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Injuries from Antitank Mines in Southern Croatia

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Objective: Antitank mines inflict devastating injuries that are usually fatal. The objective of this retrospective study was to analyze antitank mine casualties in South Croatia during the period from 1991 to 1995. Methods: Mechanism, degree of injury according to Abbreviated Injury Scale and Injury Severity Score, as well as surgical treatment were analyzed. Findings: Of 464 mine victims, 42 (9.0%) patients sustained antitank mine injuries, and 12 of these were fatal (29%). Abbreviated Injury Scale of the antitank mine injuries was 5.3 ± 10.6. Military personnel were injured in 29 cases, and civilians were injured in 13 cases. Conclusion: Although injuries from antitank mines were ravaging, and frequently fatal, a significant number of patients survived.

Introduction

Antitank mines are designed for the destruction and damage of armored and other vehicles, usually by creating minefields on the roads used by tanks. These mines, with great range, a huge amount of strong explosive, and great destructive force, can be buried in all types of ground, on railroad lines, in coastal areas and river approaches, and they can be buried in groups to form minefields or separately.

The first antitank mines appeared in World War I as a weapon against the first armored vehicles. During World War II, technological progress in the production of antitank mines enabled their widespread tactical application. One-fourth of all German tanks were destroyed by mines in the Russian-German conflict.[1,2] Further technological improvement after World War II made the antitank mine one of the most efficient and least expensive lethal weapons. There are several hundred different types of antitank mines in the world today. The war in Croatia had the characteristics of conventional contemporary conflict with the significant use of mine-explosive devices.[3-9] The conditions for the application of antitank mines were markedly favorable.[10, 11] Antitank mines amount to 20% of the presumed total 2 million land mines laid during the war in Croatia. The purpose of this article was to describe injuries inflicted by antitank mines in South Croatia in the period from June 1991 through December 1995 with regard to the type of mines used, the mechanism and location of injury, and Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS).[12-17]

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Methods

Patients injured by antitank mines in Southern Croatia from June 1991 to December 1995 admitted to Clinical Hospital Split were analyzed. Age, sex, military or civilian status of casualties, type of explosion incident, and mechanism of injury were noted. The severity of injury was assessed according to AIS and ISS. Surgical treatment and outcome were analyzed.

Results

Of the total number of 464 mine victims during the 5-year period, 42 (9.0%) were injured by antitank mines (Fig. 1). The mean age of the injured was 32 years, and all but one were men, with the only woman injured while sitting by the driver (Table I). Most of the injured (29) were armed forces personnel and 13 were civilians, mostly refugees. Among civilian victims were three American reporters whose vehicle went astray (lost its way) and met with the mines on a secondary road. A 12-year-old refugee boy was injured sitting by the driver. Of 26 vehicles that met with the mines, there were 15 cars, 3 lorries, 2 buses, 2 jeeps, 1 transporter, 1 excavator, 1 tractor, and 1 ambulance. The mean time of the vehicle meeting the mine was 13.00 ± 3.13 hours. AIS of the antitank mines injuries was 5.3 + 0.6. Of 42 injured, 3 patients had severe injury with massive tissue destruction and traumatic amputation of the upper leg and 1 had severe injury with massive tissue destruction and traumatic amputation of both upper legs as well as a ruptured liver.

There were two cases of traumatic amputation of the lower leg accompanied in both by fractured calcaneus of the opposite leg, and in one by an eye injury. Eye injuries were present in seven additional patients, and the driver of the excavator lost both of his eyes. One of these injured underwent a laparotomy because a large stone crashed into his abdomen, injuring omentum and mesentery. Calcaneus fractures, often with luxation, were found in six more injured. Two of them had a fractured tibia, one had a fracture of the femur, but with fractures of both calcanei. Three patients had only a lower leg fracture. A fractured mandibula was found in three patients, and a fractured maxilla with an eye injury in was found in one patient. Cranium fractures were found in two patients, and one of them had a brain prolapse.

Of 42 patients sustaining antitank mine injuries, 12 died (29%). Drivers, as well as the person sitting beside them, were most frequently among the dead. Only one person killed by an antitank mine was a pedestrian. The cause of death was a cranium fracture with prolapse of the brain in six patients and a massively crushed chest in two patients. One victim with a thorax wound died because of exsanguination from the ruptured thoracic aorta. Two died due to exsanguinations after severe injury and traumatic amputation of both lower limbs, and one died due to exsanguination after a traumatic femoral amputation. Three casualties whose vehicle exploded on an

