AUSTRALIAN MILITARY MEDICINE ASSOCIATION

Statement of Objectives

The Australian Military Medicine Association is an independent, professional scientific organisation of health professionals with the objectives of:

- promoting the study of military medicine
- bringing together those with an interest in military medicine
- disseminating knowledge of military medicine
- publishing and distributing a journal in military medicine
- promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine.
The Association is totally independent of the Australian Defence Force.

TABLE OF CONTENTS

EDITOR'S COMMENT 38

PRESIDENT'S WELCOME 39

OVERVIEW 40

Understanding weapons effects: A fundamental precept in the professional preparation of military physicians 40

Sometimes you hear the bullet 48

MISSILE INJURIES 51

High velocity missile wounding using military projectiles 51

Historical developments in casualty evacuation and triage 54

Over a century of service: The .303 projectile and its wounding capabilities - A historical profile 58

MUNITIONS 62

Thermobaric munitions and their medical effects 62

LESS THAN LETHAL WEAPONS 66

The medical effects of non-lethal weapons - A review 66

Less lethal projectiles - An investigation 71

INSTRUCTIONS FOR AUTHORS 74

Editor's Comment

Jenny Graham

This year continues to be a turbulent one, with the devastation caused by hurricanes in the southern United States echoing the natural disasters so close to our own borders earlier this year. As signalled in the first journal this year, a themed edition will be published in November dedicated to Operation Tsunami/Sumatra Assist, and other recent ADF Operations. It has been particularly difficult, however, sourcing material for this edition, despite the wealth of experience that has been gained from the Operation. Being your journal, I strongly encourage your participation by contributing articles for publication. I have attended a number of regional meetings this year during which there were many interesting and informative presentations given. I urge you to approach your colleagues to submit their work for publication, and perhaps even join the Association if they aren't already members.

The main theme of this issue is the health effects of conventional weapons. Over the last 14 years, a number of articles have been published which have looked at the physiological effects and management of such weapons. Given the continued operations in Iraq and Afghanistan, and the ever present terrorist threat, a review of these principles is timely. This is the second themed edition that we have produced, with a previous issue in 2004 looking at chemical, biological and radiological weapons. I wish to express my gratitude to Dr Andy Robertson for taking the lead to coordinate articles for this edition.

I have enjoyed the appointment as editor for the journal this year, which regretfully I will not be continuing as I move from Defence to a different phase of my career.

Jenny Graham

PRESIDENT'S MESSAGE

Russell Schedlich

As I sit here on a holiday long weekend, I am once again assailed by the news that ADF Health Personnel have been deployed to Bali to assist in the medevac and care of a number of Australians who have been severely injured as a result of terrorist bombings.

It is the nature of our military health personnel, both in the Permanent Forces and Reserves, that they are often required to make themselves available, and almost invariably do so willingly, at any time of the day or night to support these kinds of emergency operations.

Disaster relief operations seem to be coming more commonplace. We have had our own share in the Asia Pacific region, from Bali in 2002 to the devastating tsunami and earthquake over the last festive season. The US has recently suffered the devastation of Hurricane Katrina, with Rita following close behind, but fortunately not as destructive. In the UK a few months ago we had the Underground bombings.

These events remind us yet again of the need for our military health personnel to be as well prepared as possible for these events … with personnel, training, materiel and operational planning and procedures well developed and readily available.

I believe that the Australian Military Medicine Association plays an important part in supporting the Defence health community in its efforts to remain at the forefront of preparedness and effectiveness.

This month's journal contains a wealth of articles, previously published, on weapons and munition effects – missile, blast, thermal and non-lethal. As such, in this time of increasing tension, it serves as a timely reminder of the fundamental role of health services in the military.

In a couple of weeks' time, we will be holding our Annual Conference, in Launceston. We have had a tremendous response, both in terms of papers (over 50 submitted) and delegates – over 110 already registered.

We have been honoured to have secured the Chief of the Defence Force, Air Chief Marshal Angus Houston, to deliver the keynote address. The newly appointed Surgeon General, Rear Admiral Graeme Shirtley RAN, will also address the delegates.

Captain Art Smith MC USN (Rtd) will be delivering a keynote paper on military health ethics. This will be followed by a panel discussion and open forum on ethics. Art will also be conducting a workshop on sea-based operational health support which I am sure will be thought provoking. The workshop will be held at the Australian Maritime College on Friday afternoon, and will be preceded by a tour of the College.

If you haven't registered for the conference … do so now at www.amma.asn.au.

I look forward to seeing you all in Launceston.

Russell Schedlich

Overview

Understanding weapons effects: A fundamental precept in the professional preparation of military physicians[1]

AM Smith, RF Bellamy[2]

Short of participation in medical support of actual combat, there is no optimal educational medium to facilitate competence in the precepts of wartime casualty care. Consequently, there have been periodic calls for "military specific curricula" to help orient medical officers to the differences between the unique science of military medicine, and the practice of medicine in a peacetime military. Ultimately, any such military specific course of study should facilitate its students' understanding of the medical impact of weapons systems. The insights gained will foster a greater understanding of the entire spectrum of casualty care systems in war.

Whereas the profession of combat arms has traditionally focused its attention upon the relationship between weapons, ammunition, and their targeting, a concurrent appreciation for the impact of munitions upon human targets, and the wounding process, would benefit military physicians. Empowered with a better understanding of the physical impact of specific weapons, physicians can better comprehend the rationale for their tactical utilisation. Further endowed with a knowledge of the special requirements for management of resulting combat injuries, medical officers may logically develop a greater appreciation for medical logistics needs as well. This level of professional insight will permit them to competently assess the intrinsic assets and liabilities of the casualty treatment continuum supporting operational plans, and thereby assist combat commanders in becoming better informed "consumers" of medical care services.

WEAPONS EFFECTS

The military value of contemporary armaments is primarily adjudged by their effectiveness in producing physical trauma. Through the combined destructive forces of projectiles, blasts and incendiary agents, the judicious employment of today's combat weapons may create a diverse and widely distributed spectrum of personnel damage. Rationally, however, the goal of modern warfare is not necessarily to annihilate an

adversary, but more directly to reduce an enemy's capability for further resistance. Whether through intimidation or physical damage, the military usefulness of weapons must ultimately be judged in terms of their contribution to this objective. Indeed, the proportion of non-lethal injury may have an even greater impact on operational success than the absolute number of deaths among an opponent's force'

Observations on the fear that men develop relative to specific weapons are unfortunately quite limited. While the extent to which military effectiveness correlates with the potential for generating fear is a concept not well understood, history suggests that its role can occasionally be pivotal. For example, whistles were added to some aerial bombs during World War II specifically for psychologic effect. Perhaps the best example of a weapon system designed for the purpose of intimidation was the German "Stuka" dive bomber of World War II. When diving on its target, a wind driven siren attached to its wing was activated. Known as the "Jericho Siren", an ear-piercing shriek was produced which was loudest just before the bomb exploded. Likewise, some of the appeal of chemical weapons lies in their presumed psychologic effects as well. Except for chemical agents, however, the design of pre-nuclear weapons was not significantly influenced by psychologic considerations.

The character of modern weapons is ever changing, however, and considerable advances have been made in broadening and increasing their

1. Smith AM, Bellamy RF. Understanding weapons effects. A fundamental precept in the professional preparation ofmilitary physicians. *Aust Mil Med* 1998; 7(2):4-10.

2. Captain Arthur Smith, MC, USNR, is Clinical Professor of Surgery and Clinical Professor of Military and Emergency Medicine at the Uniformed Services University of the Health Sciences, Bethesda, Maryland. He is also Professor of Surgery (Urology) at the Medical College of Georgia, Augusta, Georgia. Colonel Ronald Bellamy, MC, US Army (Ret) is Military Medicine Editor, Textbook of Military Medicine, Office of the Surgeon General of the US Army, The Borden Institute, Walter Reed Army Medical Centre, Washington DC.

effectiveness. Furthermore, the principles of their use have been expanded. Given the often unique constitution of each tactical situation, these improvements, together, may provide an increasingly greater variety of options for operational commanders. Regardless of the methods employed, the time honoured axiom remains valid: increasing the proportion of wounded among adversary forces is a very effective “force reducer”.

Effective antipersonnel weapons cause not only multiple casualties in a population of troops, but may also inflict multiple wounds in each of their affected targets. In evaluating the potential effectiveness of a new exploding missile, the principal question to be asked is: “How far does it go in expanding the fragmentation envelope?” Rephrased in the context of intensity of injury: “How can more hits be produced without reducing the summation of damage - by creating too many minor hits and too few major hits?”

From the perspective of weapons designers, exploding missiles carry a far greater probability of hits than solid projectiles of the same size. From a medical standpoint, a weapon producing multiple random wounds is more likely to injure a critical organ than a single injury caused by an aimed missile such as a rifle bullet. Furthermore, by creating greater numbers of casualties among opposing forces, many with multiple wounds, the enemy force will not only be weakened, but the logistic needs of their medical services will be increased. This may often evolve at the expense of the combat arms, since more enemy logistical resources and personnel will need to be withdrawn from offensive operations to care for the injured and facilitate their evacuation.

WEAPONS EFFECTIVENESS: THE TACTICAL IMPACT

As a tactical situation changes, differing degrees of injury intensity may vary in their military impact. In one situation, where enemy capabilities for replacement are not great, as in the attack on an isolated strong point, weapons capable of only transient impairment of efficiency, although affecting a substantial part of the enemy force, may be of greater tactical value than weapons causing more permanent wounds to a much smaller number. Alternatively, in another situation, a premium may be placed on lethal or permanently disabling effects. Stated otherwise, are 10 casualties, losing 10 days each, equivalent to 100 losing one day each? The dilemma may be re-defined as weighing immediate tactical advantage against a long term effect upon manpower.

The expenditure of ammunition by various military forces has been reasonably well recorded. It has thus far proven impractical, however, to relate a given expenditure of munitions to a given number of enemy casualties, much less relate them to a particular type of weapon. Nevertheless, penetrating wounds of the body surface have historically caused 90% of combat trauma injuries in land warfare (in the civilian sector, where blunt injuries predominate, penetrating wounds comprise only 25 to 50 per cent of trauma cases). Blast, burns, and blunt trauma account for the other 10% of injuries experienced in land combat. [In naval warfare, the predominant form of injury is thermal. During the Falklands war, for example, 34% of British naval casualties at sea were burns.]

In most conventional land wars, wounds caused by fragment penetrations have historically outnumbered bullet wounds. Wounds from explosive fragmentary munitions have accounted for between 44 and 92 percent of all surgical cases. Under circumstances where fragments predominate, and weapons cannot be aimed at particular body regions, missiles tend to be randomly distributed in space, and hits are a function of the frequency and extent to which the various regions of the body are exposed.

Today, even terrorists may utilise explosive fragmentation devices that are as sophisticated as those used in modern warfare.

Under certain warfare conditions the ratio of fragment to bullet injuries may reverse. During combat at close quarters, where ambush and sniping are frequent, directed fire may increase, and hits upon vital areas may be more frequent. These include: military operations in urban environments; light infantry actions - such as Vietnam where 50% of the casualties had bullet wounds; low intensity warfare;

counter-insurgency actions; and jungle warfare. These differences in bullet versus fragment distributions are important to recognise, since bullets are more likely to kill their victims than fragments from explosive munitions such as artillery shells or grenades (33 versus 10 to 20 per cent).

As a result of the ongoing perfection of a class of anti-personnel munitions known as fuel-air explosives (FAE), future wars will probably have even higher proportions of casualties with primary blast injury as well. In addition, if larger numbers of troops serve in armoured fighting vehicles, the proportion of burns in land warfare will also increase. Due to exposure of crew members to battle damage fires, burns have constituted an important component of wounds seen in the protracted armour operations of the past (20 to 40 per cent). Armour casualties may experience more than burn injuries, however. They are also prone to the combined impact of blast injury, toxic gas inhalation, and tissue wounds from both the penetrators of anti-armour munitions and the shrapnel fragments emanating from the defeated armour.

The nature of war wounds is always prone to continuing change with the development and use of new weapons systems. Innovations such as futuristic laser-charged particle beams and high powered microwaves, for example, are now just beginning to demonstrate their impact as well.

EXPLOSIVE FRAGMENTATION MUNITIONS: WHAT ARE THEY?

The prototype of the exploding munition is the shell. Originally composed of a hollow metal casing, explosive powder was packed within, along with a fuse for ignition. Depending upon the shell design, various kinds of fragments, projectiles, chemicals, or other agents were dispersed upon explosion. In older designs, fragments of the shell casing created most of the damage. Subsequently, artillery forces incorporated shrapnel to increase the antipersonnel effectiveness of explosive munitions. A shrapnel ball contained explosive as well as many small lead spheres (the shrapnel) packed in resin. Blasted out of the shell at detonation, the lead spheres greatly increased the number of projectiles from the explosive munition. Subsequently, more specialised modern exploding munitions evolved, such as hand grenades, rockets, bombs and mines.

