327 indicating injury from more than one cause per patient. Other studies[13] have indicated that in the Vietnam conflict even a single wounding agent is not always correctly identified, even when a special attempt is made in this regard. In instances of multiple causes the number listed is influenced both by identification

TABLE IV

Relationship of Wound Etiology to Blood and Fluid Utilization

	Number of Casualties			
	Small Arms	Mortar	Mine	Burns
Total number of casualties	4565	6631	1854	455
Blood (Number of Units)				
1	76	90	31	1
2-5	611	552	191	5
6-10	210	188	83	2
11-25	109	66	59	1
26-50	29	21	18	1
51 and over	9	5	7	0
Total	1035 (23%)	922 (14%)	389 (37%)	10
Fluids (Number of Units)				
1	413	372	82	10
2-5	853	824	253	55
6-10	122	111	47	23
11+	52	50	34	13
Quantity not Indicated	98	105	37	16
Total	1538(33.7%)	1462(22%)	453(24.4%)	117

TABLE V

Estimated Average Blood and Fluid Use Per Wounding Agent

	Number of Casualties		
	Small Arms	Mortar	Mine
Total	4565	6631	1854
Blood			
Number given blood, any qty	1035	922	389
% given blood, any qty	23%	14%	37%
Estimated total units	7418	5767	3467
Estimated units per casualty	1.6	0.9	1.9
Estimated units per casualty transfused	7.2	6.3	8.9
Fluids			
Number given fluids, any qty	1538	1462	453
% given fluids, any qty	34%	22%	24%
Estimated total units (includes "QNI)*	5286	5060	1870
Estimated units/casualty	1.2	0.8	1.0
Estimated units/Casualty given fluids	3.4	3.5	4.1

*The "Quantity not indicated" were distributed in each group according the same proportions as those which were indicated, and the totals thus obtained.

(Burns omitted from this table because of the small number.)

and by the decisions of the person recording the data. There is also a problem in interpretation since items such as grenades are not separately listed, although they were a common cause of injury in Vietnam. An additional limitation to the data is the grouping into the categories "small arms," "mortar" and "mine." The "mortar" group probably includes all high explosive shells and rockets. The "mine" group may include in addition to the classical contact explosive device, numerous "booby trap" uses of other munitions which have different wounding effects. It can be assumed that "small arms" injury was usually interpreted to mean bullet wounds, and "mortar" injury can be assumed to be shell fragment wounds whether from rockets or artillery rounds. However, because of individuals involved in recording the data, the number of cases, and the number of medical facilities involved, these figures can probably be considered to be a reasonable representation. Distribution of wounding agents was as follows:

Small arms	4565
Mortar	6631
Mine	1854
Punji stick	139
Other Native weapon	195

(1) Small Arms: The 4565 "small arms" patients used an estimated maximum of 9865 units of whole blood (estimated total 7418) and 6470 units of fluids. This would be a maximum average

of 2.16 units of whole blood per small arms casualty and 1.42 units of fluid per small arms casualty. Estimated average (Table IV) is 1.6 units of whole blood per casualty, or 7.2 units per patient transfused. The distribution was as shown in Table III.

(2) Mortar: The 6631 "mortar" patients received a maximum of about 7685 units of whole blood and 6152 units of fluids. Distribution was as shown in Table III. This would be an average maximum of 1.16 units of blood per mortar casualty, and .93 units of fluids. The estimated averages, as shown in Table IV, are 0.9 units of blood per hospitalized casualty, and 6.3 units per patient transfused.

(3) Mine: The 1854 "mine" patients received an estimated maximum of 3738 units of whole blood and 2444 units of fluids. This would be 2.02 units of whole blood and 1.32 units of fluids per mine casualty. The estimated average (Table V) is 1.9 units of whole blood per hospitalized casualty, and 8.9 units of blood per patient transfused. Similarly, the estimated average fluid use was 1.0 units per casualty, and 4.1 units per casualty given fluids. The distribution was as shown in Table IV.