Mine	Type	Dimensions (1ength x width/diameter x height) (mm)	Weight (kg)	Body, explosive, charge weight (g)	Activation force (kg)	
TMM-1	Antitank metallic mine	300 x 90	8.6	Steel, TNT 5600 Layer for supplementary fuse	Pressure 70 - 130 kg	
TMA-1	Antitank antimagnetic mine	315 x 100	6.5	Juvidur with reinforcing ribs, TNT 5400, Tetryl 15, supplementary fuse	Pressure 100 kg	
TMA-2	Antitank antimagnetic mine	260 x 200 x 140	7.5	Juvidur, two basic fuses, TNT 6500, supplementary fuse	Pressure 120-320 kg	
TMA-3	Antitank antimagnetic mine	265 x 80	7	Plastic, TNT 7000, Three fuses	Pressure 180-350 kg	
TMA-4	Antitank antimagnetic mine	285 x 103	6	Plastic, TNT 5500, fuse, supplementary fuse	Pressure 100-200 kg	
TMA-5	Antitank antimagnetic mine	300 x 275 x 110	6.6	Plastic, TNT 5500, fuse, supplementary fuse	Pressure 100-300 kg	
TMRP-6	Antitank destructive-penetrate mine, tripwire mine, or the mine can be detonated electrically	290 x 132	7.2	Plastic body, reinforcing ribs, TNT 5200, supplementary fuse, penetrated discus, fuse with Tilt-rod (antenna)	Pressure 150-360 kg, or 1.3 kg (tilt-rod) Full-width attack capability	

Fig. 1. Yugoslav antitank mines.

antitank mine on "nobody's land" were extracted with the help of UNPROFOR after several days. Of 12 traumatic deaths, 11 (92%) occurred in the prehospital setting: 10 (91%) injured were declared dead on the spot by paramedics and 1 died during transport. The 11th victim, who was brought to hospital alive, died after 9 days due to serious brain injury. It is to be noted that two lightly injured victims were not brought to our hospital but remained in hospitals in the region near the battlefield. Of 31 survivors, 27 underwent operations. A characteristic of the wounding by antitank mines is a great number of different operations. Six patients were operated on only once, 12 underwent two operations, 6 patients were operated on three times, and 1 patient had four, 1 had five, and 1 had six operations. One of the injured, suspected of having gas gangrene, was successfully treated by hyperbaric oxygen therapy after open upper leg amputation. The hospital stay was on average 26.9 ± 14.9 days. By comparison of AIS scores (vertical axis) and time and number of our patients (horizontal axis), it can be seen that the highest number of antitank mine explosions occurred during the second and third year of war (Fig. 2). The intensity of the mine war accompanied the war events on the field. The resultant AIS assessed injury the severity of injuries in antitank mines victims by a scale from 1 (minor) to 6 (fatal). Using the AIS methodology, the probability of survival was estimated for only two of our nonsurviving patients. In the group of those injured by antitank mines, the average AIS was 3.67 ± 1.18, that is, injuries were severe and life-threatening. The ISS has been found to correlate better with mortality than the AIS (Fig. 3). As can be seen in Figure 3, ISS (vertical axis) and distribution of trauma cases by severity and body region of principal injury (horizontal axis) are plotted for each patient. Survivors are shown in white and nonsurvivors are shown in black. Causes of death for all study patients are described. Injuries to the brain were the most prevalent (50%), followed by injury to the vessels that produce ex-

TABLE I

AIS AND ISS IN ANTITANK MINE CASUALTIES

	Antitank Mine Injuries													
	Survivors							Fatalities						
	N	M/F	Age (years)	AIS	ISS	Profession	Vehicle	Deaths	M/F	Age (years)	AIS	ISS	Profession	Vehicle
1991	1	M	23	1	1	Soldier	Car							
	2	M	30	2	12	Soldier	Car	3	M	23	6	97	Guard	Car
	5	M	38	2	4	Soldier	Lorry	4	M	25	6	97	Soldier	Lorry
	6	M	29	3	22	Soldier	Lorry							
	7	M	28	3	13	Soldier	Lorry							
	8	M	29	2	4	Soldier	Lorry	9	M	41	4	48	Civil	Pedestrian
1992	11	M	38	3	17	Soldier	Car	10	M	38	6	61	Soldier	Car
	12	M	34	2	4	Soldier	Lorry	13	M	33	6	54	Soldier	Ambulance
	14	M	36	2	9	Soldier	Lorry							
	15	M	55	4	13	Civil	Bus							
	16	M	23	4	29	Civil	Tractor							
	17	M	28	3	22	Soldier	Car							
	18	M	30	3	13	Soldier	Lorry							
	19	M	36	4	48	Guard	Car							
	20	F	27	2	12	Refugee	Car							
1993	21	M	23	3	13	Soldier	Transporter							
	22	M	47	3	22	Civil	Bus							
	23	M	20	3	17	Soldier	Car							
	24	M	26	4	29	Refugee	Car							
	25	M	12	3	17	Refugee	Car							
	26	M	39	4	20	Soldier	Car							
	27	M	34	4	29	Soldier	Jeep	28	M	29	6	88	Soldier	Jeep
	31	M	40	3	22	Soldier	Car	29	M	21	4	41	Soldier	Jeep
	32	M	44	3	13	Civil	Car	30	M	21	6	61	Soldier	Jeep
1994	35	M	35	2	4	Journalist	Car	33	M	45	6	70	Journalist	Car
	36	M	26	3	27	Soldier	Car	34	M	36	6	70	Journalist	Car
	37	M	23	3	22	Civil	Exavator							
1995	38	M	34	3	17	Soldier	Car	40	M	19	6	68	Soldier	Jeep
	39	M	41	3	27	Soldier	Jeep	41	M	33	5	43	Soldier	Car
	42	M	30	3	22	Civil	Car							
	30		31.93 ± 6.93	2.9 ± 0.55	17.47 ± 7.60			12		30.33 ± 7.33	5.58 ± 0.63	66.50 ± 15.17		
Total	42		30.74 ± 9.52	3.67 ± 1.18	31.48 ± 20.23									