Depending upon the size and design of the explosive munition, several thousand metal fragments may be produced upon detonation. Fragments radiating from the detonation site may retain their wounding potential for up to several hundred metres. Such munitions can also injure through blast and burning effects. A casualty close to the point of detonation of an explosive weapon, although extensively injured by the mutilating effects of a high concentration of fragments, may also sustain blast and burn injuries. Most of these casualties die immediately from multiple high energy transfer wounds, while some die from traumatic amputations caused by the dynamic blast over-pressure. The majority of the surviving wounded, however, these generally located distant from the explosion site, will have multiple, relatively low energy-transfer wounds caused by fragments of variable size with low impact velocities. At one British Army Hospital during the 1991 Gulf War, 81% of the casualties suffered from fragment wounds. An average of nine low energy transfer wounds were inflicted per patient!

Two antipersonnel fragment families exist; one older and “random”, and the other modern and “improved”.

OLDER “RANDOM” FRAGMENTATION MUNITIONS

The older fragment family is the product of detonation of artillery shells and large caliber mortar bombs. Natural fragmentation of the projectile casing results in fragments varying in size from dust particles to metal pieces weighing more than 1 000 grams. Initial fragment velocities may be very high (as much as 1 500 to 1 800 metres per second), but decline rapidly because of the poor aerodynamic characteristics of their irregular shape. Some fragments have a Limited effective range and poor tissue penetrating power. Others, as a consequence of heavy mass and high kinetic energy, may penetrate deeply and cause massive damage. Because of their irregular shape and ragged edges, fragments produced by random fragmentation munitions often cause wounds with Jagged shape due to the drag of the projectiles within soft tissues.

IMPROVED FRAGMENTATION MUNITIONS

On future conventional battlefields, the majority of wounds will likely result from “improved” military fragmentation munitions (IFMs). The development of these newer improved munitions required a design in which the “shell” broke up into fragments smaller than those associated with random fragmentation munitions. In reality, the size of a fragment that will cause a casualty is surprisingly small - several hundred milligrams only. One of the earliest examples of the implementation of the IFM concept was the “pineapple” hand grenade of World War I (although some believed that this design characteristic resulted primarily from a desire to give the soldier a rough surface to grip).

IFMs designed post World War II usually incorporate etched fragmentation plates or notched wire fragmentation coils. Some IFMs are filled with preformed rods - hardened steel bits packed inside the munition, which are expelled when it explodes (a “canister shot”, for example, is a shotgun-like container that can hold thousands of pre-formed rods or slugs).

Modern (improved) fragmentation munitions, such as contemporary hand grenades small mortars and antipersonnel mines, contain either multiple uniformly constructed metallic spheres, or aerodynamically fashioned dart-like arrow shaped projectiles (flechettes), all of which have been designed for great penetration. Detonation of these munitions disperses a large number of such small pre-formed fragments. Weapons designers have expended considerable effort in producing a consistent fragment size, which offers an optimum compromise between range, velocity, probability of hit, and target wounding effectiveness. Their aim is to incapacitate by inflicting multiple low energy “transfer” wounds to areas not protected by modern helmets and body armour. Although the mechanical injury may be quite modest among surviving casualties who reach surgical facilities, many will have multiple wounds, often heavily contaminated with clothing, soil and skin.

An example of an improved conventional munition of the Vietnam era was the “beehive round”, a 105 mm antipersonnel round filled with 8 800 flechettes. The flechettes were released from the shell at a time determined by the fuse setting, and their aerodynamic properties allowed them to pass through helmets and armoured vests more easily than irregular fragments.

Another improved conventional munition, the cluster bomb, acts as a cargo carrying munition. It contains many small sub-munitions that in turn are filled with numerous small preformed fragments - the size and shape of which have been designed to cause a large number of casualties. Even more recent updates to this class of munitions are the US Army’s Multiple Launch Rocket System (MLRS) munition containing 644 M77 submunitions, and the 155 mm Howitzer artillery projectile containing 64 M42 and 24 M46 submunitions. When a cluster munition is detonated, (either before or upon the carrier’s impact), its submunitions or bomblets are disseminated over the surrounding terrain. When they explode, the fragments are dispersed over a much wider area than would have been affected if the same mass of potential fragments had been derived from a single thick walled shell casing. The fragments of such weapons tend to be small and numerous, with the expressed purpose of achieving not only the high probability of a wound, but multiple wounds to each casualty. They are also fairly regular in shape, ensuring adequate range and consistent performance.

The most modern improved conventional munitions have combined antipersonnel with anti-materiel potential. The latter characteristic is obtained by incorporating a shaped charged warhead into each of the individual submunitions. When the munition detonates, fragments from the side walls are disseminated in a radial direction around the armour piercing jet produced by the shaped charge warhead. Such cluster munitions, incorporating dual purpose sub-munitions, were used with great effectiveness in the Persian Gulf War.

OTHER FRAGMENTATION THREATS

Following the surface or subsurface detonation of an explosive munition, secondary missiles are also produced from objects within the environment, such as dirt, rocks, trees, or debris from buildings. The nature of the secondary fragments is generally unpredictable. They tend to be irregularly shaped, with a wide range of masses and impact velocities, and may have considerable potential to cause injuries. In the aerial bombing of cities, for example, secondary missiles often cause the greatest volume of casualties. The wounds created by secondary missiles, however, may become badly contaminated. A landmine, for example, creates high velocity secondary missiles from the ground in which it is buried. It is therefore likely that any severe wounds created will also be filled with dirt, pebbles and even chunks of plants.

THE WOUNDS CREATED BY FRAGMENTATION MUNITIONS

Penetrating missiles may cut, crush and lacerate tissues directly in the missile’s path. When penetrating the skin, an antipersonnel fragment of low mass and low velocity causes an injury confined principally to the immediate track of the missile through the soft tissue. The visible passage created in the tissue includes the wound of entrance, and if it completely passes through the tissue, the wound of exit as well. These low energy transfer wounds arise simply from the cutting and crushing action of the projectile as it penetrates the tissues. Faster moving heavy missiles have more energy to transfer, and have the potential to cause more tissue damage. This damage is caused not only by direct contact between the missile and the tissue, but by tissue being violently thrown away from the missile's path through it. The radial stretching and tearing of tissue around the missile's track is known as "cavitation".

The impact velocity of a projectile can occasionally be a misleading indicator of its potential for injury. All projectiles cut, crush, bruise and displace tissues. Some projectiles, by virtue not only of speed but also their shape, may undergo a tumbling motion within the tissues. This induces further indirect injury to tissues not directly in their path. The radial or peripheral stretching and tearing induced by such projectiles, or "temporary cavitation", is variable, and is a consequence of increasing levels of transferred energy. The excess energy or fragment motion may induce merely a bruise around the missile path, or alternatively, a grossly explosive effect such as a shattering of the heart or skull radial to the missile path. Even if cavitation is not immediately lethal, its contribution to the occurrence of war wound infection is widely overlooked.

All war wounds are contaminated from the outset by soil, clothing, and skin. Fragments and any other projectiles with sharp irregular surfaces have been shown to cut clothing materials and skin efficiently, and also transfer notable quantities of these contaminants into wounds. Low velocity projectiles regularly transfer such ragged pieces of clothing and skin contaminants into wounds. When the fragment velocity is raised and a temporary cavity is formed by the projectile, the nature of clothing contamination is further altered, fibres and large pieces of material may be finely shredded and rapidly dispersed due to the formation of the temporary cavity, resulting in contamination of tissues far distant from the permanent wound track. If the temporary cavity involves the exit wound, substantial quantities of material may also be sucked into the wound from the exit hole, creating even greater widespread contamination, and the potential for infection at multiple sites.

Describing conditions in the Korean War, one historian noted:

"Even UN soldiers arrived in hospitals with most wounds . . . grossly contaminated with field dirt, leaves of rice plants, and crumbs of human excrement plainly visible in some of them. Wounded North Korean prisoners of war showed the same problem in exaggerated form, their injuries frequently infested with hordes of maggots."[1]

BULLETS AND THEIR WOUNDS

Both the design and construction of a bullet determine the kind of wound created. The wounding effects of deforming hollow point and soft-nose hunting ammunition, for example, which change shape after penetrating tissue, are noticeably different and potentially more devastating than those of non-deforming bullets. Most bullets are long and thin, and are spun along their long axis to provide stability, and accuracy. After entering soft tissue, however, spin stabilisation is overcome and bullets become unstable. They may tumble and turn through 180 degrees, thus increasing the surface area of tissue presenting to the forward moving missile. This results in significantly greater tissue damage. If the wound track through tissue is long enough, all bullets will tumble. As a bullet tumbles, it may become deformed or break up - especially if it contacts hard, high density bone.

Bullet wounds in the battlefield are generally caused by fully jacketed military ammunition as defined by the Hague Declaration of 1899. The latter prohibited the use of any "bullet which expands or flattens easily in the human body". To meet this requirement, bullets designed for military use are comprised of lead and steel components clad within a metal jacket. As a result, it has been suggested that designers of military small arms, ostensibly formulating bullets to prevent flattening deformity of the missile, use alternatives such as bullets which readily fragment in order to cause equivalent tissue effects.

Even if not designed as such, many bullets may nevertheless fragment at close range if they strike bone. The tendency to break-up is governed by the construction of the bullet, principally the thickness of the Jacket and the efficiency of the base in preventing extrusion. The disruption of the bullet into small pieces produces irregular fragments, each with large potential for energy transfer. A temporary cavity around the fragmenting bullet will be associated with multiple diverging wound tracks. Multiple lacerations of the tissues surrounding the original wound track are the result. If the victim's skeleton is damaged by a missile as well, the fragmented bone may provide an even larger number of secondary fragments. When scattering bone fragments are combined with bullet fragmentation, widespread disruption of soft tissues is produced within the vicinity of the bone - including any adjacent blood vessels, nerves and other soft tissues.

BLAST INJURIES FROM FUEL-AIR EXPLOSIVES

An explosive munition, on detonation, produces a transient pressure that can propagate through the air at an initial velocity exceeding the speed of sound It may rupture eardrums and severely bruise and rupture both the lungs and other gas tilled organs (such as the intestines), leaving no tell-tale external marks on the victim. Very high overpressure can also cause air to be pumped into a victim's circulation, causing dangerous and often fatal air embolism of the heart and cerebral blood vessels. It can also liberate fragments of debris from the environment that may act as penetrating missiles. Furthermore, the mass of moving blast wind may forcibly blow the casualty against solid objects in the area, thereby inducing blunt injury as well.

A typical Fuel-Air Explosive (FAE) consists of a cylindrical container of a liquid fuel, such as ethylene oxide or propylene oxide, the walls of which are scored so that the container can break apart in a controlled manner. It also contains a burster charge located at the center, which extends along the long axis of the container. When the burster charge detonates, the contents of the fuel container will be dispersed as a mist-like disk shaped fuel-air cloud over the ground. It flows around objects such as trees and rocks, and into structures or field fortification ventilation systems. Next, a small secondary charge ignites the fuel-air mixture. The vast dimensions of the FAE cloud ensure that the blast effects will occur over a much wider area than that affected by any conventional explosive munitions. The FAE blast wave can go around corners, penetrating the apertures in bunkers, the open hatches in armoured fighting vehicles, and the hollows of trenches and foxholes. In Afghanistan, such FAE munitions, labelled vacuum bombs, comprised a significant proportion of the munitions dropped by Soviet aircraft. Since the Vietnam War, FAE weapons have been improved so that their blast effects now rival that of a small tactical nuclear warhead.

OTHER MILITARY SPECIFIC INJURIES

There are other mechanisms of injury predominantly confined to the military spectrum. These include burns from napalm, incendiaries, flame munitions, and white phosphorus. Crush injuries also occur in greater abundance in the military setting. The implications of crush injury extend to needed repair of skin, bone, muscle, blood vessels, and nerves, as well as the possibility of treatment for kidney failure, a common result of this form of trauma. In addition, military inhalation injuries may result. These occur from breathing the byproducts of ammunition and plastics combustion, and inhalation of particulate metallic aerosols (such as "chaff" which may be released to cloud electromagnetic transmissions of attacking missiles). Other inhalation injuries result from the breathing of rocket fuel combustion fumes, and environmental obscurant agents such as picric acid and anthracene – all common to the modern battlefield, with few equivalents in peacetime.

