

# United States Army Rangers in Somalia: An Analysis of Combat Casualties on an Urban Battlefield

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**Background:** This study was undertaken to determine the differences in injury patterns between soldiers equipped with modern body armor in an urban environment compared with the soldiers of the Vietnam War.

**Methods:** From July 1998 to March 1999, data were collected for a retrospective analysis on all combat casualties sustained by United States military forces in Mogadishu, Somalia, on October 3 and 4, 1993. This was the largest and most recent urban battle involving United States ground forces since the Vietnam War.

**Results:** There were 125 combat casualties. Casualty distribution was similar to that of Vietnam; 11% died on the battlefield, 3% died after reaching a medical

facility, 47% were evacuated, and 39% returned to duty. The incidence of bullet wounds in Somalia was higher than in Vietnam (55% vs. 30%), whereas there were fewer fragment injuries (31% vs. 48%). Blunt injury (12%) and burns (2%) caused the remaining injuries in Somalia. Fatal penetrating injuries in Somalia compared with Vietnam included wounds to the head and face (36% vs. 35%), neck (7% vs. 8%), thorax (14% vs. 39%), abdomen (14% vs. 7%), thoracoabdominal (7% vs. 2%), pelvis (14% vs. 2%), and extremities (7% vs. 7%). No missiles penetrated the solid armor plate protecting the combatants' anterior chests and upper abdomens. Most fatal penetrating injuries were caused by missiles entering through

areas not protected by body armor, such as the face, neck, pelvis, and groin. Three patients with penetrating abdominal wounds died from exsanguination, and two of these three died after damage-control procedures.

**Conclusion:** The incidence of fatal head wounds was similar to that in Vietnam in spite of modern Kevlar helmets. Body armor reduced the number of fatal penetrating chest injuries. Penetrating wounds to the unprotected face, groin, and pelvis caused significant mortality. These data may be used to design improved body armor.

**Key Words:** Urban warfare, Combat, Casualties, Trauma, Military personnel, Body armor, Kevlar, Gunshot wound.

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Urban warfare is not new to the trauma surgeon. Examples are seen every day in Level I trauma centers. Organized crime, the drug trade, and domestic and international terrorist activity have given criminals access to modern military weapons, training, and protective gear. No longer is urban warfare confined to distant places such as Beirut, Northern Ireland, or the former Yugoslavia. When

military tactics and arms are used in densely populated urban areas, mass casualties can be produced in minutes. A good example is a 1997 bank robbery in North Hollywood, California, where two assailants, each armed with an assault rifle and wearing body armor, engaged 20 to 30 police officers in a gun battle that left two people dead and more than a dozen people injured. The terrorist bombing incidents at the World Trade Center in New York City and the Alfred P. Murrah Federal Building in Oklahoma City killed and injured hundreds in seconds.<sup>1</sup> Therefore, it is important that the surgeon caring for patients with trauma, whether assigned to the military, the International Committee of the Red Cross, Doctors Without Borders, or a trauma center in a large metropolitan area, understands the injury patterns associated with combat in an urban environment.

United States military planners have recognized that in today's rapidly urbanizing, post-Cold War world, punctuated with increasing ethnic, tribal, terrorist, and organized criminal violence, tomorrow's battles will not be fought in the open, unpopulated areas seen during Operation Desert Storm but in cities.<sup>2-5</sup> Such a battle, known as the Battle of the Black Sea, was fought by United States military forces in the streets of Mogadishu, Somalia, in 1993. This battle, which was named for the area of South Mogadishu in which it was fought, is the largest and most recent discrete firefight involving United States ground forces since the Vietnam War and demonstrates the intense, violent, and close-quarter nature of combat in cities.

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# Report Documentation Page

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This study examines the casualty data from the Battle of the Black Sea, with the goal of identifying injury patterns associated with modern urban warfare compared with historical controls. Only through this type of critical analysis will all surgeons, both civilian and military, be prepared for the victims of the next urban conflict.

## BACKGROUND

On October 3, 1993, a United States Army special operations task force, Task Force Ranger (TFR), conducted a raid into a heavily armed and densely populated region of Mogadishu, Somalia, to capture supporters of warlord Mohamed Farrah Aidid. During the raid, Aidid's forces shot down two TFR helicopters with rocket-propelled grenades (RPGs). The downing of the helicopters rapidly changed the focus of the mission from a combat assault to a rescue. The rangers fought house to house and street to street through the city to secure and safeguard the crash survivors from armed crowds of Somali militiamen. In the ensuing 15-hour battle, 18 United States soldiers were killed and more than 100 were wounded in what would later be described as the longest and most intense firefight involving American forces since the Vietnam War.<sup>6</sup>

The casualties were sent to the United States Army's 46th Combat Support Hospital (CSH), located just a few kilometers from the battlefield. The 46th CSH was equipped with four operating rooms (ORs), one Level-I infuser, 12 intensive care unit beds, and 40 ward beds. This element was only part of the full CSH, and although it had a 52-bed capacity, it was only staffed for 32 beds on October 3, 1993. Basic laboratory and radiologic capabilities, including a computed tomographic scanner, were available, as well as a blood bank stocked with approximately 100 units of packed red cells and fresh frozen plasma.

This 52-bed field hospital admitted a total of 70 patients between October 3 and October 5, 1993. On the morning of October 3, before the battle, four trauma patients were admitted after the explosion of a land mine. Two of these patients underwent operations for their injuries that lasted into the early afternoon. At 3:30 PM, TFR launched the raid from its base at the Mogadishu airport. Two hours later, after the ambush of a TFR convoy, the first wave of 24 battle casualties began to arrive at the 46th CSH. Seven of the 24 underwent operations on the evening of October 3 at the 46th CSH. This first wave was part of a larger group of 36 casualties who had been triaged at a casualty collection point (CCP) near the ranger base and were then flown by helicopter on a 2 to 3 minute flight to the 46th CSH. No surgical capability was available at the CCP.

A second wave of 36 casualties began to arrive by helicopter at the 46th CSH at 6:00 AM on October 4, just as the cases from the previous evening were finishing. This latter group had been triaged and evacuated from a hastily assembled CCP located in a sports stadium near the battlefield and was part of a larger group of 76 injured patients. Most of them

**Table 1** Surgical Procedures<sup>a</sup> Performed on October 3–5, 1993, at the 46th Combat Support Hospital, Mogadishu, Somalia

Surgical Procedure	Procedures Performed (n)
Fracture washouts	13
External fixation	1
Incision and debridement of open wounds	13
Flexor tendon repair	1
Fasciotomy	2
Exploratory celiotomy	6 (2 nontherapeutic)
Bowel repair	1
Splenorrhaphy	1
Gastric repair	1
Liver and portal vein repair	1
Aortic cross-clamp	1
Sternotomy and celiotomy	1
Total hepatic exclusion	1
Vena cava repair	1
Tube thoracotomy	1
Neck explorations	2 (1 nontherapeutic)
Carotid artery repair	1
Tracheostomy	1
Scalp laceration closure	1
Burn debridement	1
Completion of hip disarticulation	1
Above-the-knee amputation	1
Closed reduction of fracture	1
Examination under anesthesia	1
Total	56

<sup>a</sup> Surgical patients (31), operative cases (34), and postoperative deaths (3) in Somalia.

had fought their way to one of the helicopter crash sites the day before and had been pinned down there for more than 14 hours before a large, multinational, armored convoy could fight its way to their location. Most had been injured the previous afternoon and had been cared for overnight in the field by medics. Twenty-one of these 36 patients were operated on, and three were operated on twice.