(4) Burns: The 455 burn patients included 70 with other types of wounds. All 70 were identified, and grouped as follows:

Small arms	5
Mortar	21
Mine	17
Punji stick	0

Other Native weapons	0
Classified	1
Other	26

Of the 455 patients, 10 received whole blood. In the form in which the data are available, the amount of blood given is not differentiated between those with associated injuries and those without. Distribution of various amounts of fluids and whole blood given to the 10 burn patients, is shown in Table III. The fluids administered were grouped as follows:

Dextran	- 3 patients
Plasmanate	- 13 patients
Human Serum Albumin	- 7 patients
Saline	- 12 patients
Lactated Ringer's	-100 patients
Other	- 11 patients
Fluids given but type not specified	- 3 patients
Total	149

It is unknown how many of the patients received more than one of the fluids listed above. The distribution of all of these fluids administered to the burn patients is shown in Table IV.
This would appear to indicate that 117 patients of the total of 455 burn patients received some intravenous fluid. Since 100 patients are listed as receiving lactated Ringer's solution, which is now the fluid commonly used in burn resuscitation, it must be assumed that at least 338 patients had minor burns. The other alternative

is that the fluid records are faulty, even though one recognized that serious burns were rapidly evacuated out of the country. Details of this study indicate that 233 of the patients were hospitalized in Vietnam less than 6 days, and 279 evacuated at some time post injury.

Summary of WRAIR Data

In summary, these data indicate that the average amount of whole blood used per hospitalized casualty was between .75 and 1.5 units (estimated average 1.11) and the average amount of whole blood used per patient transfused was between 4.9 and 9.8 units (estimated average 7.11).

The average amount of volume expander other than whole blood was between .57 and 1.5 units per hospitalized casualty (estimated average 1.15) units and was between 2.1 and 3.8 units per patient given fluids, (estimated average 3.57).

It must be noted that the above estimations are limited by the fact that the maximum amounts of blood and fluids given are not actually listed, and that a fairly large number of fluids were listed as "quantity not indicated."

These comparisons of estimated average blood and fluid use per wounding agent are summarized in Table IV. It is probably significant, and compatible with clinical experience, that a smaller percentage of the "mortar" patients required blood, and that those who did, received less blood per casualty than in the other two categories. It is also compatible with clinical experience that a higher percentage of the "mine" casualties required blood, and that those transfused required more blood, than in the other two categories.

These can be compared in another way: of the 1035 small arms casualties receiving whole blood, 357 (29%) received more than 5 units of blood. Of the 922 mortar casualties receiving blood, 280 (30%) received more than 5 units of blood. Of the 389 mine casualties receiving blood, 167 (43%) received more than 5 units of blood. This relatively crude manipulation of figures does not permit determining whether there is a statistically significant difference between the "mine" group and the others, but the observation that this group required more blood than either of the other two groups is probably valid.

III. U.S. Navy Vietnam Studies

The third source of information is from studies done by the U.S. Navy personnel in Da Nang. This is in two groups. The first studies were in 1966, and the second in 1968.

a. 1966 Study

Between January and July 1966, a study reported by Moss[14] was done "to further define the role of salt solution in the initial resuscitation of the badly injured combat casualty." During this time, 944 battle casualties were treated at the US Navy Station Hospital. Within this period, helicopter evacuation time from the battlefield to the hospital averaged one hour in a group of 284 orthopedic injuries, although 2/3 of these patients were in the hospital within 30 minutes of injury. According to Moss, the initial therapy was rapid volume expansion with "balanced salt solution."

The buffered saline contained sodium 242m Eq/L, chloride 154m Eq/L, and bicarbonate 88m Eq/L. Lactated Ringer's solution was also used. Twenty-five grams of mannitol and 4 ampules of sodium bicarbonate (176 mg) were given immediately thereafter.