IMPLICATIONS FOR DELIVERY OF MEDICAL SERVICES

Most peacetime models and experiences are of limited value when preparing medical officers for service in the combat setting. Many of the enormous peacetime technical advances in modern surgery - those which have transformed the outlook for patients born with congenital abnormalities, or those suffering from such degenerative conditions as arthritis, heart disease, and cancer - do not have immediate application on the battlefield! The wartime phenomena of large numbers of casualties which are generated simultaneously, many bearing multiple wounds and concurrent injuries from the entire spectrum of militarily unique weapons, are not ordinarily seen in peacetime medical practice. They differentiate and complicate casualty management in the military medical field system. As a noted authority in combat medical care once noted: "The practice of medicine and surgery in peacetime prepares physicians for war as well as police department duty would prepare infantry for combat, or as well as commercial aviation experience prepares pilots for close air support in wartime".[2]

There are undeniably fundamental differences, oftentimes forgotten, between medical treatment practices in peacetime and those employed in war. Indeed, the very nature of warfare precludes a neat transformation in place from such successful peacetime models of healthcare. These are best exemplified by two contrasting hypothetical examples:

- In the peacetime setting, a victim of urban violence who sustains a perforating soft tissue wound of the thigh by a 9 mm pistol bullet, is often rapidly transferred by emergency medical services, within minutes, to a civilian trauma hospital designed to provide a full spectrum of needed care. Within these centres, in response to multiple demands of such nature, effective treatment methods have evolved. These efforts are commonly supported by the general availability of teams of multi-disciplinary consulting specialists, buttressed by sophisticated medical imaging techniques such as CT scanning and NMR (nuclear magnetic resonance) scans. The most modern broad spectrum antibiotics are often administered within minutes of wounding. Finally, there is access to well staffed intensive care units, where changes in patients' conditions can be intensively followed for days and weeks, often without time limits.
- A military rifleman, recently sustaining a similarly located thigh wound following the nearby explosion of a rocket propelled grenade, perhaps complicated by blast injury to his lungs and white phosphorus burns of his torso, lies in a muddy field heavily contaminated with human and animal wastes elsewhere across the globe. Because of tactical and logistical limitations, the soldier may have remained in that muddy field for many hours before being retrieved, causing his general condition to worsen, and bacteria in his wounds to multiply. He may then be deposited, with a group of other bleeding wounded, at a military evacuation hospital which is so busy that only 5 minutes can be allotted to the immediate care of each casualty. Subsequently, he may be entered into a protracted evacuation chain entailing temporising increments of treatment. This process may involve multiple transfers and the passage of a significant amount of time until arrival at a definitive care facility.

The contrast between the two hypothetical examples is self evident, yet directly relevant to the unique characteristics of the professional practice of military medicine in the operational setting. Indeed, the historical record readily confirms that military physicians must periodically provide their treatments in such a setting of physical and logistic austerity as denoted in the second example, and further carry them out in the incremental or echeloned fashion typical of military field medical systems. These require medical judgements far removed from those utilised in peacetime! Unfortunately, military surgeons have traditionally received their indoctrination to wartime surgery by "on-the-job training" within the combat zone. In contrast to clinical practices during peacetime, surgeons have had to become reoriented to various historically validated special techniques for rendering rapid but often only "adequate" care to victims of massive military wounds and massive trauma. US Army surgeon Captain Richard Hornberger of the 8055th Mobile Army Surgical Hospital (MASH) in Korea, speaking as Richard Hooker, pseudonymous author of M*A*S*H, provided meaningful perspective on this one phase of reality during the early surgical reception of combat casualties:

"Meatball surgery is a specialty itself. We are not concerned with the ultimate reconstruction of the patient. We are concerned only with getting the kid out of here alive enough for someone else to reconstruct him. Up to a point we are concerned with fingers, hands, arms and legs, but sometimes we deliberately sacrifice a leg in order to save a life, if the other wounds are more important. In fact, now and then we may lose a leg because if we spent an extra hour trying to save it, another guy in the preop ward would die from being operated on too late... Our general attitude around here is that we want to play par surgery on this course. Par is a live patient"[3]

SUMMARY

Sustainability during combat operations is a paramount concern of every operational commander. His judgements will often determine whether his war-fighting concepts and plans are supportable. Since health maintenance and casualty management programs are crucial underpinnings of any operational plan, the structure and operation of combat medical services must be thoroughly integrated with tactical operations. Therefore, the decision for a specific form of supporting activity in any given manoeuvre, such as medical support, is ultimately the commander's responsibility!

As a commander weighs the various benefits and tradeoff's associated with a combat casualty support program, he must also assess the cost of such support in terms of the competing demands of an essentially logistical function for portions of his offensive assets, as well as their impact upon his tactical mobility. For these decisions, the operational commander is beholden to his medical staff for informed advice. The inherent differences between wounding agents, as well as the unique logistical requirements for management of combat-unique casualties, within a setting of austerity and restricted support, must therefore be clearly recognised - not only by professional medical authorities, but by the line commanders who depend upon their counsel and support.

The ground rules for practicing the precepts of combat medical support differ from those utilised in peacetime military medical practices. It is therefore incumbent upon medical officers to become well informed resources for their operational counterparts. An understanding of weapons effects is an important facet of that required knowledge base, in order to facilitate a functional transition from the procedures and expectations of peacetime medical practice to the realities of combat.

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Overview

Sometimes you hear the bullet[1]

A Leavy[2]

The comedy/drama MASH, which concerned the lives of American army medical staff stationed just behind the front lines in the Korean War, was one of the most successful television programs of the 1970's. During its eleven year history, it presented an enormous range of issues from the essentials of friendship and loyalty to the concerns of bigotry and the irony of war. In between, MASH provided a mirror for society's changing attitudes, particularly by revolutionising the public's perception of the medical fraternity.

MASH began as a novel by Richard Hooker and was produced as a cinematic feature in 1970 by Ingo Preminger. Between 1972 and 1983, 250 half hour episodes of the series were produced for television. During that period and under the direction of a variety of writers, directors and producers the program remained a consistent performer in the top twenty television programs of countries around the world[1-3]. It collected 14 Emmys, and the final two and a half hour special was the highest rated program of its type in American history.

Although MASH was set during the Korean war (1950-1953), it had its roots in the late 1960's, a revolutionary period of history incorporating the 'flower-power', hippy era, rock and roll, student demonstrations and most notably, the Vietnam war. Traditional opinions on many subjects were being challenged during this time, notably public attitudes towards war and morality. These changes were reflected in MASH which, in many ways, was a pioneer in television production history.

Shortly after the end of the Korean War, American television was makings its first forays into the genre of medical drama. The initial result was a docudrama entitled 'Medic' which made a serious attempt to present medical issues to the public. It was killed by controversy in 1956[4]. In 1961, 'Dr. Kildare' and 'Ben Casey' reached the screens and each lasted five years, to be followed in 1969 by 'Marcus Welby M.D.', 'The Bold Ones' and 'Medical Centre'. All of these programs presented an idealised image of doctors. They were either young, alert and handsome or older, wise and definitely genteel, but as a fraternity they were, generally, infallible combatants of illness and disease, dispensers of wisdom and justice and guardians of moral order[4]. MASH chose to present a far more realistic picture of the medical profession and was aided in this by the setting of the program.

Mobile Army Surgical Hospitals, the real MASH units, were a significant development of the Korean War. Combat experience established that the survival of trauma victims is inversely proportional to the time from injury to effective treatment[5]. The introduction of helicopters reduced transport time, which was further cut by moving fully equipped surgical hospitals to just behind the front lines[5-7]. Time from injury to definitive care averaged 2-4 hours in the Korean War, which dropped as low as 81 minutes during the Vietnam conflict[8]. The cost of moving the hospitals forward was to increase the risk to the staffing personnel and hence the stressors imposed upon them. However, it was this pressurized setting that made it possible for the MASH writers to more fully explore the limits of human response to the variety of circumstances. Although a model of ensemble acting, the central characters in MASH were Benjamin Franklin "Hawkeye" Pierce and his companion in bedevillary "Trapper" John McIntyre (replaced in later series by B.J. Honnicutt). As protagonists, their appearance and behaviour deviated markedly from that of previous television doctors. Unshaven and frequently stained with sweat and blood, they made a mockery of any dress code. Their living and working conditions were similarly in stark contrast to the accepted television standards of the time.

One of MASH's central themes was examining how the characters responded to being moved from their comfortable 'Stateside' lifestyles to be placed in the chaotic environment of a MASH unit. This was done essentially by contrasting the response of two characters, Majors Frank Burns and Margaret Hoolihan, to that typified by Hawkeye. Burns and Hoolihan maintained a strict adherence to military

1. Leavy A. Sometimes you hear the bullet. *Aust Mil Med* 1998; 7(1): 21-23.

2. Dr Anna Leavy was a Lieutenant, RAN, serving at HMAS STIRLING at the time of this article.

rules, regulations and, in anything that did not concern their relationship, codes of ethical and moral behaviour. Their dependence on the bureaucracy of the military to provide the ground rules for physical and mental survival was contrasted with Hawkeye's irreverent overall behaviour but reliance on the basic goodness inherent in humanitarian values to guide his actions and ethical commitments. The battle between bureaucracy and humanitarianism was among many of the issues covered by MASH, as was its corollary which accepts that there are limits to individualism when survival is dependent upon team-work (for further discussion see Fass[9]).

Perhaps one of the best examples of a complex theme was dealt with most completely in MASH, and which is always relevant to members of the medical profession, is one which was carried by Hawkeye from the movie to the final episode. It examined Hawkeye's ability to cope with the insanity of being stretched to the limits of professional ability and personal responsibility. In general, Hawkeye and his fellows maintained their links with sanity, in the conventional sense, by inoculation with small doses of insanity in the form of elaborate pranks and hijinks. However, this form of defence is not without its limitations.

In the movie, Hawkeye is instrumental in helping the character of Painless (the dentist) to overcome his fears of sexual impotency. Throughout the television series, it is Hawkeye who must deal with questions concerning his own worth and ability, hence his potency as a healer. An example of this occurred in the 1972-1973 season in an episode entitled 'Sometimes You Hear the Bullet' written by Carl Cleinschmitt. When Hawkeye was unable to save the life of an author friend and is discovered in tears by the commanding officer, Henry Blake, he is counselled with the advice that there are two rules: 1. Patients die and 2. Doctors can not change rule number one. Unfortunately, Henry's advice is valueless in the final episode of the program (Goodbye, Farewell and Amen, 1983) when Hawkeye witnesses a mother suffocate her baby in an attempt to silence it and avoid detection when an enemy patrol approaches their stranded bus. The baby's death devastates Hawkeye and he retreats through a process of denial. His eventual recovery and acceptance of reality, tragic though it can be, is a slow process guided by a psychiatrist, Dr. Sidney Freidman.

In the final episode, MASH comes full circle, recapturing the sentiment of the theme song for the move, the lyrics of which did not follow the music in the transition to the small screen (see below). Essentially, life is often difficult and death and suffering raise awkward questions. In order to survive these questions doctors need to return to the roots of their profession and become, when healing fails, philosophers. It is not enough to turn away from the questions of "Why?", some attempt at an answer must be made for the sake of the patient's, the relative's and the doctor's own mental well-being.

In the end, MASH lasted three times longer than the Korean War which is depicted. In doing so, it provided a valuable medium which tempered drama with comedic relief and thus allowed the viewer to confront difficult and often dark issues without the risk of being engulfed by them. MASH also demonstrated the need for doctors to acknowledge not only their humanity and humility but also the vulnerability of that humanness.

SUICIDE IS PAINLESS

Through early morning fog I see
Visions of the things to be
The pains that are withheld for me
I realise and I can see

*That suicide is painless
It brings on many changes
And I can take or leave it
If I please

The game of life is hard to play
I'm gonna lose it anyway
The losing card of someday laid
So this is all I have to say

* chorus
The sword of time will pierce our skin
It doesn't hurt when it begins
But as it works its way on in
The pain grows stronger
Watch it brim

* chorus
The only way to win is cheat
And lay it down before I'm beat
And to another give my seat
For that's the only painless feat

*chorus
A brave man once requested me
To answer questions that are key
Is it to be or not to be
And I replied "Oh, why ask me?"

* chorus

Lyrics: Mike Altman
Music: Johnny Mandel, Chappell Music

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MISSILE INJURIES

High velocity missile wounding using military projectiles[1]

Corporal Martin Andrew

This paper discusses high velocity missile wounding caused by military projectiles. For the purpose of this paper, military projectiles considered will be those of eight mm diameter or less, fired from small arms like rifles, sub-machine guns and machine guns. High velocity is defined as speed in excess of 750 m sec[1].