Four patients with orthopedic injuries (three operative cases) were triaged to a nearby Swedish United Nations military hospital. A collegial relationship had previously been established between the Swedish physicians and the 46th CSH during weekly joint medical conferences. Additional support was provided by a contingent of German physicians who arrived at the 46th CSH at around 12:00 PM on October 4. This group was stationed outside Mogadishu and had arranged helicopter transportation on its own initiative after word of the ongoing battle spread.

As a result of the combat operations on October 3 and 4, 1993, two general surgeons and one orthopedic surgeon at the 46th CSH would participate in 34 cases involving 56 procedures over a 48-hour period (Table 1). A third general surgeon assigned to the 46th CSH was not present during the battle. He and a respiratory technician had been required to accompany a patient, who had been severely injured a few days earlier during a shark attack, on the aeromedical evacuation flight to Germany.

The nonsurgical patients were evaluated by 12 medical officers, including general medical officers and specialists in emergency medicine, family practice, internal medicine, radiology, and anesthesiology, as well as nurse anesthetists, a psychologist, and a dentist. These physicians were assigned to the 46th CSH and nearby military units.

A total of 55 patients were evacuated to Landstuhl Army Medical Center, Germany, on October 4 and 5 aboard two United States Air Force C-141 aircraft. One of the general surgeons assigned to 46th CSH accompanied the second planeload of casualties. Laboratory and radiographic results remained at the patients' bedsides and later accompanied the patients during aeromedical evacuation. After stabilization and additional surgery, as needed, these patients were flown from Germany to military medical facilities in the United States for additional care or convalescence.

## MATERIALS AND METHODS

From July 1998 until March 1999, data were collected for retrospective review of all United States casualties incurred during the Battle of the Black Sea. Data sources included hospital admission logs, medical evacuation flight manifests, OR logs, patient medical records, and postmortem examination reports. Involved unit records, as well as historic, eyewitness, and news media accounts, were also reviewed. After review of all available sources, data were entered into a computerized database.

Patients were divided into four categories using commonly accepted definitions: killed in action (KIA), defined as those who died on the battlefield before reaching a medical facility; died of wounds (DOW), defined as those who died after arriving at a medical facility staffed by a physician; wounded in action (WIA), defined as those who were injured severely enough to require admission to the hospital for at least 24 hours; and carded for record only (CRO), defined as those with minor injuries who were treated and returned to duty the same day.<sup>7,8</sup> This study follows the recommendation of Bellamy<sup>9</sup> and does not include the CRO patients in the calculation of the KIA and DOW rates. The inclusion of patients in the CRO category, many of whom required little or no treatment, would cause significant distortion of the KIA and WIA rates.

Postmortem examination reports were reviewed with a forensic pathologist at the Office of the Armed Forces Medical Examiner (OAFME), Armed Forces Institute of Pathology, Washington, DC. Involved surgeons were questioned about operative cases and patients who died of their wounds. Medics and other participants of the battle were asked about prehospital presentation, care of the injured in the field, wounding agents, and the circumstances of the injury. Because of their significantly increased morbidity and mortality, penetrating injuries to the head, neck, thorax, and abdomen were classified separately from nonpenetrating injuries to the same anatomic region, as suggested by Carey.<sup>10</sup>

**Table 2 Total United States Casualties, Battle of the Black Sea**

Casualty Category	Casualties (n)	Percent
Killed in action (KIA)	14	11.2
Wounded who died	4	3.2
Wounded in action (WIA)	58	46.4
Carded for record only (CRO)	49	39.2
Total	125	100
KIA rate = KIA/(KIA + DOW + WIA)		18.4
DOW rate = DOW/(DOW + WIA)		6.4

KIA and DOW rates do not include the CRO category.

Several patients suffered multiple wounds. These were the result of mixed mechanisms (i.e., blunt force injuries and fragments or multiple injuries caused by a single mechanism, such as multiple fractures from a helicopter crash, multiple fragment wounds from a grenade, or multiple gunshot wounds). In previous reports of battle casualties, patients with multiple wounds were either excluded or simply classified as multiple injuries.<sup>11</sup> In an effort to present as much information as possible regarding surgical care and demands on material resources, each wound that required medical attention was noted. For example, if a soldier were struck by fragments from an RPG that caused an open fracture of the tibia, an amputation of a digit, and a major soft-tissue wound of an extremity requiring OR debridement, then all three of these injuries were noted separately. With the relatively small numbers of casualties examined here (125 compared with almost 8,000 cases in the United States Army Wound Data and Munitions Effectiveness Team in Vietnam [WDMET] study<sup>12</sup>), excluding these patients or simply classifying them as multiple injuries would have resulted in the loss of a significant amount of relevant wound data.

## RESULTS

There were 125 total United States casualties sustained during the Battle of the Black Sea (Table 2). In seven instances, the initial hospital admission records documenting injuries did not match the medical record or records from the involved units. These inconsistencies usually related to whether fragments or bullets caused wounds. Because the 52-bed 46th CSH admitted a total of 70 patients (including 65 trauma patients) and evacuated 55 of them to Landstuhl Army Medical Center in Germany within 48 hours, the inpatient medical record was thought to be more accurate than the initial admission log. These kinds of discrepancies are not unusual in the collection of casualty data<sup>7,13</sup>, and are believed to have little impact on the overall findings.

Seventy-six casualties sustained injuries resulting in death or hospitalization (KIA, DOW, or WIA). Wounding mechanisms for these casualties were bullets (55%), fragments (31%), blunt trauma (12%), and burns (2%).

Gunshot wounds caused 12 of the 14 deaths from penetrating trauma. The other two deaths from penetrating trauma

include a soldier struck by an unexploded RPG round (which acted more like a bullet than an exploding rocket) and one death from fragment injury after an almost direct hit by an RPG. Most of the fragment injuries were the result of exploding RPGs.

### **Killed in Action**

Gunshot wounds to the head caused 5 of the 14 (36%) battlefield deaths. Three deaths were caused by single wounds. The other two fatalities sustained multiple gunshot wounds, with head wounds as the likely fatal injury. Four bullets penetrated the brain and one bullet penetrated the cervical spinal cord. In four instances it appeared that bullets entered from a frontal or frontal oblique angle through an area not protected by the Kevlar helmet. In the remaining instance, multiple rounds struck a soldier with a fatal injury to the parietal-occipital area of the head from what witnesses described as a ricochet bullet. The soldier was not wearing a Kevlar helmet at the time of injury.

Multiple blunt force injuries from helicopter crashes resulted in 4 of the 14 (29%) fatalities. In both crashes, the helicopters were hit by RPGs while flying at low level. In the first instance, the aircraft landed on its left side. The two pilots sustained severe blunt force injuries and were killed on impact, but, amazingly, the six passengers riding in the back of the aircraft all survived the crash. In the second instance, the pilot executed a controlled crash and landed the aircraft upright. Both pilots survived the crash with fractures to the lumbar spine and lower extremities, but the two crew chiefs riding in the rear were killed, one with a cervical spine fracture that severed the spinal cord and the other with multiple internal injuries.