Small quantities of either Plasmanate or twenty-five percent serum albumin were also administered. Moss, in personal communication, states that Plasmanate and albumin were used "when they were available," but that at the time of his study these were in short supply at the hospital. According to Moss, if adequate volumes were given, and hemorrhage controlled, the classical signs of shock were regularly reversed prior to the administration of "carefully cross-matched blood."(14) Blood "was usually transfused as the central venous pressure began to rise and was given not as a volume expander but rather to maintain a critical red cell mass in the range of 25% hematocrit levels."(14) Blood, in the majority of cases, was cross-matched prior to transfusion. In several instances, however, it was necessary to use uncross-matched low titered, Group O, Rh negative blood.(14) According to one informant (Captain Brodine - personal communication) in January 1966, it was sometimes about 30 minutes before group specific blood was ready for a patient, but after about one or two months, group specific blood was routinely ready within 15 to 20 minutes especially in the research unit.

In Moss' report, there is unfortunately no indication at all of the amounts of colloids and fluids other than blood given, except for the statement "It was not uncommon to infuse 6-8 liters (of balanced salt solution) before central venous pressure would begin to rise."[14] This study is decribed in considerable detail because it may represent an unusual use of blood: to restore the lowered hematocrit following the combined effect of hemorrhage and the administration of probably large amounts of fluids. Although the title of the report suggests that successful resuscitation was done with "balanced salt solution" alone, it is possible that the Plasmanate, serum albumin, and mannitol may have also had a significant influence on the results. In this group of observations, 36% of the casualties required blood and the average volume transfused was 7.5 units. According to Moss, (personal communication) these values represented the first week of hospitalization.

b. 1968 US Navy Battle Casualty Study, NSA Da Nang (James Garrick and Larry Carey)

The second U.S. Navy study was conducted at Naval Support Activity Da Nang, in 1968. These observations were made for a few weeks before the Tet Offensive, during the Offensive, and for several weeks afterwards (1 January 1968 to 15 May 1968). It therefore, like the other Navy study, represents the treatments methods used by U.S. Navy personnel in one hospital, during a limited time span. The evacuation procedures and type of combat experienced are essentially

those peculiar to the Navy-Marine activities in the 1st Military Region (northern part of South Vietnam). With these limitations, this study has the advantage of representing detailed observations during the height of combat activity.

A total of 2021 casualties were included. These were all U.S. military personnel with battle injuries. All completely closed injuries were omitted, but, according to the investigators (personal conversation with Dr. Garrick and Dr. Carey), very few such injuries were seen in their hospital at this time.

The amount of blood recorded was that used from the time of admission through the initial surgery (essentially, the first 24 hours post admission). Blood given prior to admission was not recorded, but probably none was given to these casualties pre-admission. Results are summarized in Table VI and Table VII.

Unfortunately, this study included no data at all on the use of fluids and colloids. During this time, detailed studies of a series of patients admitted in shock were also being done, [15-16-17] and the use of colloids and fluids in the shock treatment study influenced somewhat the selections of resuscitation fluids in the other patients. Dr. Garrick recalls some albumin being used early in series, (personal communication). Clautier, Lowery, and Carey[15] studied 56 of the 1968 Navy group of patients. These patients were selected because they were admitted in a state of hemorrhagic shock, had no CNS or thoracic wounds, and no resuscitative fluids had been administered before hospitalization.

TABLE VI

Blood Requirements vs. Tenor of Combat (US Navy Study 1968)

	Pre-Tet (1 Jan-29 Jan) 1968	Tet (30 Jun-10 Feb) 1968	Post-Tet (11 Feb-15 May) 1968
Casualties	257	270	978
% Requiring Blood	26.5%	21.0%	26.4%
Mean Blood Requirements (All Casualties)	1.7 units	1.5 units	1.5 units
Mean Blood Requirements (Casualties Requiring Blood)	6.5 units	7.3 units	5.7 units

(US military, open injuries, "injured as result of hostile action").

First 24 hours, through initial surgery.