EXPLANATION OF BALLISTIC TERMS

Rifling
Rifling is the grooves that are machined inside a barrel, designed to impart a spin on the projectile as it leaves the barrel. Rifling imparts a gyroscopic effect on the projectile, giving it stability in the air. The tighter the twist of the rifling, the greater the stability of the projectile, since the rate of spin is faster. A one-in-seven twist is lighter than a one-in-twelve twist.

Bullet Construction
There arc two main types of bullet construction in military projectiles. These are single and dual cores. The single core uses lead, whereas dual core uses a combination of lead and another material, usually steel. Projectiles using lead at the rear have improved stability in flight due to the rear centre of gravity. The jacket thickness is also important. The thicker the jacket, the less likely will the bullet fragment on impact with human tissue. Under international law, all military projectiles must have a jacket covering the nose and sides, hence the term ‘full metal jacket’

Trajectory
The trajectory of a projectile is the path the projectile travels through the air until it impacts against a surface. The angle that a projectile impacts upon a body is important in wound ballistics. The greater the impact angle, the more likely will the projectile pass through the body tangentially.

Drag
Drag is the resistance to movement on an object in a medium. The greater the density of the medium, the greater the drag. A projectile upon entering human soft tissue goes from a medium (air) of 1.2 kg m^3 to one of 1,000 to 1,100 kg m^3.

Yaw
Yaw is the deviation of a projectile in its longitudinal axis from the straight line of flight. At close range, under 30 m, high velocity projectiles exhibit a large amount of yaw as the stability effect of rifling has yet to start. Due to insufficient twist, some projectiles never become stable in flight, and yaw continually until impact. Yawing determines the surface area of the projectile upon impact.

Tumbling
Tumbling is the forward rotation around the centre of gravity of a projectile. Tumbling is determined by a projectile’s yawing, drag and design. A greater angle of yaw increases the drag and promotes quicker tumbling. Dual cores by their nature cause quicker tumbling. Jacket construction also contributes to quicker yawing, as a projectile may be more likely to break up upon impact.

THE MECHANICS OF WOUNDING

The Hague Convention of 1899 stated that: ‘the contracting parties agree to abstain from the use of bullets which expand or flatten easily in the human body’.

This was subsequently written into the 1949 Geneva Convention. To adhere to this, all military projectiles became fully jacketed, and are so to this day. The exception to this is shotgun rounds, which are able to be legally used without a jacket.

When the Hague Convention was drafted, nearly all nations went from round nosed to spitzer projectiles, that is, ones with pointed tips. Round nosed bullets have poor long range ballistics due to drag, but excellent penetration on soft tissue as they have minimal yaw, thus also having poor tumbling characteristics. Spitzer bullets exhibit better yawing, thus better tumbling effects on soft tissue.

In all high velocity missile wounding, the two major mechanisms of wounding are cavitation and the effect of secondary missiles.

1. Andrew M. High velocity missile wounding using military projectiles. Aust Mil Med 1994; 3(2):13-14.

Cavitation

There are two types of cavitation, permanent and temporary.

The permanent cavity is tissue crushed during a missile's travel in the body. This is determined by tumbling, bullet deformation, secondary missiles and the missile's weight upon impact. The greater the penetration and surface area of the missile, the larger the permanent cavity.

The temporary cavity is the momentary stretch or acceleration of tissue away from the bullet track. It might be thought of as blunt trauma surrounding a portion of a missile's travel in soft tissue. Elastic tissue like lungs, bowel wall and muscle tolerate stretch much better than non-elastic solid organs like liver, kidneys or a full bladder.

Secondary Missiles

Secondary missiles are objects which perforate tissue away from the main wound track. These fragments increase the amount of blood vessels injured, tissue perforated and organs damaged. Examples of secondary missiles are bone splinters, missile fragments, zips, buckles, buttons and pieces of hard body armour.

Projectiles can be designed to break up or fragment. Projectiles such as the German 7.62 x 51 mm NATO bullet, and its Swedish counterpart of the same calibre, have a deliberately thin jacket when compared to the United States equivalent. The Australian 7.62 mm round has a thick jacket similar to the US bullet.

By incorporating a lead core in the rear of a dual core projectile, it is made stable in flight. Upon hitting tissue, however, it quickly tumbles due to its rear centre of gravity. Dual core rounds also tend to break up at the join of the cores, causing greater wounding with two main wound channels and numerous smaller ones.

Historically, wound ballistic studies have over-rated the temporary cavity at the expense of the permanent cavity and secondary missiles. There arc many variables that affect the temporary cavity size and its effects. These need to be taken into consideration when studying reports about the effects of missiles fired into gelatine blocks simulating human tissue.

The effects of secondary missiles and temporary cavities arc synergistic in high velocity missile wounds. Secondary missiles cause multiple tissue perforations away from the wound track, which are then stretched by the temporary cavity. The weakened tissue splits in many places and pieces of muscle become detached. This creates a larger permanent cavity. At velocities over 900 m s^{1}, in conjunction with the temporary cavity, secondary missiles cause explosive type wounds, even if bone is not struck.

A large, heavy, slow moving missile will have similar effects to a high velocity round, excepting that the permanent cavity is due to the missile's surface area and weight, not its velocity.

WOUNDING EFFECTS OF MILITARY PROJECTILES

To establish the effects of missiles, the then Colonel Fackler at the United States Army Letterman Army Institute of Research, established the Military Trauma Research Division in 1981. He developed the Wound Profile. This is a method that allows tissue disruption by missiles in soft tissue to be presented graphically. This part of the paper has been written using notes and wound profiles provided by Dr Fackler when he was in the US Army,

Dr Fackler's work has removed many of the misconceptions of wound ballistics. The wound profile enables the physician and researcher to establish why missiles behave differently at different depths of penetration, without bias. The following wound profiles describe the military projectiles most likely to be encountered. They describe the effects of projectiles fired three metres from a gelatine block.

The 7.62 mm NATO projectile, as used by the Australian Defence Force, and the Russian 7.62 M43 projectile as used in the SKS and AK 47 family of assault rifles have similar wound profiles. The NATO bullet yaws and causes a large temporary cavity and a medium sized permanent cavity, and ends up travelling backwards. The Russian 7.62 machine gun and sniper projectile is similar, yawing twice with a small permanent cavity initially, and a larger one after it.

Both projectiles only tumble deep inside the body if soft tissue is involved, and thus cause uncomplicated wounds in most cases of soft tissue injury. In many instances, the Russian projectile only causes wounds that resemble much lower velocity hand gun wounds. Both the NATO and Russian projectiles have thick jackets and have a forward centre of gravity which gives them stability in soft tissue.

Comparing the Russian M193 and NATO 5.56 mm projectiles, the M193 yaws at 90 degrees early in its travel, flattens at the tip, and breaks at the cannelure. The rear of the projectile breaks into multiple fragments. The NATO 5.56 projectile's tip does not deform, but separates from the rear lead core. This creates two deep wound channels and multiple fragments. Both bullets will break up on contact with soft tissue at up to 200 metres.

The 12-gauge solid slug and 12-gauge number 4 buckshot produce the most devastating close range small arms wounds. In each case the permanent cavity through soft tissue is 6 cm square in cross sectional area. The tissue destruction produced by buckshot is massive when compared to other small arms projectiles, despite its low velocity, and is a good example of multiple projectile paths in a small area.

CONCLUSION

Much can be learnt of the likely nature and extent of individual wounds by studying experimentally the effects of various types of projectiles impacting upon synthetic tissue substances. Detailed graphic analysis of these effects can assist in predicting the threat to troops in an operational environment.

MISSILE INJURIES

Historical Developments in Casualty Evacuation and Triage[1]

R. Pearce

EARLY TREATMENT

With the vastly different technology, and almost primitive surgical skills, available to military commanders at the beginning of the nineteenth century, their attitude towards the wounded would appear to be callous. Apart from the commanders themselves, and perhaps some officers of nobility who might depend upon aides or personal servants to recover them from the battlefield,[1] there was rarely any plan for critical care or evacuation of the injured soldier, of which there were commonly vast numbers. Henri II of France developed the concept for a mobile hospital in 1550, but one can readily understand that the contingencies of war during the campaigns of Napoleon Buonaparte would not allow for delays and interruptions necessitated by the care of the wounded. Yet it is precisely during this period in Europe, when Buonaparte was intent upon expanding his empire through military conquest that the most notable efforts were made to institute a system of casualty evacuation.

Napoleon's early campaigns left thousands of dead and dying on the fields of battle, some crying out after the army had moved on for a merciful death. Knowing the practice of local villagers, who plundered anything of value from the casualties left behind, they preferred to seek a swift and humane outcome. Those fortunate enough to find their way to a local shelter or barn might receive medical attention. When it was known that a surgeon like Dominique Jean Larrey was on hand, the casualties could be brought to him with some hope or expectation of treatment within sight and sound of the war.[2] Dominique Jean Larrey, who served with Napoleon in every one of his campaigns, became not only a skilled surgeon through his military experience but was essentially humane. He was prepared to take surgery to the battlefield, where he ignored the obvious risks to himself. Larrey then devised his flying ambulances, horse drawn carts to carry the wounded from danger to a collective area for treatment. His efforts to evacuate the wounded and his tireless endeavours to relieve their suffering earned him the respect of officers and men on both sides. But, more important, was the value he placed on the lives of individuals by his concern for their welfare, regardless of rank. It would be reasonable to state that Larrey set a standard of care that was difficult for most other military surgeons to emulate, yet he simply demonstrated the need for early evacuation and treatment if lives were to be saved.

In casualty evacuation, Larrey demonstrated his ingenuity and resourcefulness. After the battle of Bautzen, he wrote " .... it is important for the head surgeon to study well the countries that the armies cross, in order that he might know to benefit the injured using resources that localities might offer."[3] Larrey evacuated 150 wounded from Bautzen to Dresden using wheelbarrows in a single file, utilising local resources. He described medical evacuation as "the salvation of the injured and the conservation of the morale of the soldier."

Once the spectre of Napoleon had disappeared from Europe, there was a period of relative peace and adjustment during which the medical profession addressed their short-comings while the military became progressively more dormant. In the years between Waterloo and the Crimea, a large number of books appeared dealing with gunshot wounds and war surgery (Larrey, 1812-1817; Guthrie, 1815; Dupuytren, 1834; Stromeyer, 1855), particularly in Edinburgh, where the first Chair in Military Surgery was established in 1806 and young surgeons were trained in the management of trauma.[4]

In 1815, two experienced Scottish surgeons were amongst those who visited Waterloo: John Thomson, the first Regius Professor of Military Surgery at Edinburgh University, and Charles Bell, whose illustrations of some of the wounded depict better than words the injuries sustained in this battle.[5] As usual, inexperienced military surgeons quickly learned how to deal with major trauma. Although their system of triage was possibly as primitive as selectively treating only those who might have a chance of survival, such decisions were not always simple. Limb

1. Pearce R. Historical developments in casualty evacuation and triage. Aust Mil Med 2005; 14(2): X-XX.

injuries from cannon or musket ball were readily assessed and subsequently were commonly treated by amputation. Their success or survival rate varied from five to sixty-five percent and depended largely on the experience of the surgeon. Head injuries and body cavity injuries from saber, lance or shot were generally considered to be potentially fatal, although there are reports of some miraculous recoveries which no doubt benefitted from being untreated by the surgeons. While we have no statistics on the wounds sustained by those killed in battle, the fate of the injured who could receive treatment was determined significantly by the delay in receiving attention, a delay which could extend to several hours or even days.

It soon became obvious, even to Wellington, that his army had no-one to match the daring or courage of Napoleon's surgeon, Dominique Larrey.[6] Larrey taught and practiced a form of triage or casualty selection. He was a prolific writer, and in his extensive "Memoires de chirurgie militaire, et compagnes", published between 1812 and 1817, he records "…it is necessary to always begin with the most dangerously injured, without regard to rank or distinction." In practice, of course he could not afford to waste time on the critically wounded where there was no chance of survival. It must also have been obvious and frustrating to Larrey, and to all military surgeons of his time, to realise that selection of casualties for treatment was dictated by their own very limited surgical knowledge and expertise.

TRIAGE

The first military surgeon credited with using a formally graded system of triage under battle conditions was the famous Russian surgeon, Nikolay Ivanovich Pirogov (1810-1881).[7] Pirogov, who referred to battle casualties as an 'epidemic of trauma', arrived at the Crimea in November 1854, after the battles of Alma and Inkerman, where the sick and wounded numbered in the thousands and established medical facilities were inundated. He came with the blessing of the Grand Duchess, Helena Pavlovna, whose personal concern for the care and welfare of Russian wounded had prompted her to found many charitable institutions including the Sisters of Mercy of the Community of the Cross. This latter organisation is recognised as one of the first professional nursing organisations in the world.