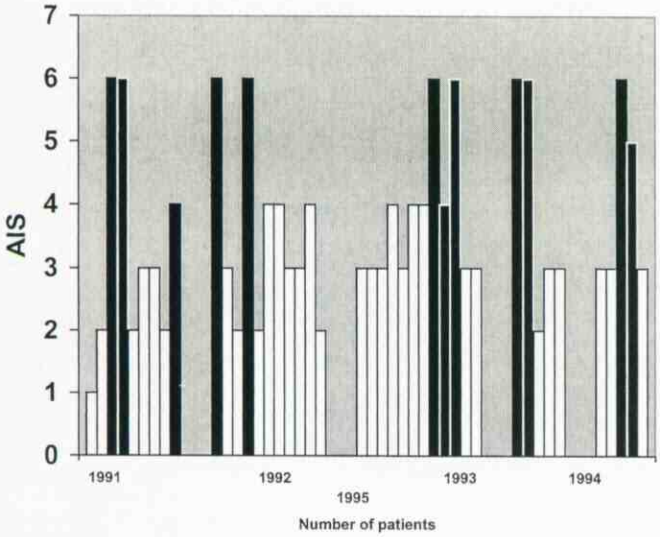

Fig. 2. Frequency of antitank mine casualties by year (□, survivor; ■, nonsurvivor) as graded using an AIS score.

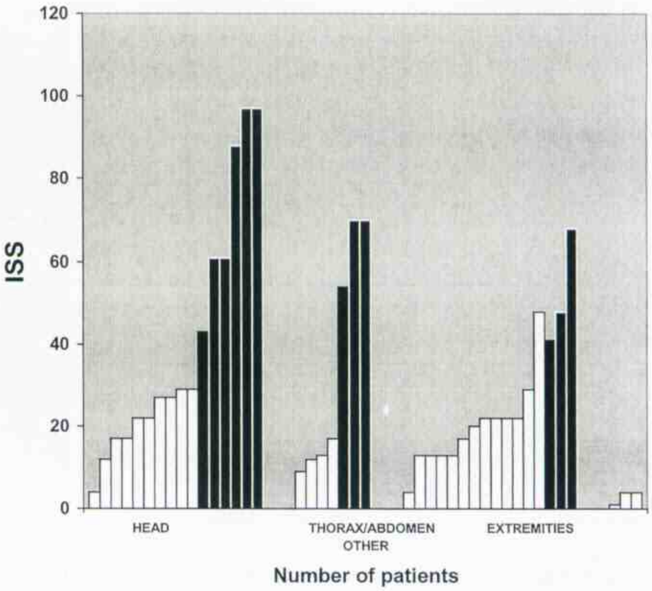

Fig. 3. Comparison of ISS scores between survivors (□) and nonsurvivors (■) in study patients, $N = 42$. Distribution of patients injured by antitank mines classified by severity and body region of principle injury.

sanguinating hemorrhage (33%). Massive thoracic injury with organ failure was the third most common cause of death, accounting for 16% of patients. This type of graph is useful in identifying unexpected deaths as well as unexpected survivors. All deaths that fall below the ISS value of 50 should be reviewed for trauma care system failure. However, in war conditions, the difficulty of evacuating the injured (vicinity of the enemy, distance from the nearest war hospital, bad roads, inadequate communication, and vehicles entering minefield) can explain such unexpected deaths.

The mean value of the ISS in our patients amounts to 31.48 ± 20.23; therefore, the mortality of 29% is predictable and defines major trauma based on anatomic injury.