Penetrating injury to the chest resulted in 2 of the 14 (14%) fatalities. One soldier was shot in the upper back, just left of the midline. He went into shock and died within minutes, according to witnesses. The bullet presumably struck the heart or great vessels. Another soldier was struck in the left chest with an RPG that severed his left arm and penetrated the chest cavity but did not explode. This soldier presented to the triage area a short time later with agonal respirations. A physician then discovered the live, unexploded round during his primary survey. By this time the patient had no pulse, spontaneous respirations, or blood pressure, so his body was removed to a protected area, and the unexploded warhead was later disarmed by an Explosive Ordnance Disposal technician.

Another soldier died from a gunshot wound to the groin that lacerated his femoral artery and vein. A medic attended to the soldier within moments. The wound was too proximal to apply an effective tourniquet, so it was packed with gauze, and continuous direct pressure was applied by the medic and nearby soldiers. This soldier could not be evacuated from the battlefield because of the tactical situation. Although approximately 6 L of intravenous crystalloid solution was given, he

died after worsening shock and cardiopulmonary arrest approximately 2.5 hours after injury.

Two battlefield deaths were the result of multiple gunshot wounds. Decompositional changes in the bodies present at the time of recovery made precise assessment of fatal injuries difficult, but it seems that one probably sustained a lethal GSW to the abdomen and the other a lethal GSW to the neck.

The above findings are on the basis of external and radiographic examinations only. Complete autopsies were not conducted on the fatalities.

### **Died of Wounds**

Four patients died after reaching medical facilities. The first three general surgery cases from the mass casualty on October 3 all died acutely as a result of hemorrhage while in Somalia; all three casualties presented to the 46th CSH in extremis. There was one late death in another casualty after evacuation to Germany.

One of the casualties had sustained a gunshot wound to the abdomen. The bullet entered the right flank, injuring the liver, portal vein, and spleen. The patient required aortic cross-clamping to sustain blood pressure. With the triage area full of surgical patients and scarce personnel, time, and resources, this patient was triaged expectant on the table and moved out of the OR. He died almost immediately after the aortic clamp was removed.

The next two patients underwent damage control surgery,<sup>14-16</sup> consisting of ligation of major bleeding vessels and abdominal packing, but both died in the intensive care unit. One had a massive injury to the left hip from an RPG blast that resulted in a near-complete traumatic amputation, with injuries to the left iliac artery and vein and the descending colon. He underwent an exploratory celiotomy with ligation of the left iliac artery and vein and completion of the hip disarticulation. The patient survived for approximately 12 hours. He regained consciousness briefly after the application of military antishock trousers but died a short time later. The other patient had a gunshot wound to the pelvis, which shattered the sacrum and disrupted the presacral soft tissues and neurovascular plexus with injury to the colon, small bowel, and right internal iliac artery. The right common iliac artery was ligated, and the pelvic and sacral fracture was packed with gauze. The patient survived for 7 hours after his injury. Of note, during this case the electrical generator failed, temporarily necessitating operating by flashlight.

The final patient who died of wounds had a right thoracoabdominal gunshot wound with a retrohepatic laceration of the inferior vena cava and a right hemothorax. He was the first patient operated on during the second wave of casualties on the morning of October 4. His evacuation from the battlefield was delayed because of the tactical situation, but he remained conscious and hemodynamically stable with bilateral breath sounds while awaiting transport. The interval from time of injury to surgery was 5 hours. In the OR he underwent

**Table 3** Percentage of Wounded who Died, by Conflict (DOW)

Conflict	Wounded (n)	Wounded Who Died (%)
Spanish American War <sup>a</sup>	1,600	7
WW I (excluding gas) <sup>a</sup>	153,000	8
WW II <sup>a</sup>	599,724	4.5
Korea <sup>a</sup>	77,788	2.5
Vietnam <sup>a</sup>	96,811	3.6
Desert Storm (7 <sup>th</sup> Corps) <sup>10</sup>	143	2.1
British in Northern Ireland <sup>29</sup>	1,700	4.8
Somalia	62	6.4

Adapted from Carey ME. An analysis of US Army combat mortality and morbidity data. *Mil Med.* 1987;152:6-13.

<sup>a</sup> US Army only.

an exploratory celiotomy and median sternotomy. Total hepatic exclusion was performed after the administration of 4 units of fresh whole blood with subsequent repair of the retrohepatic inferior vena cava. The patient remained hemodynamically stable postoperatively and was transferred to Germany the next day, sedated and on a ventilator. He died after arrival in Germany.

At 6.4%, the DOW rate in the Battle of the Black Sea is higher than that seen in other modern conflicts (Table 3). Three factors influence the DOW rate: speed of evacuation, quality of hospital-level care, and method used to calculate the DOW rate. The high DOW rate in this case is likely attributable to the fact that three of the four patients who died from their wounds were part of the group that was ambushed in a vehicle convoy and was able to be rapidly evacuated from the battlefield. All three patients sustained significant injuries and presented to the hospital in hemorrhagic shock. Two of the four deaths were from pelvic injuries that resulted in exsanguination despite gauze packing. This comparatively high DOW rate may also be related to the relatively small number of casualties examined in this study. For this reason,

**Table 5** Hospital Bed Days for Wounded in Action (WIA) Patients

Number	<3	3-7	7-30	>30
Bed days				
Patients <sup>a</sup>	16	12	15	11
Hospital stay in days				
Average			22	
Minimal			1	
Maximum			190	
Total bed days for WIA patients			1,184	

<sup>a</sup> Hospital data were not available for 4 of the 58 WIA patients.

care should be taken when comparing data from a single battle with that derived from wars or longer campaigns.

### Wounded in Action

Fifty-eight patients were classified as wounded in action, sustaining 91 injuries (Table 4). Their average hospital stay was 22 days (Table 5). Twenty-five patients had more than one isolated injury: 12 patients had multiple or combined injuries; 11 had multiple fragmentation injuries to more than one anatomic area (i.e., injury to the trunk and extremity, to two or more extremities, etc); and 2 patients had multiple fractures from blunt trauma. One of the latter was the pilot of a downed helicopter with an open femur fracture, vertebral fracture at the L-2 level, and multiple facial fractures. The other was the first casualty of the battle, a ranger who fell approximately 40 to 70 feet from a helicopter during the insertion phase of the mission. He sustained a closed head injury, skull fracture, retroperitoneal hematoma, multiple rib fractures, and fractures of the femur and humerus.

Penetrating trauma was the result of gunshot wounds (GSWs) in 38 instances and fragments in 39 instances. The vast majority of these injuries were from AK-47 assault rifles and Soviet Bloc RPGs.

**Table 4** Distribution of Injuries for Wounded in Action

Anatomic Area	Gunshot	Fragments	Blunt	Burn	Total (by Anatomic Area)	Percent
Head/face	1	5	3	0	9	9.9
penetrating <sup>a</sup>	0	1			1	1.1
Neck	0	1	0	0	1	1.1
penetrating <sup>a</sup>	1	1			2	2.2
Thorax/back	2	0	4	0	6	6.6
penetrating <sup>a</sup>	0	0			0	0
Abdomen	1	0	1	0	2	2.2
penetrating <sup>a</sup>	0	1			1	1.1
Genitalia	1	0	0	0	1	1.1
Extremities	32	30	4	2	68	74.7
Total	38	39	12	2	91	
Percentage	41.7	42.9	13.2	2.2		100

<sup>a</sup> Injuries of the head, neck, chest, and abdomen are classified as penetrating if they violated the skull, platysma, chest cavity, or peritoneum.