For the first time in the history of military and field surgery, all nursing sisters and doctors were allocated to functional groups. On Pirogov's orders, the first group was in charge of sorting out the wounded, according to the type and severity of disease or injury, and of keeping a register of their belongings. Thus, the Pirogov plan of triage was put into practice at the first aid stations in Sebastopol, where wounded were assessed in four categories.

The hopelessly sick and mortally wounded were entrusted to the care of the Sisters of Mercy and priests. The seriously wounded, who required urgent surgery, received it at the emergency dressing station in the hospital referred to as the 'Building of the Assembly of Nobles'. With three teams operating, it was possible to perform ten major amputations in an hour and up to one hundred major surgical procedures each day.

The third group was those less seriously wounded who could be transferred for surgery the following day. Finally, those troops who sustained minor injuries were given immediate treatment and returned to their regiments. This enlightened plan was necessary to deal with the large number of casualties and with limited resources. But it is obvious that the Sisters of Mercy played an impressive role in making the system work. Eventual evacuation of amputees and other casualties from the battle zone was by horse and cart over rather rough terrain and significantly long distances.

One positive outcome from this period followed a publication of Jean Henri Dunant (1828-1910), who was present at the battle of Solferino (Un souvenir de Solferino, 1862).[8] His account of the sufferings of the wounded in that battle led to the Geneva Convention of 1864 and the foundation of Red Cross, both of which would subsequently endeavour to ensure the humane care and safety of prisoners and wounded.

It is unlikely that Pirogov would have used the term 'triage' to describe his method of sorting casualties. In the eighteenth century, the word 'triage' (derived from the Fr verb trier, meaning 'to sort, to select') was applied by traders to the sorting of wool clips, and in the 1820's the term was applied to the sorting of coffee beans. Today, "triage" is used to indicate the application of priorities to injuries/ casualties for the sake of management where medical resources may be limited.

Historically, by far the greatest experience in the treatment of mass casualties belonged to the military where experience and organisation were intended to anticipate the trauma and sickness that befell an army at war. Civilian management of mass casualties from natural disasters has evolved in relatively recent times and draws extensively on that military preparation. But there is evidence that earlier consideration was given to some form of selection in hospital practice.

During the eighteenth century and the first half of the nineteenth century in Britain, where charitable care was made available to large sections of the community who were unable to pay for medical treatment, facilities in most centres were inadequate for the numbers seeking help. At the London Foundling Hospital at Great Ormond Street, for example, a ballot system was introduced which randomly selected those children who could be seen or examined in a session.[9] In fact, Thomas Coram, the hospital's founder, disapproved of the ballot system as in his opinion it did not contain "...any test by which the merits of each case could be ascertained." Coram obviously would have preferred a system of priority based upon some initial assessment and classification according to degree of urgency, but his pleas were in vain.

The British Army at the Crimea (1854-1856), for all its mismanagement, recorded some important firsts during this campaign. Florence Nightingale, with a small band of women under her tutelage, provided essential nursing care to the sick and wounded at Scutari. Journalists and photographers were allowed to observe and record details of the war first hand, and casualties were further evacuated from the scene by train and ship. However, the railroad was a method of casualty evacuation used more extensively in South Africa (1899-1902), where distances were great,[10] and during World War One in France.

THE AMERICAN CIVIL WAR

Meanwhile, the Civil War in America (1861-1865), which was essentially a war of secession between the North and the South, provided few innovations in casualty collection or management. The numbers of casualties were horrendous, in the region of two hundred thousand dead and over four hundred thousand sick and wounded. As with previous conflicts, the non-battle casualties far outnumbered the wounded, but they all required medical attention and the outcome in terms of mortality was often worse where some diseases were present in epidemic proportions.[11] It is fair to say, however, that the Crimean disease rate was halved in Union camps and hospitals where Sanitary Commissioners constantly demanded better hygiene, better food, more comfort and medical care for the men.[12]

Records show that surgical field stations dealt with limb injuries by amputation, commonly without anaesthetic due to the shortage of supply, while injuries to the head and body cavities were rapidly assessed and considered inoperable. Acute medical cases were managed in field hospitals or transferred with serious or convalescent battle casualties to the nearest town facility. One advantage the Union Army had over the Confederate forces was ready access to established roads and railroads for resupply and for evacuation of casualties. But here again, the shortage of facilities and trained surgeons was compounded by the delayed collection and evacuation of casualties from the battlefield. An Ambulance Corps consisting of horse-drawn wagons was established, but surgeons often elected to operate at field stations close to the field of battle, unwittingly placing themselves and their wounded at further risk. A comprehensive "Medical and Surgical History of the War of the Rebellion", written by George Alexander Otis,[13] appeared in three volumes between 1870 and 1881.

STRETCHER BEARERS

Throughout all of these conflicts, stretcher bearers played a major role in transporting wounded (Hannibal had provided litters to carry the wounded while crossing the Alps in 219 BC). In the British Army, stretcher bearers became part of the establishment of Regimental Aid Posts (RAP) and Casualty Clearing Stations. Bandsmen attached to a deployed Regiment also filled the dual role as stretcher bearers when required.

Lessons were learned from the British and Colonial forces involved in the South African War (1899-1902), more in terms of preparedness and the management of large numbers of non-battle casualties, but here the main lethal weapon was the rifle with small calibre bullets. The introduction of antiseptics and anaesthetics, together with the earlier treatment of casualties by field hospitals, considerably lessened the suffering of the wounded. Public awareness of progress in the war, or lack thereof, was influenced by the stories submitted by journalists such as Winston Churchill who reported the victories and the blunders of the British Generals. But not until after the disclosure of incriminating evidence, at two Royal Commissions after the war had ended, was there any significant effort made to reorganise the army medical service.[14] By the commencement of the First World War, this reform was in place.

THE GREAT WAR

During the Great War of 1914-1918, for the first time deaths from wounds now exceeded those from disease. Machine guns were more lethal while shell-fire produced more dreadful wounds and new methods of treatment were devised which included debridement and irrigation with hypochlorite antiseptics.

The new military organisation catered for improved medical and surgical facilities and casualty evacuation, particularly using the new motorised ambulances. But there was room for ingenuity too. The steep hills and gullies of Gallipoli proved ideal terrain for donkey transport of the wounded, as demonstrated to good effect by Simpson and others at ANZAC Cove in 1915. The desert sands covered by Chauvel's Desert Mounted Corps on its way to Damascus provided opportunities for evacuation by camel, and the flimsy aircraft of the day were not confined to aerial combat but were gradually utilised in suitable conditions for reconnaissance, aerial photography and evacuation of wounded.

Although World War One is considered by some to be the true birthplace of triage, the concept obviously developed over many generations from the experience of military surgeons faced with the prospect of dealing with mass casualties under less than ideal conditions. However, there is no doubt that military doctors in this war were better organised to take advantage of those developments in medicine and surgery that would benefit the troops significantly. The emergence of new specialties in radiology, pathology and various departments of surgery may have resulted from or been promoted by the necessity of war but they also assisted in the process of triage as medical staff could provide earlier and more accurate diagnosis and treatment of injuries. Since then, the processes of casualty evacuation and triage have continued to develop in association with advances in technology and the requirements of modern warfare.[15,16] It is evident, however, that to an increasing extent, the organisation of emergency services in peacetime and the management of civilian casualties from natural disasters becomes more closely parallel to that of military experience.

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Over a century of service: the .303 projectile and its wounding capabilities - a historical profile[1]

David Andrew[2]

'We shot them under rule .303'[1]

ABSTRACT

The .303 military round has been around for over 100 years and went from a round nose projectile full metal jacket, Mks I and II, to a soft point Mk II*, the so called dum-dum projectile. The hollow points, Mks III, IV and V, followed before going back to the round nose full metal jacket bullet Mk VI, and finishing with a spire point Mk VII.

The projectile was dogged with controversy; first, for being not lethal enough, then too lethal, then the non full metal jacket bullets were banned under the Le Hague Convention in 1899 but were still used until 1904, then the projectiles were considered too lethal again. The spire point projectile was dual cored making the centre of gravity at the rear of the bullet causing it to tumble when striking tissue.

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INTRODUCTION

The .303 round first saw active service in India in the late 1800's. Australian Forces first used it in the Boer War with the Lee Metford and last used it with the No.1 Mark III*HT (Aust) Sniper rifle[2], which was replaced in 1979 by a 7.62 NATO sniper rifle[3]. In its first twenty years, the ball round went through ten official changes and several unauthorised battlefield changes.

HISTORY

Powder Rounds

The .303 round first entered British service in 1889 as the Powder Mark I, which was loaded with black powder, a boxer primer (one using a single flash hole), and a full metal jacket bullet[4]. The round was used for only one year, as the jacket of the projectile tended to detach from the lead core, and in 1890 was replaced with the Powder Mark II that had a thicker jacket and improved design[4].

This round again only lasted one year as it also had a major design problem like the 577/450 Martini-Henry it replaced. Being loaded with black powder meant that, when fired, the smoke produced betrayed the shooters position and obscured his field of fire[4]. The replacement round for the Black Powder Mk II was loaded with smokeless powder and called the Cordite Mark I.[4] None of these rounds saw active service as they were soon replaced by the Mark II round[4].

Cordite Rounds

The Cordite Mark II round, which now had berdan priming (twin flash holes), started production in 1893 and was produced in Britain as well as Canada, India and New Zealand1. This round saw service in India and Africa. Australia started production of this round in 1900[5] and changed to the Mark VI round in 1904[5] or 1905[6].

Complaints were soon coming back from the colonies that the new service round lacked sufficient killing power. In Africa, there were complaints that in conflicts the Mark II bullet lacked the damaging power of the old Martini-Henry bullet[7]. During the Chitral Operations in India, captured Mullahs were executed in secret by firing squads using both the old Martini-Henry and the new .303 rifles to compare the injuries at post-mortem[8] as the troops were complaining about the lack of stopping power as well[9].

Dum-Dum Rounds

This problem was addressed in India with the introduction of the Mark II Special or Mark II*, made at the Dum Dum Arsenal[4]. The term dum-dum has become synonymous with any bullet not having a full metal jacket. It was actually a normal Mark II bullet with 1mm depth of jacket at the nose removed and

1 Andrew D. Over a century of service: The .303 projectile and its wounding capabilities - a historical profile. Aust Mil Med 2003: 12(3):105-9.

2 Sergeant David Andrew BN RN RAAOC (davidandtheresa@bigpond.com) is posted to 7CSSB at Enoggera and works for Queensland Health as a Registered Nurse.

giving a 4mm-diameter circle of lead core exposed[10]. This made it a soft point bullet, which was made in India and Britain.

Much was made of the increased effectiveness of the Mark II* projectile and it took on almost mythical proportions. The House of Commons requested a report on the effectiveness of the bullets used in India and this was presented on 8 July 1899[11]. It is the definitive work and lists the injuries of the Mark II & II* bullets on people shot by them from 1895 to 1898, as well as tests done on bullocks. A field modification of the projectile where 1/12 of an inch was filed off a Mark II round was also tested. The filing off of tips of Mark II bullets was commonly done in India[12] and in Sudan[4].

Other Rounds

The British War Office was busy responding to the problem by trialling six various hollow and soft point projectiles in 1896-1897 and decided on a new round, the Mark III[4]. The Cordite Mark III round was issued in October 1898 and withdrawn almost immediately due to problems in production of the projectile[13]. It is of note that no loaded rounds are known to still exist.

The Cordite Mark IV round was issued in February 18994 and also suffered from design problems, with the jacket sometimes staying in the bore of the rifle after firing[14]. This round was manufactured in Britain, Canada and New Zealand[6]. It was widely issued and was well reported on by troops in the Sudan[4, 12]. The Mark V round replaced it in October due again to the jacket separating in the rifle bore[4].

Major Mathias, RAMC, who inspected the battlefield after Omdurman, observed a young man, who had been struck twice by a Mark IV bullet,

He had a bullet wound of the left leg above the knee. The wound entrance was clean cut and very small. The projectile had struck the Femur, just above the internal condyle; the whole of the lower end of this bone, and upper end of the Tibia, were shattered to pieces, the knee joint being completely disorganised.

He had also been wounded in the right shoulder… The whole of the shoulder joint and scapular were shattered to pieces. In neither case was there any sign of a wound of exit[12].

The Mark II* and Mark IV rounds were considered by other world powers, predominantly Germany[15] and some Irish MPs in the House of Commons[8], to be inhumane and should be banned. In 1898, Professor von Bruns, of Tübingen in Germany, published a work titled, 'The Effects of Lead-Pointed Bullets (Dum-Dum Bullets)'[16]. His experiments were flawed as there were no control experiments, the word 'explosive' was used to describe the effect of the bullets when they contained no explosive, and the tests were not done using British Military Bullets but with modified German military bullets and soft point hunting projectiles16. It was believed the paper was written to promote his desire to have these projectiles excluded from civilised warfare by international agreement16.