TABLE VII

Blood Requirements vs. Wounding Agents (US Navy Study 1968)

	Gunshot	Artillery (Mortars/Rockets)	Mines & Booby Traps**
Casualties*	481	787	346
% Requiring Blood	23.7%	21.2%	37.0%
Mean Blood Requirements (All Casualties)	1.1 units	1.0 units	3.4 units
Mean Blood Requirements (Casualties Requiring Blood)	4.7 units	4.6 units	9.1 units

*Does not total 2021 because burns, multiple agents, and unknown categories were excluded.

**Booby traps include grenades, which are otherwise omitted.

The patients were given only lactated Ringer's solution or normal saline solution in addition to blood. "There were no preset formulas for fluid administration."

In Proctor's study[16] initial resuscitation was by Ringer's solution at a rate of 200-300 cc 1 min. until systolic arterial blood pressure was at least 100 mm Hg., central venous pressure was greater than 6 mm H_2O or cross-matched whole blood was available (saline cross-matched blood available in 10-15 minutes).

In this article, the only information on amounts of fluids given is the statement ".... the mean volumes of fluids infused for resuscitation, operation, and maintenance for the remainder of the first 24 hours following admission were: 5,075 cc, salt solution, 1232 cc D_5W and 11,023 cc whole blood, packed cells, or "plasma." In spite of efforts to reduce fluid administration to a minimum, evidence of fluid retention was present at 24 hours, as evidenced by mild periorbital edema, and an ensuing diuresis and weight loss over the last three days of the study period." Other evidence of fluid retention in these patients was based on radioisotope studies "in which there was a considerable increase in the extracellular water at 24 hours. This returned to normal by the 120 hour sample time." In this study, a group of "massively injured" patients was compared with "bed rest controls" and a group of patients with congestive atelectasis or "shock lung." However, no comparison or listing of the amounts of fluids received by each of these groups was made.

The "plasma" referred to was possibly Plasmanate, referred to elsewhere in the same reference. Toward the end of the series, Ringer's lactate and blood were the sole resuscitative fluids in practically all the patients. Dr. Carey recalled (personal communication 1972) that approximately 2.3 to 2.5 volumes of Ringer's lactate was used per each unit of blood, and that the Navy use of blood tended to be less than the use in Army hospitals. According to Captain Brodine, in the 1968 series (Carey, Garrick) larger amounts of salt solution and less blood were used than in the 1966 study. In 1969 (Proctor) series, less fluids and more blood were used than in the 1968 studies. If necessary, group specific blood would be transfused about 15-20 minutes after the sample was drawn pending the final steps of the cross-match.

Summary

The Military Blood Program Agency's records indicate that approximately 46% of hospitalized casualties in U.S. military hospitals in Vietnam required transfusion. The average use of whole blood was between 1.5 and 2.5 units per hospitalized casualty, and between about 3.7 to 5.0 units of whole blood per patient transfused. Most of the transfusions were of group specific blood rather than "universal donor" (group O) blood.

The Walter Reed Army Institute of Research records suggest that in the group of patients studied in U.S. Army hospitals, 15.7% of hospitalized casualties required transfusion. The use of whole blood averaged between about 0.75 and 1.5 units (estimated average 1.1 units) per

hospitalized casualty and between 4.78 and 9.43 units (estimated average 7.1 units) per patient transfused.

The 1966 U.S. Navy study (Moss) indicated that 36% of the 944 casualties required blood, and the average volume transfused was 7.5 units per patient transfused during the first week of hospitalization. The average amount per hospitalized casualty was therefore about 2.7 units.

The 1968 U.S. Navy study indicates that 21% to 26.5% of their hospitalized casualties required transfusion. This was about 1.5 to 1.7 units per hospitalized casualty, and 5.7 to 7.3 units per patient transfused.

Therefore, subject to the limitations of the data discussed in the text, in the U.S. military experience in Vietnam, the average amount of whole blood used per hospitalized casualty was not less than about 1.5 units, and not more than about 2.7 units. The average amount of whole blood used per patient transfused was not less than about 3.7 units, and not more than about 9.4 units. These are overall averages and do not represent the treatment of individual cases. (In this report "casualty" includes injuries as the result of hostile action and non-battle injuries, but excludes non-injury hospitalizations).