There was only one patient with a penetrating head injury in the WIA category. A ranger was hit in the forehead by a 3-mm fragment from an RPG. The fragment lodged 3 to 4 cm between both frontal lobes of the brain, causing no apparent neurologic deficit. The soldier thought nothing of his injury at the time and continued to fight. Immediately after the battle, he was evaluated and found to have a 2- to 3-mm laceration on his forehead and a normal neurologic examination. He was subsequently returned to duty. The next day he experienced a headache and noticed clear fluid leaking from the wound, both of which resolved the same day without medical advice or intervention. He presented for reevaluation 2 days after the injury; the fragment was then discovered on roentgenography and computed tomographic scan of the head. At that time he was asymptomatic with a normal neurologic examination. He was placed on antibiotics and anti-convulsants and evacuated to Germany. After arrival in the United States, he experienced a generalized seizure and 10 days later developed an intracerebral abscess. He recovered fully after a craniotomy, antibiotic therapy, and a 2-month hospitalization.

Another ranger sustained a nonpenetrating GSW to the occiput. The round penetrated his Kevlar helmet, causing a scalp laceration, brain contusion, and momentary blindness, but it neither penetrated nor fractured the skull. The patient survived without complication. There are several other anecdotal instances where bullets or fragments impacted helmets but caused little or no injury. Other injuries to the face and head were the result of lacerations from fragments or facial fractures from blunt trauma.

A GSW to the neck resulted in one casualty with injury to the spinal accessory nerve, a cervical spine fracture, and carotid artery injury that required repair with a greater saphenous vein patch and a tracheostomy. Also, there were two patients with fragment wounds to the neck; one penetrated the platysma and was explored, but no additional repair was required. All neck injuries were in Zone II, between the angle of the mandible and the clavicles.

There were no penetrating injuries to the chest among the WIA, and there was only one penetrating abdominal injury. This patient was a young soldier, evaluated almost 12 hours after his injury, who was found to have some small puncture wounds to his back and flank, no abdominal tenderness, and normal vital signs. Upon exploratory celiotomy, approximately 1 L of blood was found in the abdomen secondary to a fragment injury to the spleen and stomach. Both were repaired without complication.

As in all other modern battles, the vast majority of survivable injuries (74%) seen among the WIA in Somalia were to the extremities (Table 6). Nearly half of the extremity injuries were uncomplicated, minor soft-tissue injuries requiring only basic wound care. Individually, many of these small fragment wounds could have been placed in the CRO category. However, the wounds were often associated with other, more severe injuries, large areas of the body were often

**Table 6** Extremity Injuries

Injury	Number
Soft tissue, minor <sup>a</sup>	31
Soft tissue, major <sup>b</sup>	11
Burns	2
Long-bone open fracture	11
Open fracture (wrist, ankle, hand, or foot)	5
Closed fracture	3
Complete or partial amputation of digits	4
Major amputation (above the knee)	1
Total	68

<sup>a</sup> Required basic wound care only; <sup>b</sup> Required operating room management.

peppered with dozens of these small wounds, or the wounds required evaluation for possible joint space penetration.

Seven of the major soft-tissue injuries requiring operative management were caused by GSWs. One particularly severe soft-tissue injury was seen in a ranger whose vehicle was hit by an RPG during an ambush. The blast left a large tissue defect in the popliteal fossa that exposed the popliteal artery and destroyed the posterior tibial and peroneal nerves. On presentation to the 46th CSH, his dorsalis pedis and posterior tibial pulses were palpable. The injury was washed out and packed in Somalia, and he was transported to Germany the next day. In Germany, a skin graft was placed over the defect to cover the exposed nerves and vessels before a permanent procedure could be done. The patient was then transferred from Germany to the United States where, approximately 1 week after the injury, the skin graft was found to be nonviable and was subsequently removed. The posterior tibial nerve was then found to be grossly burned and contused, and the peroneal nerve was found to be severed. The possibility of an amputation was discussed at the time, but the patient adamantly refused. The wound was subsequently covered with a latissimus dorsi flap. After rehabilitation, he was medically discharged with a left foot drop, left leg atrophy, and an essentially insensate leg below the knee. Presently, he ambulates well but still requires a brace.

There were 11 open fractures of long bones and one open fracture of the ilium secondary to gunshot and fragment wounds. Fractures of the lower extremity as a result of GSW were associated with some of the longest hospital stays and the most complications. Five patients had fractures of the tibia secondary to GSW. Two of these had associated injuries to the peroneal nerve, four became infected, and nonunion or malunion complicated three. The average hospital stay for these patients was 74 days (hospital data were only available for four of the five patients.) Two of these patients, each with initial bone loss greater than 8 cm, underwent Ilizarov fixation and bone grafting. The large soft-tissue wounds were covered with pedicled muscle flaps.<sup>17</sup> Both of these patients underwent lengthy rehabilitation, but they have since returned to full active duty and are presently serving in phys-

**Table 7 Wound Infections**

Wounding Mechanism	Injury	Time to Surgery (h)	Hospital Bed Days	Complications
GSW	III-B fracture of tibia and fibula	Unknown, but <6	119	Polymicrobial infection, malunion; Ilizorov fixation
RPG blast	Large soft-tissue defect to popliteal fossa	6.5	86	Skin graft necrosis, scar fibrosis, seroma
GSW	Open femur fracture, testicular avulsion	22.5	87	Pseudomonas
GSW	Near amputation of thumb	Unknown, but >6	80	Flap necrosis, extensive reconstruction
GSW	Open wound to forearm with neurovascular injury	No surgery in Somalia	54	Forearm contracture, nerve injury
GSW	III-B tibia fracture	19	52	Polymicrobial infection, Ilizorov fixation
GSW	III-B tibia fracture	17	48	Malunion, peroneal nerve injury
GSW	III-B fracture of tibia and fibula	5	>11 days; total unknown	Postoperative infection
Helicopter crash	Open femur fracture	11 days	22	Pseudomonas; held as prisoner for 11 days
GSW	Soft-tissue injury of upper arm	No surgery in Somalia	9	
GSW	Open wound to flank with fracture of ilium	18	8	Retained foreign body
GSW	Major soft-tissue injury to wrist	14	6	Retained foreign body
RPG fragment	Soft-tissue injury of knee and patellar tendon	No surgery in Somalia	6	
GSW	Open fracture of ankle	25	5	Wound abscess, cellulitis
Multiple RPG fragments	Multiple soft-tissue injuries, open fracture of metatarsals	21	5	Wound abscess, cellulitis
GSW	Soft-tissue wound to back	No surgery in Somalia	2	

GSW, gunshot wound; RPG, rocket-propelled grenade.

ically demanding infantry and special forces assignments. The other three patients with GSW to the tibia have left military service.

An RPG blast to the lower extremity resulted in the only major amputation (above the knee). The patient's leg was partially amputated at the knee by an almost direct hit from an RPG. He and another soldier immediately applied an effective tourniquet, stopping what was described as severe bleeding from the injury. The amputation was later completed at the 46th CSH. Presently, the patient is still on active duty and has continued to maintain a rigorous physical fitness regimen with his prosthesis.