Ogston, in Britain, did a series of experiments on cadavers with the Mark 2, 2* and IV, and Mauser Game bullets to compare their effects[17]. He admits that the experiments are difficult to do as it hard to hit the same part on different bodies and the peculiarities of the bullet must be taken into account. His results bring Von Brun's experimental results into question and one wonders on the political bias on both experiments. It was at this time that the Hague Convention was coming to an end.

The Peace Conference's or the Hague Convention's Final Act, as published in 'The Times' on 1 August 1899, was a document designed to maintain the general peace, unite the members of civilised nations and extend the reign of international justice[18], and is called the 'Hague Convention'. The Third Declaration prohibited contracting parties (including Britain), 'from making use of bullets which expand or flatten easily in the human body'[18].

In 1899, the Lancet published an article tilted 'Modern Military Bullets: A study of Their Destructive Effects', where cadavers and bars of soap, were again shot to compare current British and German military rifle bullets[19]. This was of significance as the Boer War started on 11 October 1899[20] and the Boers were supplied rifles by Germany[21].

The use of Mark IV & V ammunition in South Africa by the British Forces and soft point ammunition by the Boers is always one of conjecture. The British Government sent an order to the General Officer Commanding South Africa in July 1899, that only Mark II ammunition was to be issued on mobilisation[22]. This was reinforced after the outbreak of war that all hollow point ammunition was to be returned to England[22]. The Boers used a number of different military rifles as well as hunting rifles[21], and battlefield recovery has shown the use of both Mark IV by the British Forces and soft point ammunition by the Boer Forces[6,21].

The Cordite Mark V round, identical to the Mark IV round apart from the addition of 2% antimony to the lead core and an additional 1.3 mm in length, was issued in October 1899[4]. It was controversial from the start as it violated the Hague Convention. The round was soon withdrawn from service and replaced with the Mark II in the interim until the Mark VI came into service in 1904, with this round being almost a replica of the Mark II[4]. The Mark V was reissued, as a limited production, into service in Somaliland where the British forces were up against the forces of the 'Mad Mullah'[22]. It is interesting to note that the use of Mark 2*, III, IV & V ammunition was only acceptable against savages and not Europeans[9,12,22,23].

Later Rounds

The Mark VI was the standard round from January 1904 and was identical to the Mark II bullet except for a slightly thinner jacket. The Mark VI was only an interim measure until a more effective round could be made that was in accordance with the Hague Convention. This was the Mark VII round[4]. Australia produced the Mk VI round from 1904[5] until January 1918, when it changed to Mark VII ammunition[6]. Australian Forces at Gallipoli and the Middle East[6] used Mark VI ammunition, but not on the Western Front where the British Forces standard round for all forces was the Mark VII[24].

The Mark VII issued in November 1910 became the standard .303 round thereafter, although a Mark VIII round was issued from 1938 for use in Vickers Machine Guns[4]. The Mark VII round was of unusual design for the time as it had a dual core of aluminium in the nose and lead in the rear. It was also the first British military round to have a spitzer or pointed tip[4].

With a pointed bullet, the centre of gravity is at the rear of the projectile and, with a lighter nose, more so[12]. A slight deflection of the tip, such as entering the body and striking hard tissue, will cause the rear of the bullet to rotate on its transverse axis or tumble[25]. Experiments on recently killed sheep and horses in 1911 showed that bullet tumbled in 63% of the wounds[12]. A German surgeon seeing wounds inflicted by British rifle ammunition in 1914 remarked upon similar results[26]. It was also noted that the bullet broke up and the cores separated, causing an 'explosive action', and he suspected that the sometimes the tips were being broken off before firing by soldiers[26]. This could be achieved by breaking them off in a hole in the action and the author has been able to do this.

The cores were not always made of aluminium, as it was a strategic material and could be used to make aircraft instead of bullets, so other materials were chosen[4]. In WWI, the British used pressed cardboard[27] and in WWII pressed cardboard and plastic[5]. In WWII Australia used red plastic[27].

CONCLUSION

The .303 round went through many changes in its first 20 years of production. It went from black powder to smokeless powder, boxer to berdan priming and from full metal jacket projectiles with a lead core, to soft points, hollow points and then to a dual core round. Lethality was a big issue with these rounds, and was politically sensitive from 1895-1905.

The round was the mainstay of the British Empire through many conflicts, and on a television report of a supposed aircraft highjacking in India on 4 October 2001, there were police or military at the airport armed with .303 rifles. Not bad for a cartridge originally designed over 110 years ago.

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MUNITIONS

Thermobaric Munitions and their Medical Effects[1]

David Andrew[2]

ABSTRACT
Thermobaric munitions are those munitions that, by design, produce more heat and overpressure than conventional explosives by exploding a vapour in the blast zone. Their main use initially was in airborne fuel-air explosive bombs. Whilst the United States has concentrated on airborne weapons, Russia has produced thermobaric weapons and warheads, from airborne bombs to rifle grenades.

Their medical effect is principally primary blast and they affect organs where there is a tissue interface of varying densities, such as the lungs, bowel and inner ear. Damage manifests itself in the severity and onset of occurrence, depending on distance from the blast and orientation of the victim, and can be diagnosed by simple investigative techniques.

This paper was originally written as a presentation for the Australian Military Medical Association Annual Conference in October 2001 and was displayed as a poster at the Defence Health Symposium in 2002.

INTRODUCTION
Thermobaric munitions are those weapons that are designed to produce enhanced temperature and pressure compared to conventional explosives and are often referred to as fuel-air explosives (FAEs). They produce a much greater incidence of primary blast injury than conventional explosives and this is their main mechanism of injury.

This first part of this paper will discuss the history, design, and weapons employed to deliver thermobaric munitions. The second will discuss the medical effects and treatment, concentrating on the sequelae of primary blast injury.

HISTORY
Thermobaric munitions can be traced back to the German Army of World War II who used a six barrelled 15cm Nebelwerfer rocket launcher on the Eastern Front. One of the launcher's loadings incorporated propane gas. The first five rounds carried the gas and the sixth was the detonating round. This gas was released when the round landed, mixed with the air to produce an explosive vapour, and was then detonated by the final round[1]. At a later stage, larger calibre rockets contained conventional explosive inside a thin wall to give an increased blast effect. Following these early attempts, little was developed until the 1960's.

The United States started using FAEs during the Vietnam War[2] and had various loadings of aircraft bombs. The Soviet Union started using thermobaric weapons during their war in Afghanistan and the Russia has used them more recently in Chechnya. Russia has loadings in aircraft bombs and rockets, and ground launched rockets down to a man portable size[3].

DESIGN
Thermobaric munitions work by initially dispersing an aerosol cloud of gas, liquid or finely powdered explosive. Known fuels such as ethylene oxide, propylene oxide[1], ammonium nitrate[2], and powdered PETN4 have been reported. This cloud flows around objects and into cavities and structures. It may penetrate small openings, such as openings in buildings, bunkers and engine bays of armoured vehicles[1], before being ignited.

The result is a plasma cloud that reaches temperatures of between 2,500-3000° Celsius[4]. The time that the cloud burns is slow compared to conventional high explosive and aluminium powder is added to some explosives to enhance this[5]. It is this longer duration or dwell time of the blast wave or overpressure, which can be up to 73 kg/cm^2 (1000 lb/sq in), that is the main reason for its lethal and destructive effects[4]. The injuries are more severe in confined spaces as the blast wave reflects back and forth, submitting the target to multiple insults.

One should not forget the burning effects of the explosion either, as it consumes all oxygen in the area

1. Andrew D. Thermobaric munitions and their medical effects. Aust Mil Med 2003; 12(1):9-13.

2. Sergeant David Andrew BN MRNCA RN RAAOC, 5 Camellia Court Toowoomba QLD 4350, (davidandtheresa@bigpond.com) is posted to 7CSSB at Enoggera and works for Queensland Health as a Registered Nurse.

and the resultant vacuum pulls loose objects into this void4. If the explosive does not detonate, the affected area can be highly toxic, as one of the common fuels used is ethylene oxide. Ethylene oxide is a gas used as a sterilising agent in the health industry and is extremely toxic if inhaled[6]. This may lead to accusations of the use of chemical warfare if this situation were to occur.

WEAPONS

The employment of thermobaric munitions starts at the soldiers' level with Russia using RPO-A Shmel disposable rocket launchers and thermobaric rockets for the RPG-7 family of weapons. The effectiveness of the Shmel round has been compared to the 122mm artillery round, especially against buildings[7]. There is also a 42mm hand held magazine grenade launcher[8].

Next in line are the anti tank rocket launchers that are either wire or radio guided and include the Shturm, Ataka, Fagot and Kornet systems. The Shturm and Ataka can also be helicopter launched[3].

The USSR has been fond of multiple ground-launched rocket systems since Stalin and this tradition has continued since. There are Uragan and Buratino 220mm launcher systems and the 300mm Smerch rocket systems[3].

Airborne weapons include the 80mm S-8D and the 122mm S-13D unguided rockets, 500 kg ODAB-500PM bomb, the KAB-500kr-OD television guided bomb and the ODS-OD BLU dispenser with BKF ODS-OD-cluster bomblets[3].

The United States has the CBU-55 cluster bomb[2], the BLU 96 guided glide bomb1 and, the granddaddy of them all, the BLU 82[9]. The BLU 82 is a high blast bomb launched on a pallet from the back of an USAF MC-130H Combat Talon (Hercules) Aircraft and it was first used in the Vietnam War2. It contains 5715 kg of a jellied slurry explosive called GSX, a mixture of ammonium nitrate, aluminium powder and polystyrene soap, and produces an overpressure of 1000 lb/sq in. It is reported to be able to clear a 3 mile path through a minefield[9]. It is often launched in pairs giving these weapons the title of the 'Blues Brothers'[10].

In the war against terror in Afghanistan, the United States used a new generation of thermobaric bombs, the BLU-118/B11. It is the BLU-109 2000lb penetrating warhead with a thermobaric filling of 560lb, and can be fitted with a laser guidance or glide bomb kit[12]. A warhead for the Hellfire missile has also been developed[13].

PRIMARY BLAST INJURY MEDICAL EFFECTS

Primary blast injuries are those caused by a blast pressure wave or blast wave[14, 15, 16,] which emanates from the epicentre of the explosion at a pressure of thousands of pounds per square inch[14]. Normal atmospheric pressure in comparison is 14.7 pounds per square inch[17]. Gailbraith[18], describes this phenomenon as a combination of shock wave[15], and dynamic overpressure, and damage is dependent on the pressure and length of its duration[16].
This causes disruption of air spaces in the body and shear forces where there is an air /tissue interface or where tissues of different densities connect[16,19].
It predominantly affects the pulmonary, cardiovascular, auditory, gastrointestinal, and central nervous systems.

General treatment is based on airway, breathing and circulation assessment, in conjunction with oxygen therapy. Prophylactic antibiotics[16] and tetanus vaccine[14] should be considered. Follow up should be done at a medical facility.

PULMONARY SYSTEM

Mellor et al.[16] describe the mechanism of injury, when the blast wave hits, as dependant on the bodies alignment to wave and when it passes through tissue interfaces. This sets up a stress wave that causes damage, particularly at the lobes, along the ribs on the side of the blast, mediastinum and alveoli, and, if low velocity, may rupture the more rigid bronchioles. The alveoli, if ruptured, leak fluid into the lungs, which could lead to complete filling or 'shock lung' or 'blast lung'[18]. Other complications of alveolar rupture are arterial gas embolisms[14,19,] pneumothorax and/or haemothorax[14]. Mellor et al[16] note that respiratory distress related to a non-fatal injury may not present for several hours, with Armstrong[14] suggesting 48 hours.

Treatment first requires assessment by continuous auscultation, to detect abnormalities, as well as continual assessment of rate and depth of respiration and pulse oximetery to assess pulmonary function[14]. Mellor et al.[16] add serial blood gases and erect chest radiographs, and oxygen therapy and chest drain if a pneumothorax or haemothorax is present.

CARDIOVASCULAR SYSTEM

The cardiovascular system may be affected by an air embolus in the heart or coronary arteries[16, 18], or by diffuse damage to the myocardium[16]. Sharpnack et al. describe a post mortem sheep's heart with extensive epi and sub-epicardiac haemorrhage after exposure of a live sheep to blast overpressure.

Symptomatic treatment is required and detection is the key. Auscultation for bruits, indicating vascular leakage, and for faint heart tones, indicating cardiac tamponade, and monitoring ECG changes, that might indicate heart damage, is required[14].