Both the WRAIR study and the 1968 U.S. Navy study showed a higher overall requirement for blood for management of patients injured by "mines" than those injured by artillery and small arms. This is in accordance with clinical experience, but is herein documented.

Colloids used included dextran, Plasmanate, (purified protein fraction), and human serum albumin. The US Naval hospital also used plasma (and packed red blood cells). Crystalloids included saline and lactated Ringer's solution. Data on usage of blood volume expanders (colloids and crystalloids) are less complete than that for blood. The available data suggest that the Army hospitals used about half as many units of fluid as of blood per patient transfused, whereas, at least during part of the period covered, the US Naval hospital used 2 to 2.5 times more fluid than blood per patient infused.

The Vietnam experience represents a situation in which abundant fresh whole blood was immediately available to all patients. Therefore, especially in the U.S. Army hospitals, it probably represents the maximum ratio of whole blood to blood volume expanders in the management of the types of casualties encountered.

From the data presented here, it appears that for planning purposes in the treatment of casualties of the types incurred in Vietnam, and under medical evacuation conditions similar to those in Vietnam, the overall blood requirement is between 2 and 3 units per hospitalized casualty, and between 4 and 9 units per patient transfused, the maximum average per patient transfused probably being closer to 7 units than to 9. In this type of combat situation, although group O "universal donor" blood is sometimes needed, the administration of group specific blood is usually practical and preferable.

The fluid (crystalloid and colloid) requirement when blood is readily available is between 0.5 and 2.5 times that of the blood requirement. The colloid requirement under these conditions appears to be about .03 of the non-colloid fluid requirement. The use of colloids in resuscitation of trauma patients when blood is not readily available is not considered in this report, as this situation essentially did not occur in Vietnam.

REFERENCES

1. Kendrick, Douglas B: Blood program in World War II. Office of The Surgeon General, Department of the Army, Washington, D.C., 1964, p630.

2. Ibid. p752

3. Ibid. p525

4. Ibid. p227

5. Ibid. p437

6. Ibid. p227

7. Ibid. p223-224

8. Ibid. p227

9. Kiel, F: Development of a blood program in Vietnam. Military Medicine 131:1469-1482, December 1966.

10. Beecher, H. K.: Resuscitation of men severely wounded in battle. Chap I, General Surgery, Medical Dept., U.S. Army, Surgery in World War II, Vol. II, Office of The Surgeon General, Department of the Army, Washington, D. C., 1955, p3-39.

11. Barnes, A. and Allen, T. E.: Transfusions subsequent to administration of universal donor blood in Vietnam, J.A.M.A. 204:147-149, May 1968.

12. Fisher, G. W.: Letter to Chief Surgical Consultant, Office of The Surgeon General (Army), 3 March 1966.

13. Evaluation of wound data and munitions effectiveness in Vietnam, Vol. 1 AD 879 516 L, Vol. 11 AD 513 342 L, Vol. 111 AD 879 517 L, Defense Documentation Center, December 1970, (including unclassified unpublished data from this study).

14. Moss, G. S.: The Use of Balanced Salt Solution in the resuscitation of battle casualties in Vietnam. Intermeies Proceedings: Combined Injuries and Shock, 291-302, 1968.

15. Cloutier, C. T., Lowery, B. D., and Carey, L. C.: The Effect of Hemodilutional Resuscitation on Serum Protein Levels in Humans in Hemorrhagic Shock, J. Trauma 9:514-521, 1969.

16. Proctor, H. J., Ballantine, T.V.N., and Broussard, N. D.: An Analysis of Pulmonary Function Following Non-Thoracic Trauma, with Recommendations for Therapy, Ann Surg. 172:180-189, August 1970.

17. Lowery, B. D., Cloutier, C. T., and Carey, L. C.: Electrolyte Solutions in Resuscitation in Human Hemorrhagic Shock, Surgery, Gynec. and Obst. 133:273-284, 1971.