Another patient's thumb was partially amputated secondary to a GSW. Although he had a severe associated neurovascular injury that required an extensive reconstruction complicated by thrombosis and infection of his initial graft, his thumb was salvaged and partial function was restored with a neurovascular island graft from his ring finger. Eleven patients in the WIA category subsequently developed wound infections (Table 7).

**Carded for Record Only**

The vast majority of patients in the CRO category were not seen at the hospital but were cared for by the medics, physician assistants, and physicians from their respective units. Many of these individuals did not seek medical attention until 1 or 2 days after the battle. Data on wounding agents and anatomic location of injuries were available for all but 15 of the 49 lightly injured patients who were CRO. The unit surgeon who evaluated most

**Table 8 Injuries Carded for Record Only**

Injury	Number
Fragment wounds	23
Ruptured eardrums	3
Contusions	2
Minor burn	2
Grazing gunshot wound	1
Corneal abrasion	1
Broken teeth	1
Sprain	1
Abrasion	1
Total	35



**Table 9** Relative Frequency (%) of Bullet and Fragment Wounds in Various Conflicts

Wounding Mechanism	Conflict					
	World War II <sup>a</sup>	Vietnam <sup>12</sup>	Northern Ireland <sup>23</sup>	1982 Lebanon <sup>b</sup>	Desert Storm <sup>26</sup>	Somalia
Bullets	38	30	45	18	5	55
Fragments	58	44	33	65	95	31
Other	4	26	22	17	0	14

<sup>a</sup> Beebe GW, DeBakey ME. Effectiveness of weapons. In: *Battle Casualties*. Springfield, IL: Thomas; 1952: Chapter 9, Table 68.

<sup>b</sup> Bessar Y. *Military Operations in Urban Terrain, Medical Aspects, Lebanon War 1982: A Case Study*. Bethesda, MD: Uniformed Services University of the Health Sciences; 1985.

of the 15 patients stated that the majority of these individuals sustained minor fragment wounds of the extremities or soft-tissue lacerations, abrasions, and contusions (Dr. Thomas Larkin, written communication, 1999). This pattern of injury is thought to be consistent with that of the other CRO patients with documented injuries (Table 8). Most of these soldiers were immediately returned to duty.

## DISCUSSION

The incidence of bullet wounds in the Somalia engagement is high in comparison with other conventional battles but is similar to other military actions in urban areas. Combatants in urban warfare fight in streets and along walls, where they are particularly vulnerable to machine gun and sniper fire, often at very close range. The masonry and concrete construction of roadways and buildings do not absorb fired bullets as do trees and earth. Ricochets travel alongside these structures for some distance. Although ricocheting causes projectiles to lose some kinetic energy, it also causes them to fragment and produce secondary missiles from impacted concrete and masonry.<sup>18</sup>

The nature of injuries on any battlefield reflects the predominant weapon or weapons used by the combatants. In the Battle of the Black Sea, the AK-47 assault rifle was the most common weapon of the Somali soldiers, followed by RPGs. The distribution of injuries among TFR soldiers certainly reflects this. Large fragment-producing bombs and artillery shells, the most significant casualty producers in modern warfare, were not used by either side during the Battle of the Black Sea and thus were not a factor. The high incidence of bullet wounds is similar to the British soldiers' experience in Northern Ireland, where small arms predominate, but is in contrast to the Israeli soldiers' experience while fighting in urban areas during the 1982 Lebanon War, where most of the Israeli soldiers' injuries were the result of RPGs (Table 9). Used at close range in an urban environment, as they were in Mogadishu, RPGs tended to produce multiple, simultaneous casualties when they struck buildings, vehicles, or aircraft where troops were clustered.

The unexploded RPG found imbedded in the chest of the patient at the CCP highlights a little known but highly emotional event in combat casualty care: how to deal with unexploded ordnance. If these casualties arrive alive, the round

can be removed with minimal risk of explosion. Agonal or dead casualties should be removed from the patient care area, and the EOD should be notified. Certain precautions before transport or removal must be observed, which are nicely outlined by Lein et al.<sup>19</sup>

Blunt trauma accounted for the remaining deaths and some severe injuries. The majority of blunt injuries were the result of helicopter crashes, which are associated with significant mortality and unique injury patterns.<sup>20</sup> Aircraft crashes are not discussed additionally in this analysis. Blunt force injuries do occur during urban warfare. It is probable that in future urban conflicts, individuals will be killed and injured in vehicle crashes and falls that produce injuries similar to those seen in a typical civilian trauma center. Buildings and other manmade structures will be targeted by exploding munitions, producing blast injury, crush injury, burns, and penetrating trauma. The Marines killed in their Beirut barracks<sup>21</sup> and the victims in the bombings of the Oklahoma City Federal Building<sup>1</sup> and United States embassies in Kenya and Tanzania provide examples of the types of injuries and casualty evacuation problems that may be encountered in future urban warfare or terrorist attacks. Locating, extracting, and evacuating casualties trapped in vehicles, aircraft, or destroyed buildings while under fire on an urban battlefield is both difficult and dangerous.

Penetrating wounds to the head remain a significant cause of mortality on the battlefield. Although the head represents only 9% of the exposed body, it accounts for 34% to 46% of deaths.<sup>4</sup> In Somalia, head wounds caused 36% of deaths from penetrating injury, a figure that lies between values predicted by two Vietnam studies, 34% in the WDMET study<sup>12</sup> and 39% documented by Maughon,<sup>22</sup> who analyzed 988 Marine deaths. Bullets caused all fatal wounds to the head in this population of casualties in Somalia. Remarkably, in every instance, according to witnesses and post-mortem examination reports, the bullets entered through areas not covered by the Kevlar helmet. Given the added protection of the Kevlar helmet (not available in Vietnam), one would reasonably expect a lower incidence of fatal head wounds, but such was not the case. This high rate of GSWs to the head may have been the result of well-aimed sniper fire, which is a common and significant threat when fighting in built-up areas.<sup>23-25</sup> Also of interest are the anecdotal ac-

counts of projectiles striking helmets and causing little or no injury, particularly the one individual shot in the back of the head who sustained only a scalp laceration and brain contusion. Had he not been wearing his helmet, he almost certainly would have been killed. Conversely, the one individual who was hit in the head by a ricochet bullet may have survived had he been wearing a Kevlar helmet. The head and face are preferred targets for well-aimed fire in a close-quarter urban battle such as this, especially when fighting against troops that are known to use body armor. It is likely that the head was targeted more often than other anatomic areas by the Somali forces during this battle. If United States forces in Somalia had not been wearing the Kevlar helmet, the morbidity and mortality of penetrating injuries to the head would have been greater. Future body armor research should be directed at protecting the vulnerable face and anterior head. This statement is supported by Maughon's<sup>22</sup> study of fatal injuries in Vietnam, written almost 30 years ago. He states, "A large proportion of these casualties were fully and properly clothed in protective armor, yet the small vulnerable parts of the face and neck were hit. Most of the missiles entered anteriorly, causing one to wonder about the protective effect of a suitable face and neck shield, in addition to the present head and body armor."