AUDITORY SYSTEM

Gailbraith[18] describes auditory damage in stages. In mild damage, the tympanic membrane is ruptured[15, 19], with mild hearing loss. In more severe cases, the membrane could disintegrate and the ossicles dislocate, requiring surgical intervention. In the worst cases, the inner ear is damaged producing 'sensori-neural' deafness and disabling pain, nausea and balance problems. Mellor et al.[16] concur and add that dislocation of the ossicles may occur without tympanic rupture, the organ of corti is most at risk and labyrinthine rupture will lead to dizziness and vertigo. Investigating a patient's ears will detect damage[14, 18]. In mild cases, the ears should heal naturally but, in more severe cases, surgery is required[18].

GASTROINTESTINAL SYSTEM.

Mellor et al.[16], feel gastro-intestinal damage is probably more common than is diagnosed and occurs when stress waves cross pockets of gas trapped in the bowel. Bruising occurs in mild cases[15] but, in severe cases, perforation may occur, particularly at the ileocaecal junction[16]. Monitoring for peritonitis, due to leaking bowel contents[18], and haemorrhaging is required[14]. This can occur up to 14 days after the injury[18]. Treatment for the perforations and haemorrhage is surgery[18], and close monitoring is required to detect these injuries and their complications[14].

CENTRAL NERVOUS SYSTEM

The main injury to the central nervous system from primary blast is a cerebral arterial gas embolism and this may cause an unexplained deterioration in function or death[18]. Sharpnack et al[20] describe a post mortem sheep's brain exposed to blast overpressure showing air emboli within the basilar artery and posterior portion of the arterial circle of the brain.

Hyperbaric oxygen therapy is the main treatment and 100 percent oxygen if this is not available[21]. Detection is by closely monitoring the patient's level of consciousness and peripheral nerve function[14]. In these cases, air may be seen in the retinal vessels[16].

CONCLUSION

Thermobaric weapons have been around for over sixty years and their main damaging effect is through primary blast injury. The mechanism and treatments for primary blast injury have been described, and it can be seen that a patient may have more than one system involved[18].

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The medical effects of non-lethal weapons - a review[1]

A.G. Robertson[2]

ABSTRACT

Non-lethal weapons have seen increasing use in the police forces and, more recently, the military forces of various countries around the world. With increased use in military operations in areas such as Panama and Somalia, there is an increasing likelihood of military health service officers coming in contact with the medical effects of these weapon systems.

This review summarises the physiological and psychological effects of these weapons, weapons which will be of increasing interest in the future.

INTRODUCTION

Non-lethal weapons have seen increasing use in the police forces and, more recently, the military forces of various countries around the world. Defined as those weapons which `have a reversible effect on their human targets', the term non-lethal weapons is a misnomer as there will always be an element of risk associated with the use of any weapon system.[1] Historically, these weapons have been classified by their effects, principally whether they disable, disorient, discourage, demobilise or deceive.[1] The medical effects of these weapons do not easily fall into this taxonomy. Any discussion of these effects needs to be based on the target organ system or the specific psychological effect. Some non-lethal technologies aimed at weapon or communication systems may have peripheral effects on personnel. These may include burns from high powered microwaves or supercaustics, or falls on areas coated with very low friction substances. These collateral effects are not included in this review.

The medical effects of non-lethal weapons may be broadly categorised into:

- blunt trauma effects
- eye effects
- auditory effects
- electrophysiological effects
- toxicological/pharmaceutical effects
- psychological effects.

BLUNT TRAUMA EFFECTS

Non lethal riot control ammunition uses rubber, timber or plastic projectiles to deliver a numbing blow and temporarily incapacitate the target. There are two main groups: unconventional ammunition fired from conventional weapons (eg stun bags) and large slow projectiles fired from riot guns and grenade launchers.[1] These projectiles aim to produce the maximum release of blunt trauma to the body without killing. This shock consists of impact shock and neurogenic shock. Impact shock is the mechanical effect of the blow and is caused by the elastic impact of the projectile. It produces localised bruising and, depending on the range, may cause fractures and ruptures of internal organs. Neurogenic shock is due to a temporary partial or complete blockage of the nervous system from high frequency shock waves spreading from the point of contact.[1]

Plastic bullets cause fewer serious injuries to face and chest, although the laryngeal framework is particularly susceptible to injury because of its relatively unprotected position.[2] Plastic bullets, however, produce more serious injuries to skull and brain, and therefore cause more deaths than rubber bullets.[2] Wooden 'Broomstick' rounds may produce internal injury or death at close range and may leave splinters in the target at greater ranges.[3]

Stun bag ammunition may cause serious skull injury, liver damage or death[3] at less than 5 metres, produces contusions and broken bones at 5 - 10 metres and is ineffective over 20 metres. Large slow projectiles have a similar effect to stun bags at close range but only distract at long range.[1]

Other non-lethal weapons systems utilise water, lasers or sound to produce blunt trauma effects. High pressure water sprays, used to knock down targets, may produce blunt trauma.[4]

Pulsed chemical lasers may be used to produce plasma in front of a target. This will create a blast wave and subsequent blunt trauma to the target with a stun effect.[5,6] Acoustic bullets use a high frequency non-

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2. CMDR Andy Robertson was the Senior Medical Officer at Fleet Base West in 1997.

penetrating sound wave to produce a plasma in front of the target, which creates an impact wave that produces incapacitation by blunt object trauma to the target.[5, 7]

EYE EFFECTS

An anti-eye laser weapon has two main applications: temporary visual disablement, such as flashblinding at night, dazzle or veiling glare, or more permanent eye damage (partial or total blindness).[8, 9] Low-energy lasers can be used to dazzle and temporarily blind targets.[1, 10] More powerful lasers can be used to permanently blind human targets.[11] The eye magnifies any laser light hitting the eye by a factor of approximately 100,000. Given that only a low level of energy density is required at the retina to cause severe damage, lasers may produce extensive retinal damage and blindness. If the macula is affected, the target will become functionally blind. Even laser eye hits from oblique angles may produce retinal bleeding into the eyeball and subsequent blindness.[8]

Pyrotechnic Flash devices are devices are formulated to produce intense flashes of temporarily blinding light of 1 to 6 million candela. As 10 million candela is required for temporary blindness, the current devices will only temporarily dazzle targets.[1] There are, however, more powerful devices. These are the optical munitions. There are two types of optical munition. The Omni-directional Radiator or Isotropic Radiator produces a very bright multidirectional broadband burst of visible light. The directional radiator produces a similar intensity uni-directional light.[5] These systems may produce the dazzle, temporary blindness,[8] or, rarely, permanent blindness,[1,12] seen with laser weapons.

Strobing lights, particularly in the red and blue wavelengths, can effect the target's brain alpha patterns. This can create disorientation, vertigo and nausea (Bucha Effect).[1,12] Epileptic seizures may be induced in susceptible personnel.[12] Bright lights can also be used, in conjunction with noise, to prevent rest.[1] They may also be used to disorient a crowd at night by temporarily immobilising their night vision.[3]

AUDITORY EFFECTS

Stun grenades produce temporary hearing loss, aural pain and stunning effect by single or multiple blasts of loud noise. These devices generate noise in the range 140 -170 decibels. Confined spaces, however, may amplify the noise and may produce ruptured ear drums and other inner ear damage at levels above 180 decibels.[1]

High intensity ultra-low frequency sound may disable by producing body organ resonance. The infrasound may be manipulated to produce distress and anxiety,[6] or to produce temporary incapacitation from disorientation, vertigo, nausea, vomiting, bowel spasms or diarrhoea.[10, 13] At frequencies between 50 to 100 Hertz and intensity up to 153 dB, nausea, subcostal discomfort, cutaneous flushing and tingling may be produced. At 60 and 73 Hz, coughing, severe substernal pain, choking, salivation, and pain on swallowing can be produced.[1] At very high intensity with prolonged duration, death may result.[14] The effects cease on turning off the generator.[15] Other effects can also be produced by manipulating sound. Given sufficient intensity, ultrasound may be used to rupture internal organs.[16]

ELECTROPHYSIOLOGICAL EFFECTS

Electrical Stun Guns are weapons which fire electrodes into a target to stun but not kill. The electrodes discharge up to 50 kV at low amperage. This electrical discharge overloads and temporarily disables the peripheral nervous system. A single shock will disable a limb briefly, a one second burst will drop a person to the ground and a 5 second burst will disable a person for up to 15 minutes.[1] These weapons may have effects on cardiac rhythm and respiratory function.[17] In addition, they produce a round erythematous rash, with or without central paleness, which may be accompanied by circumferential abrasions.[18]

TOXICOLOGICAL/PHARMACEUTICAL EFFECTS

These effects include those produced by tranquillisers, soporifics, lachrymators, sternutators and incapacitants. Dart guns, injecting up to 3 ml of tranquilliser, have been developed. The effect is not instantaneous and depends on the route of administration with intramuscular routes being faster than subcutaneous routes.[1] Other routes for administering tranquillisers are less successful. Opiates and strong sedatives are too dangerous on account of their low margin of safety and milder tranquillisers cause little actual loss of performance capability.[19]

Soporifics are sleep inducing or sedative drugs which, when mixed with a solvent like dimethyl sulphoxide (DMSO), are rapidly absorbed through skin or lungs.[1,12] These may be variations of currently available compounds, like Lysergic Acid Amide (a milder form of LSD), or tailored synthetic neuroactive peptides,[19, 20] like Delta Sleep-inducing Peptide analogues.[21]

Lachrymators are irritants characterised by a very low toxicity (chronic or acute) and a short duration of action.[22] Little or no latent period occurs after exposure. Orthochlorobenzylidene malononitrile (CS) is the most commonly used irritant for riot control purposes. Chloracetophenone (CN) is also used in some countries for this purpose in spite of its higher toxicity. A newer agent is dibenzoxazepine (CR) with which there is little experience.

CS is used as a riot control agent in many countries. The limit of perception by taste ranges from 0.25-0.5 $mg.m^3$. The minimal irritant concentration ranges from 0.1-1.0 $mg.m^3$, the ICt 50 from 5-10 $mg.m^3$ and the LCt 50 for man very much larger, estimated as 60,000 $mg.min.m^3$. This provides a high margin of safety in its use. The CS cloud is white at the point of release and for several seconds after release. Exposure is associated with a pepper-like odour, the presence of intense eye effects, dyspnoea, coughing and rhinorrhoea. During exposure an individual is incapable of effective concerted action.

CR is similar in its effects to CS, but the minimum effective concentration is lower and the LCt50 is higher. CN has a minimal irritant concentration is 0.3 $mg.m^3$. It has been estimated from experimental data that the LCt 50 for man is 7000 to 14000 $mg.min.m^3$, but inhalation of 350 $mg.m^3$ for 5 minutes may be dangerous. The ICt 50 is 20 to 40 $mg.min.m^3$. CN is more toxic than CS. Exposure to CN primarily affects the eyes, producing a burning sensation, lacrimation, inflammation and oedema of the eyelids, blepharospasm, photophobia and, at high concentrations, temporary blindness.[23] The severest of these symptoms is reached in a few minutes and then gradually decreases. After about one or two hours all symptoms disappear. High concentrations can cause irritation of the upper respiratory tract, inflammation of the skin with vesicle formation, visual impairment and pulmonary oedema. Drops or splashes in the eye may cause corrosive burns, corneal opacity and even permanent visual impairment. Drops or splashes on the skin may cause papulovesicular dermatitis and superficial skin burns. Ingestion of food or water contaminated with CN causes nausea, vomiting and diarrhoea.

Sternutators[22] produce strong pepper-like irritation in the upper respiratory tract with irritation of the eyes and lacrimation. They cause violent uncontrollable sneezing, cough, nausea, vomiting and a general feeling of bodily discomfort. The principal agents in this group are diphenylchlorarsine (DA), diphenylaminearsine chloride (Adamsite (DM)) and diphenylcyanarsine (DC). They are dispersed as aerosols and produce their effects by inhalation or by direct action on the eyes. The onset of symptoms may be delayed for several minutes after initial exposure (especially with DM); effective exposure may, therefore, occur before the presence of the smoke is suspected. Inhalation is followed by a burning sensation in the nose and throat, hypersalivation, rhinorrhea, coughing, sneezing, nausea and vomiting. Mental depression may occur during the progression of symptoms. The paranasal sinuses are irritated and fill with secretions and severe frontal headache results. Prolonged exposure may cause retrosternal pain, dyspnoea and asthma like symptoms. Symptoms reach their climax after 5 to 10 minutes and disappear one to two hours after cessation of exposure. Effects on the eyes are slight and are restricted to a burning sensation and lacrimation. Exposure of the skin to high concentrations will cause erythema and itching, proceeding to a burning sensation and vesicle formation. Ingestion of food and water contaminated by sternutators may cause nausea, vomiting, diarrhoea (sometimes bloodstained) and weakness and dizziness have been reported.