Discussion

Antitank mines consist of the body, the explosive charge, and the detonator. The body of the first mines was made of wood. As wood was found to rot and because of the need for faster production, the body of antitank mines was later made of metal, mostly of cast iron. The invention of the mine detector functioning on the principle of electromagnetic induction prompted the practical demand for reducing the amount of metal in the antitank mine. An adequate material for the body of antitank mines was found in polyvinyl. The body can be cylindrical (round) or rectangular (prismatic) and has the function of connecting all parts of the mine. The inner part of the mine contains the explosive charge, and, on the outer sides, there are places for basic and additional fuses. The explosive charge is most often composed of cast trotyl or plastic explosive. Cast trotyl has been chosen for its devastating force and long-term stability. An antitank mine usually contains 4 to 7 kg of explosive, which is sufficient to cause major damage to a vehicle. The fuse in an antitank mine may function on pressure (classical type) or be of some other kind. There is no rule for selecting the type of fuse in antitank mines. Basic fuses most frequently belong to the pressure type, but the mine can have additional fuses on the sides or on the bottom. Sensor fuses may be used (in "smart mines"), which activate the mine if previously determined conditions (sound resonance and/or temperature) are satisfied.

Contemporary antitank mines can be laid in all types of ground and in all climatic conditions (snow, water, ice, etc.), and they are resistant to the blast wave of the atomic bomb. To make detection by modern mine detectors more difficult, materials of an antimagnetic nature are used in production of the mines. Antitank metal mine (TMM-1) has a round body made of metal. It can be placed in all types and categories of ground. Buried under the ground, it can remain efficient for as long as a year. It is often equipped with special additional fuses, which makes demining even more difficult and dangerous.

Antitank antimagnetic mines (TMA-1, TMA-2, and TMA-5) have a body made of plastic material of elliptical or prismatic shape. On the upper side there is the pressure plate (one or two), and underneath is the case for the basic fuse (one or two). The upper surface is corrugated, making the body more solid and resistant. On the bottom, they have a place for an additional fuse. These mines do not last long because they are not hermetically closed.

Antimagnetic antitank mine TMA-4 has a round body made of plastic mass, and TMA-3 has no body, but the explosive charge is poured into a glass wool and jute cloth lining. These mines are hermetically closed, therefore they remain efficient for years even in unfavorable conditions. As they have three fuses, the possibility of their being activated by stepping on them is increased.

Injuries from antitank mines belong to the most severe, and their treatment is exceptionally complex and expensive. The extensive injuries sustained in land mine accidents require the application of an inordinate amount of resources at the expense of non-land mine-related patients. The extent of damage and the localization of the wound are in direct connection with the type of land mine used.[10,11,18–28]

Antitank mines cause damage to all parts of the body. The extent of injuries is in direct proportion to the distance of the injured person from the mine. Other important parameters are the strength of the explosive charge, the brunt of the airwave, and thermal activity.[25–30] Wounds inflicted by mine-explosive devices are multiple, with several organs or organic systems being generally included. Large defects of skin and subcutaneous tissues, irregularly formed wounds accompanied by severed muscles, the presence of asymmetrical pockets in all directions, often containing secondary projectiles, are their characteristics.[26–32] The explosion of a pressure mine, as a rule, destroys the foot and lower leg, causing multiple wounds to the other leg, genitals, arms, and face. Traumatic amputation is very common, and secondary surgical amputation is frequently inevitable. The explosive brunt destroys blood vessels high within the extremity, therefore, surgical amputations are done rather high.[33] Although all war injuries are unclean, mine injuries are particularly dangerous. Explosive brunt carries particles of ground, dirt, bacteria, remnants of clothing, and fragments of metal and plastic profoundly into soft tissue and bones, provoking secondary infection.[31–34] Radiological detection of these particles is often difficult, therefore, the surgical intervention remains incomplete.[35] Patients with mine injuries generally remain in the hospital longer than other war victims, use double the blood, and undergo at least two major surgical operations with a high perspective of subsequent reamputation.[36,37]

In comparison to antipersonnel mines, antitank mines are placed in considerably smaller numbers and present probably a lesser danger to people, but when activated, the consequences are much more severe. Although antipersonnel mines injure, antitank mines leave less chance for survival, as they contain great amounts of explosive (5–6 kg of cast TNT). Injuries or fatalities in our group have been caused most often with antitank mines (TMRP-6).[10,38–41] In the regions affected by war, a special danger lies in mixed minefields, where antipersonnel mines are placed to secure antitank mines.[42,43] Although injuries from antitank mines are ravaging, and frequently fatal, a significant number of patients survive.[44,45]

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