The ranger who developed a brain abscess after being struck in the forehead with the small fragment highlights two important points concerning combat-related penetrating head injuries. First, patients can initially present with a normal neurologic examination and innocuous-appearing injuries. Carey<sup>26</sup> describes a similar patient, injured during Operation Desert Storm with "a small fragment wound to the brain who was talking on hospital admission." All wounds in proximity to major structures should prompt radiographic evaluation at a minimum. Second, penetrating head injuries associated with CSF fistulas or leakage from the wound are cited in numerous studies as a major risk for infection and should be managed accordingly.<sup>27</sup>

The relatively low rate of penetrating chest wounds deserves mention. Historically, the chest and abdomen are predicted to be the locations of major wounds 12.5% and 10% of the time, respectively.<sup>11</sup> In one Vietnam study,<sup>22</sup> 37% of the casualties who were KIA died of thoracic injuries, and 9% died of abdominal injuries. In the Somalia group, two (14%) of the KIAs with penetrating injuries had chest wounds and two (14%) had fatal abdominal wounds; yet all four of the casualties who DOW had penetrating injuries to abdominal organs (two had wounds to the pelvis, one had a thoracoabdominal wound). Had evacuation been as delayed for the patients in the ambushed convoy as it was for those around the crash site, it is likely that three of the four DOW patients with penetrating abdominal wounds would have died on the battlefield.

The distribution of injuries in these casualties is interesting in that no projectiles entered through the region of the anterior chest or upper abdomen where a solid armored plate,

**Table 10 Comparison of Anatomical Distribution of Fatal Penetrating Injuries from Somalia and Vietnam**

Body Area	Vietnam <sup>12</sup> (%)	Somalia (%)
Head	35	36
Neck	8	7
Chest	39	14
Abdomen	7	14
Thoracoabdominal	2	7
Pelvis	2	14
Extremities	7	7

in addition to the soft-body armor, was worn by the combatants. In all of the penetrating injuries to the chest and abdomen, bullets or fragments entered through the relatively softer areas of the body armor protecting the back and flanks or passed inferior to the body armor in the area of the waistline, groin, or pelvis. In one soldier who was KIA, the front plate stopped an exiting bullet that had entered through the back, traversed the mediastinum, and exited through the anterior chest.

Body armor seems to have reduced mortality from injuries to the chest (Table 10). This statement is additionally supported by the comments of TFR soldiers. There are at least a dozen anecdotal accounts of soldiers whose armor was hit by bullets and fragments, some of which were recovered from the damaged body armor after the battle. One individual was hit in the flank by an AK-47 bullet that first struck a wall he was standing near. His only injury was a severe flank hematoma that eventually extended around to his groin a few days later. His urine tested negative for blood, and he was returned to duty during the battle. One of the authors (R.L.M.) was a participant in the battle and witnessed a ranger shot in the center of the armored chest plate. The soldier was knocked over, looked down at his chest, then got to his feet and returned fire. The bullet had hit his chest and ricocheted off his armored plate into his arm, causing only minor soft-tissue injury.

In addition to directly saving lives, one of the most significant contributions made by body armor is the prevention of small fragment wounds to the abdomen, where any evidence of penetrating injury, no matter how innocuous appearing, must be assumed to represent a penetrating intra-abdominal wound.<sup>28</sup> The widespread use of body armor prevented these injuries; eliminating the need to perform additional diagnostic studies, serial examinations, and surgical exploration required by such casualties, thus significantly reducing the surgical workload.

Timely exploration of questionable wounds is a sound military surgical principle and should not be ignored. During the Battle of the Black Sea, a large number of surgical casualties were managed by three surgeons with minimal support personnel and material resources. Evacuation times to the receiving hospital were long, and a surgeon was not always available to accompany casualties on the evacuation

aircraft. These are all circumstances commonly encountered during military mass casualty situations. Therefore, serial observation or nonoperative therapy was not used. All casualties with possible penetrating cervical or abdominal wounds underwent exploration in Somalia before aeromedical evacuation.

The injuries sustained by the United States casualties in Somalia are similar to those seen by surgeons in previous conflicts.<sup>29</sup> Fortunately, the two general surgeons at the 46th CSH were equally comfortable treating vascular, thoracic, and abdominal injuries. As surgical training programs become more specialized, case loads decrease, and military general surgeons are denied vascular and thoracic operative privileges at military treatment facilities, it is the authors' concern that future deployed general surgeons may be performing vascular and thoracic procedures for the first time in several years. The solution to this problem is to allow military surgeons the opportunity to perform elective vascular and thoracic cases at the military treatment facilities. This would allow the same surgeons, who will be doing these complex cases in tents under adverse conditions while deployed, the opportunity to perform them electively on a scheduled basis.

One aspect of combat surgery not emphasized in recent writings but clearly stated in Beecher's<sup>30</sup> World War II text is the value of a brief but positive discussion with the injured soldier in the immediate preoperative period. In contrast to elective surgery, there is no need for elaborate counseling sessions replete with diagrams and all of the potential poor outcomes. However, there is a need to reach out emotionally to the patient, touch him, and tell him he will be okay and that he will be taken care of. The authors found that even brief words of encouragement before surgery were extremely valuable to all of the patients.

The two patients who underwent damage control procedures both died. Patients undergoing these types of procedures consume enormous quantities of blood, time, material, and personnel resources. In Level I trauma centers, these patients have at best a 50% chance of survival.<sup>31</sup> Because manpower and material resources are often limited during large military mass casualty events, it is questionable whether traditional damage control procedures should be performed. It is important to note that both of these patients presented early in the sequence of events on October 3. Damage control procedures were already underway before the 46th CSH was notified of the scope and intensity of the ongoing battle. If these patients had been received later, in the middle of the patient flow, they may have been declared expectant.

Missile injuries to the pelvis and groin were particularly severe in this battle, as elsewhere. All casualties with pelvic fractures or injuries to the large vessels secondary to penetrating trauma in that region died. Mattox et al.,<sup>32</sup> in their study of civilian cardiovascular injuries, found that vessels in the lower abdomen and groin were more vulnerable to gunshot wounds than vessels in other locations. In another civilian study, gunshot wounds to the groin above the inguinal

ligament with associated arterial injuries have a perioperative mortality rate of 39%, even with fairly rapid surgical intervention (20–90 minutes).<sup>33</sup>

Although most studies concerning battle casualties do not classify wounds to the pelvis and groin separately, it may be reasonable to do so in the future, as these injuries are a source of significant mortality. In fact, with improvements in body armor of the head, chest, and abdomen, the relative percentages of severe groin, pelvis, urogenital,<sup>34</sup> and proximal extremity injuries may increase in future conflicts.

The experience in Somalia is consistent with analyses of most other modern military conflicts in that open extremity wounds represented the largest fraction of survivable injuries.<sup>29,35–37</sup> Fragment injuries to the extremities were more numerous but were typically less severe, whereas GSWs, especially when associated with open fractures or nerve and vessel damage, were the most morbid injuries, requiring the longest hospital stays and recuperation periods.

Tourniquets were used liberally at the CSH and at least once on the battlefield on casualties with severe extremity wounds, thus significantly decreasing blood loss before surgery could be performed. Small, uncomplicated fragment wounds, not associated with other injuries, were managed with daily wound inspection, dressing changes as needed, and antibiotics given by medics and physician assistants in the troop living area while under the supervision of the task force medical officers. This conservative approach, used successfully in other conflicts with few complications,<sup>38,39</sup> saved a tremendous amount of hospital time and resources. It also ensured that lightly injured soldiers were available for additional combat operations, if needed.

Several of the more serious wounds became infected (Table 7). Most infected wounds were in the group of casualties whose evacuation was delayed for 14 hours. Current United States Army doctrine on prehospital care does not include antibiotic administration by medics in the field. Information on field use of antibiotics in this battle is only anecdotal, but it seems that very few of the casualties received antibiotics before reaching a casualty collection point or hospital. Early administration of antibiotics to combat casualties is recommended in many studies.<sup>40,41</sup> For example, the *NATO Emergency War Surgery Handbook* suggests that parenteral antibiotics be given as early as possible to all patients with penetrating abdominal injuries, open comminuted fractures, and extensive soft-tissue extremity wounds.<sup>42</sup> Because evacuation to definitive surgical care is likely to be delayed more than 6 hours in future urban conflicts, antibiotic therapy should be initiated by medics in the field, preferably within the first hour of injury.

Delayed evacuation is typical in urban conflicts. Buildings and the close proximity of combatants make helicopter evacuation difficult, if not impossible. In cities, armored vehicles are vulnerable to ambush with antitank rockets and RPGs along narrow streets and alleys. Crossing exposed streets and moving through rubble with casualties on litters is

dangerous and manpower-intensive. All of these factors were present in Somalia, where seven medics managed 39 casualties for more than 14 hours before they could be evacuated. The medics formed four or five small casualty collection areas and cared for 4 to 12 patients each. These treatment areas were located in rooms and courtyards of Somali houses near one of the downed helicopters, in some cases just a few feet from the ongoing battle. This experience is in marked contrast to the expectation of timely evacuation that presently guides the training for our conventional military medics. Future urban conflicts will demand medics who are trained for prolonged care in the field. Such training is presently available only to medics serving in special operations units.

Anticipated evacuation times to and from the forward hospitals must be based on the reality of unpredictability and unavailability. The longest interval from the time of injury to arrival at the CSH for a casualty in Somalia was approximately 14 hours. Aeromedical evacuation flights arriving from Germany took 12 hours to reach Somalia and another 8 to 12 hours to return to Germany. Logistic and personnel plans during training exercises are often predicated upon a 4- to 6-hour evacuation process based on somewhat arbitrary criteria. Evacuation times for future training exercises and combat operations should be adjusted to reflect more realistic contingencies.

In 1993, United States Air Force aircraft used for casualty evacuation were staffed with only nursing personnel. These nurses were not trained to care for critically ill patients. Surgeons or physicians from the forward hospital were required to accompany critically ill patients on aeromedical evacuation flights. These doctrinal problems have been remedied by the United States Air Force's development of critical care air transport teams, comprised of critical care physicians, nurses, and respiratory technicians. These teams are designed to accompany the transport aircraft into the theater of operations and then care for critically ill patients during evacuation, leaving valuable medical personnel and equipment at the forward hospital.

In the post-Cold War era, the majority of future combat operations will likely continue to involve rapidly deployable, light infantry-type forces that can quickly respond to a variety of contingencies without a large amount of logistical support, including large forward medical facilities. In future operations, it is conceivable that an injured soldier will be evacuated directly from the battlefield to a forward surgical team, undergo lifesaving surgery in a tent on some distant airfield, and then be loaded directly onto an aeromedical transport. The patient may still be sedated, possibly on a ventilator, and perhaps have an open abdomen during the long evacuation flight to a fixed medical facility. The rapid deployment of a critical care air transport team will be needed to ensure the survival of the most severely injured combat casualties during air evacuation in this scenario. As the size of forward surgical footprint (surgeons, ORs, nurses, holding beds) in theater decreases, the reliability of dedicated aeromedical evacuation

assets with critical care capability must approach 100% if the most severely injured are to survive. Conversely, as the size of the forward surgical presence increases, regular, dedicated, evacuation assets become less critical.

The importance of hospital personnel preparation for mass casualty events cannot be stressed enough. The single most important concept critical to the successful performance of the 46th CSH during the battle was the recognition by the hospital's senior leadership early on during the deployment that the hospital must care for patients with traumatic injuries on a regular basis. The 46th CSH cared for many injured Somali civilians as well as numerous United States and allied soldiers with combat wounds before the October 3 battle. This ensured that all hospital personnel were ready when the TFR casualties began to arrive. Triage, resuscitation, and OR teams all functioned smoothly because everyone knew and had done their respective jobs multiple times before the battle. This type of preparation is not only a positive local civic action, but, more importantly, it ensures that the hospital will function at peak efficiency during combat operations.

The receiving hospital in Germany had little advance information about the patients and extent of their injuries before the arrival of the two planeloads of patients. They essentially experienced their own mass casualty event. With the ubiquitous use of digital photography, Internet access, and voice communication, a simple, easy system to transfer casualty data to the receiving senior surgeon should now be possible. During the 12-hour evacuation, this would have allowed deliberate planning for the receiving and triage areas, operating rooms, and optimal mobilization and use of appropriate personnel.

As in almost every conflict in which United States military surgeons have been involved since World War I, uncross-matched, untested, fresh, whole blood transfusions were given after blood bank supplies were depleted. The donors were the hospital personnel and personnel from nearby military units. During the battle, 120 units were drawn and approximately 80 units were transfused. Blood type was determined on the basis of dog tags. These transfusions were required for hypothermic and coagulopathic patients, as neither platelets nor cryoprecipitate were available. The available fresh frozen plasma was stored in bags that fractured one third of the time upon thawing. The operating surgeons were extremely impressed with the ability of fresh, warm, whole blood to stop diffuse coagulopathy. No evidence of acute transfusion reaction was noted, and all survivors were evaluated for viral transmission upon returning to the United States. A rapid card-based system of blood typing and testing would be a valuable addition to the care of these patients. Such a system is used in other countries and should be authorized for use by deployed forces.

While attempting to reverse the coagulopathy in the critically injured patients, the authors encountered the problem, eloquently described by Cannon and Fraser<sup>43</sup> in 1918, of the detrimental effects of hypothermia during the evacuation

chain and in the combat hospitals. Patients who left the operating room in Somalia cold and coagulopathic died just as they did in Cannon and Fraser's<sup>43</sup> era. The United States military does not presently have a coherent plan to prevent and treat hypothermia during the various phases of casualty care. Such planning will be necessary to improve patient survival in the future, especially as more severely injured patients are evacuated longer distances.

In this group of patients, uncontrolled hemorrhage caused 22% of the fatalities. Hemorrhage continues to be a major cause of battlefield death and is the leading cause of combat death when evacuation is delayed for more than 6 hours.<sup>12</sup> The soldier who slowly exsanguinated from a proximal femoral artery and vein injury in spite of the efforts of a medic and others to stop the bleeding is a particularly poignant example. This again illustrates the point made by Bellamy<sup>11</sup> in 1984, when, in his discussion on improving the salvage of combat casualties, he stated, "first and foremost, there is a need to improve the field management of hemorrhage." Clearly, the management of choice for severe extremity hemorrhage is an effective tourniquet followed by surgical repair or ligation of the injured vessels. But what about injuries not amenable to a tourniquet, such as those to the lower abdomen, groin, axilla, and proximal extremities? What is the optimal management for these patients on the urban battlefield of the future, where evacuation may be significantly delayed? Military antishock trousers, although not indicated as a resuscitation device or for patients with thoracic injury, may tamponade injuries of the abdomen, pelvis, and lower extremities not amenable to a tourniquet.<sup>11,44</sup> They also stabilize associated open fractures of the hip and pelvis, which can be significant sources of bleeding. Should these patients be aggressively resuscitated with intravenous fluids, as the patient in Somalia was? There is increasing evidence that aggressive fluid resuscitation, especially with crystalloid,<sup>45</sup> in the context of uncontrolled hemorrhage may be detrimental.<sup>46,47</sup> The Israeli soldiers, while fighting in Lebanon in 1982, recognized the difficulty in evacuating patients from urban areas and supplied blood to the medical units attached to the forces fighting there.<sup>24</sup> Is there a role for battlefield transfusion if evacuation is delayed? The United States Army should continue to support research directed toward delivering newer hemorrhage control techniques and devices to medics and surgeons in the field, such as the dry fibrin bandage.<sup>48,49</sup> As advances in materials and technologies continue to improve the care of the trauma patient, interaction between the military medical research and development community and the trauma surgery community should serve to balance new and advanced technologies with the realities of the battlefield.

In traumatic deaths, the importance of the autopsy in assessment of internal injuries, confirmation of projectile pathways, and documentation of complications of injury or medical intervention is well-known. Unfortunately, at the time of this operation, the OAFME did not have the legal

authority to conduct complete death investigations, including performance of complete autopsies, when soldiers died because of hostile action. Only those procedures required to certify identity, cause of death, and manner of death were allowed under the existing Department of Defense rules. Thus only external and radiographic examinations were performed on the fatally injured soldiers in Somalia. Clearly, useful data were irretrievably lost because autopsies were not performed. Recently passed United States federal legislation (10 US code, section 1471) has granted the OAFME broader jurisdiction over service members' deaths, allowing performance of complete death investigations, including the performance of autopsies.

Perhaps the greatest lesson learned from this battle is that there continues to be no system in place to capture detailed combat casualty data or the lessons learned by the surgeons, physicians, and medics caring for wounded casualties. A comprehensive combat trauma registry, similar to the civilian trauma registry that is in place at every trauma hospital in the United States, does not exist. Were it not for the authors' personal interest in combat casualty care and, in many instances, direct firsthand knowledge of how casualties in Somalia were managed, this analysis could not have been conducted.

The data presented here were obtained through painstaking retrospective review from multiple potential sources. Despite this exhaustive effort and the availability of many observations from this isolated event, the scenario and current patient data suggest many more questions than conclusions. The immediate effects of military trauma on the casualty and the response to field treatments has only once been documented by a large prospective effort.<sup>12</sup> The evidence upon which military penetrating trauma treatments are based is mostly anecdotal experience and, at best, retrospective analysis of the subgroup of patients that happens to be available to a particular investigator. A critical step in addressing the factors and treatments affecting combat mortality and morbidity is the collection of sets of complete data. Obviously, some military situations will make data collection impossible. However, a full registry of military trauma with prospective data collection of defined subsets is achievable and would allow evidence-based validation of resuscitative and surgical interventions.

Previous attempts to gather prospective data have lacked the commitment of appropriate authority. (e.g., in Desert Storm and Bosnia) The following quote was found in the *Activities of the Surgical Consultants*\* "Clinical and laboratory investigation should have been considered an integral part and function of the medical department during service in a foreign theater. . . . One ranking medical officer in the theater Chief Surgeon's office bitterly opposed 'research in

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\* Glen F. Chapter 17, Sixth U.S. Army. In: Carter N, McFetridge EM, eds. *Activities of the Surgical Consultants: World War II*. Vol. I. Washington, DC: Office of the Surgeon General, Department of the Army; 1962:504.

the jungle.' A base surgeon of equal rank was insistent that such an organization would deprive the wounded of proper care. Such attitudes were relics of the dark ages and they delayed progress." This sad observation was reiterated in the final report of the casualty data assessment team's Letterman Army Institute of Research Report #469<sup>†</sup> after an analysis of casualty data from Operation Desert Storm. During Operation Desert Storm, casualty data collection teams were not allowed into the theater of operations.

Only the military itself has the access and resources to accomplish a military trauma registry. The benefits of documentation of injury and effects of treatment have been well established in other areas of civilian trauma care.<sup>50</sup> The United States soldier, sailor, airman, or Marine deserves the benefit of this same analysis of military trauma.

## CONCLUSION

Military planners have recognized that in the future, armed conflict in urban terrain is likely to be the predominate form of war. It is an extremely violent form of combat conducted at close quarters and produces unique hazards and patterns of injury. Evacuation of casualties during urban conflict will often be delayed, requiring exceedingly well-trained medics and corpsmen to manage multiple casualties for prolonged periods.

In the Battle of the Black Sea, members of the United States military wore body armor reinforced with solid armored chest plates, which reduced the number of fatal chest wounds, but the face, neck, pelvis, and groin remained vulnerable to severe injury. Improved protective gear for the military and law enforcement should be designed. Analyses such as this make clear the need for specific improvements in equipment and training to prepare our armed forces for the urban battles of the future.

The formation of a combat trauma registry similar to the trauma registries in place at civilian trauma centers would be an invaluable asset in improving the care of our wounded patients. The beneficiaries of this data collection would be the military services and, ultimately, the casualties.

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## EDITORIAL COMMENT

Dr. Mabry and his coauthors should be commended for their efforts in recording the medical events that occurred in Mogadishu in 1993. Indeed, the events that occurred on October 3rd resulted in the highest number of casualties sustained by the U.S. Army since the Vietnam War, therefore, a unique experience to review “lessons learned,” again.

Extremity injuries, as in previous conflicts, occurred in 74% of all casualties. Exsanguination and death from single-extremity injuries continue to be a challenge. Tourniquets for field use capable of controlling bleeding from femoral vessels are urgently needed. The casualty who remained alive for 2.5 hours after a gunshot wound to the groin clearly illustrates the need of such a type of device.<sup>1</sup>

The nonoperative management of penetrating abdominal wounds in patients who present without hemodynamic compromise or abdominal findings is possible if continuous re-evaluation is feasible. Such type of care is not possible in a forward military hospital. The findings in the patient who was operated on without clinical symptomology and the two negative laparotomies illustrate the understanding of military medical concepts by the surgeons involved in the management of these patients.

Significant injuries to the lower extremities produced by RPGs occurred in two instances. An immediate amputation in one casualty resulted in a favorable recovery and eventual return to duty. In the second casualty, whose initial evaluation showed transection of posterior tibial and peroneal nerve, and most likely an insensate foot, attempts were made to save the extremity. When amputation was considered at a later date, the patient refused and currently has an insensate leg. The mechanism of injury (RPG), the magnitude of neurologic damage, even in the presence of palpable pulses, should have resulted in an immediate amputation.

During the Vietnam conflict, blood drawn from servicemen in-country was used to care for patients with dilutional coagulopathies after large volume transfusions. During Desert Storm, the lack of state-of-the-art component therapy to manage posttransfusion coagulopathies was identified before and during the operation. The surgeons' efforts to control hemorrhage in Somalia were enhanced by the use of in-

country servicemen blood donors. The Department of Defense should revisit policies as to how to manage the multiple transfused coagulopathic patient in theater, otherwise appropriate surgical efforts would be unsuccessful.

Operations like the one in Somalia are characterized by their unexpected high intensity and short duration; therefore, the “learning curve” is not an option. While newer communication systems and recognition by the Air Force of their responsibility during transfer should improve the casualties care across different echelons, realistic joint exercises and a chain of command that can immediately react to events such

as the one in Somalia are necessary to successfully manage future incidents.

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