High concentrations are not expected in the open owing to movement of air, but may be met within enclosed spaces (shelters, tents etc), and under these circumstances the skin may show vesicle formation, capillary damage and localised swelling, while corneal necrosis and pulmonary oedema are possible results. Unsteady gait and a positive Romberg sign have been reported. Other neurological results of severe exposure include hyperaesthesia, anaesthesia and paraesthesia, especially in the legs. Loss of consciousness has been reported.

Incapacitants[22] are chemical agents which produces a temporary disabling condition that persists for hours to days after exposure to the agent has occurred. There are two major categories: CNS depressants (anticholinergics) and CNS stimulants (LSD).

CNS depressants produce their effects by interfering with transmission of information across central synapses. An example of this type of agent is BZ (3-quinuclidinyl benzoate). Small doses of BZ cause sleepiness and diminished alertness. Diagnosis can be made by noting increased heart rate, dry skin and lips, drowsiness and a progressive intoxication in the untreated individual as follows:

- 1-4 hours
- Tachycardia, dizziness, ataxia, vomiting, dry mouth, blurred vision, confusion, sedation progressing to stupor.
- 4-12 hours
- Inability to respond to the environment effectively or to move about.
- 12-96 hours
- Increasing activity, random unpredictable behaviour with delusions and hallucination.

The principal CNS stimulant is LSD. The clinical manifestations of LSD (D-lysergic acid diethylamide) intoxication often include an early stage of nausea followed 45-60 minutes after dosage by a confused state in which delusions and hallucinations are common but not always experienced. Subjects intoxicated with LSD show evidence of sympathetic stimulation (rapid heart rate, sweating palms, pupillary enlargement, cold extremities) and mental excitation (nervousness, trembling or spasms, anxiety, euphoria and inability to relax or sleep). Hyperthermia has been reported. Subjectively, feelings of tension, heightened awareness, exhilaration, kaleidoscopic imagery, emotions of every type, hilarity and exultation are characteristic. Paranoid ideas and more profound states of terror and ecstasy may also occur, especially in highly suggestible individuals. True hallucinations are rare, as is homicidal or suicidal behaviour.

Foul smelling gases may be used to dispel crowds. Hydrogen Sulphide and NaS[8] have been proposed. Hydrogen sulphide, however, is a powerful asphyxiant in moderate doses. At lower doses, it may produce nausea, eye irritation, respiratory irritation and pulmonary oedema.[10, 19]

PSYCHOLOGICAL EFFECTS

The psychological effects of non-lethal weapons may vary depending on the physical context in which it is used, whether the target is a crowd or an individual, whether the target is trained or not trained to expect or counter the effects of such weapons or whether it is used in a crowd control, counter-terrorist or battlefield situation. Camouflage and psyops are not part of the non-lethal weapons area as they are conceptually and operationally different.[24]

The use of blinding lasers will have significant psychological impact once personnel realise that observing the terrain as well as looking towards the enemy may entail a significant risk of being blinded.[8] After an attack, medical companies can expect to handle many personnel who think they have been hit by lasers when they have not.[9] These psychological casualties may be reduced by appropriate training.

With regard to other non-lethal weapons agents, obscuration foams may induce panic from a perceived difficulty in breathing coupled with restriction in sight and hearing.[1] There is little documented on the psychological effects of other non-lethal weapons and further research is required in this area.

CONCLUSION

This paper has reviewed the physiological and psychological effects of non lethal weapons.
The definition and classification of non-lethal weapons remains unclear. Many authors use the term Non Lethal Weapons, and other similar terms, to include weapons that affect both weapon, and command and control systems, where there is little or no human element involved. The taxonomy used for military effects does not fit easily with physiological effects and further clarification of both the definition of non-lethal weapons and its categories is required.
The health effects vary in severity from the temporary disabling effects of lachrymators, infrasound and stun grenades to the potentially permanently disabling effects of blinding lasers and non-lethal projectiles.
In most areas, the information on physiological and psychological effects is limited and further research is required to delineate both short term and long term effects of these weapon modalities.

The Wall Street Journal notes that the 'move into nonlethality could pry open a Pandora's box of chemical, biological, and nuclear weaponry that diplomats have spent much of the 20th century trying to keep closed.'[16] The majority of the chemicals cited are in contravention of the Chemical Weapons Convention and several of the other technologies would probably contravene the Inhumane Weapons Convention because of their indiscriminate effects. Further research is required to identify the legality of these weapon systems in the Australian context.

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LESS THAN LETHAL WEAPONS

Less Lethal Projectiles - An Investigation[1]

David Andrew[2]

"Load up, load up, load up, the rubber bullets"[1]

INTRODUCTION

The Australian Defence Force is becoming more involved in military non-combatant control and peacekeeping in areas such as Timor and Bougainville, boarding parties, and the handling of illegal immigrants. This is compounded by Defence Aid to the Civil Power requirements, in events such as boarding parties, the Olympics, and the Commonwealth Heads of Government Meeting. The issue of non-combatant control becomes critical where the use of lethal force would be illegal.

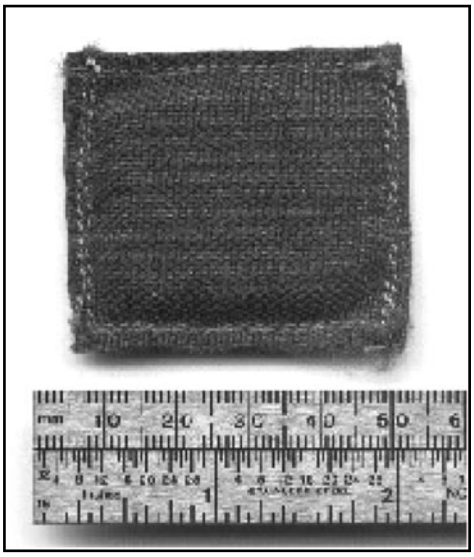
Less lethal projectiles could fill this niche and can be used with current weapon such as the Steyr F88 rifle, the M79/203 grenade launcher and the Remington12-gauge shotgun. Less lethal projectiles are those designed to incapacitate a target without inflicting lethal injuries[2], but will do so if used incorrectly[3]. This paper will discuss their design, use and effects, concentrating on rubber and plastic bullets and beanbags.

FLEXIBLE PROJECTILES - BEAN BAGS

Less Lethal projectiles can be categorised into two groups[2]: flexible and non-flexible. The flexible projectile is one that is not of solid formed construction and the one most widely used is the 'Bean Bag' design, which is a tightly woven bag loaded with fine lead shot[4]. It can be fired out of 12-gauge shotguns, 37mm gas guns[2] and 40mm grenade launchers[5]. It is folded into a wad and then inserted into a shell. The bean bag shown in Figure 1 is made by MK Ballistic Systems and weighs 40.4 grams.

In data obtained from 106 United States law enforcement agencies up until 30 May 2001, these projectiles had caused four deaths from 623 firings when used against citizens. The victims were hit in chest (three) and neck (one). Two of the chest impact deaths resulted from penetration into the thoracic cavity and the other still has a coroner's report pending[6]. The majority of non-lethal injuries are bruises and abrasions to the abdomen, chest and back. Impacts to the head tended to cause lacerations and fractures over 50% of the time.[6]

Figure 1: Bean Bag.



Current training in the Los Angeles Police Department is to have the point of impact within a six inch radius of the navel and on a frontal aspect[7], but movement of the target, obscured vision and the extreme situation involved does not always allow this to happen[4]. Personnel are taught to shoot at the centre of mass with lethal weapons so under stress this aim point may be taken[7]. This may lead to an unwanted penetration of the thoracic cavity or head.

In a series of tests in Canada, Dahlstrom, Powley and Penke[8] fired Deftech 23BR 12 gauge bean bags at three different targets 21 feet (6.5 metres) away to try to understand a previous fatality with the ammunition. Five rounds were fired into a block of ballistic gelatin, three rounds into a block of gelatin with pig's ribs embedded 1-2 inches from the entrance surface, and three rounds into a block of gelatin with the fresh draped belly skin of a pig over the entrance surface. They also studied the bean bag's orientation

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2. Sergeant David Andrew BN RN RAAOC (davidandtheresa@bigpond.com) is posted to 7CSSB at Enoggera and works for Queensland Health as a Registered Nurse.

when it hit the target. This could be with the projectile open and contacting the target surface flat, with the sewn edge striking first, or being still rolled up and contacting target surface with sewn edge of bag as leading edge.

The five bean bags that were not of flat orientation in all but one instance (when the bag struck a rib) penetrated deeper than the flat orientation. The other non flat bag broke three ribs and penetrated deeper than the flat bean bag that passed between the ribs (7.6 cm versus 5.1 cm)[8]. This could lead to a fatal injury.

Bean bags must be used cautiously, and tested to determine the minimum distance for shooting so penetration is not a consequence. The round must also not be shot at or into the chest, back or head to avoid a potentially fatal injury[4,6-8].

NON FLEXIBLE PROJECTILES

Non-flexible rounds come in a variety of types, shapes and sizes, and include wooden, rubber or plastic bullets fired from 37mm gas guns[9], plastic bullets fired from rifles, rubber bullets fired from rifle canisters, and rubber balls and pellets fired from shotguns[9].

The rubber bullet, or rubber baton round (RBR), is made of slightly flexible rubber, is 37mm diameter and 15cm long with a slightly rounded tip[10]. It has no gyroscopic stability, its flight path is unpredictable and it readily tumbles on firing. 55,000 of these rounds were used in Northern Ireland from 1970-75, causing three deaths, two from head impacts and one from a chest impact, and many skull fractures, eye injuries and lung contusions[10]. Soldiers were instructed to fire at the legs of rioters but, as the rounds were inaccurate, they did not always go where aimed[10].

Millar et al. reported on 90 patients that presented at hospitals in Northern Ireland with injuries from rubber bullets. The number of rounds fired during their study was 33,000. The mortality ratio was 1:16,000, the serious injury ratio 1:800 and a disability ratio of 1:1900, with 54% of injuries to the head and neck, 26% to chest and abdomen and 20% to the limbs. 67% of the victims were male, with 64% of these in the 10-19 age group[11].

Of all the injuries, 87 had skin lesions, 21 had sustained fractures of the face and skull bones, 24 had eye or adnexa injuries, three had severe brain injuries with one being a fatality of an 11 year old boy allegedly shot from 2-3 metres[11]. Nine had chest injuries and three had abdominal injuries with the other fatality being a chest injury that may have been caused by the projectile injury or as a result of respiratory obstruction on route to hospital[11]. Of the 90 studied, two died, 14 had various degrees of blindness, 4 were facially disfigured, three had anosmia and one had a stiff finger joint, with the other 62 having no permanent disability or disfigurement[11].

The study raises the issue of using rubber bullets against young or disabled people involved in the riots, as the youngest person hit was seven and one victim had osteogenesis imperfecta[11]. The severity of injury is increased in children due to the reduced body mass and immature bone growth. Such use could also lead to claims of brutality against children and disabled people with the ensuing political and legal ramifications.

The 37mm plastic bullet, or plastic baton round (PBR)6, replaced the rubber baton round used in Northern Ireland in 1975. Up to 1999, over 60,000 had been fired and, even though they were more accurate, they caused more injuries. This was due to their tendency to strike head on as a consequence of their rod like shape, which meant that the energy was transferred over a smaller surface area causing more injuries[10]. There had been fourteen deaths in Northern Ireland with ten from head strikes and four from chest strikes[10].

The American experience shows that the belly button aim point often lead to chest injury. The three recorded deaths[7] were from the rounds fracturing a rib, which pierced the heart in one case, the lung in the second and both the heart and lung in the third[6]. The literature does not expound the non-lethal injuries caused by individual types of projectiles.

Rocke in 1983 compared Millar et al's research[11] to a similar number of people struck with plastic bullets and found that, while the plastic bullets tended to be more lethal when the skull is hit, the rubber bullet struck more people in the face and also caused more lung contusions[12].

Rubber and plastic ammunition is used in Israel and was designed to be used by the Israeli Defence Force to cause sudden and reversible immobilisation of demonstrators by inflicting painful and non-penetrating injuries[13]. This was to avoid the serious wounds and deaths caused by conventional military ammunition[13]. There are four variants of the rubber bullets, which are fired from a canister mounted on either the M-16 or Galil combat rifles. Two are spherical rubber balls 1.8 cm in diameter known as the Standard Rubber Bullet (SRB)[13]. The other two are cylindrical projectiles of the same diameter and 1.8 cm in length[13]. The plastic bullet is fired from a 5.56 assault rifle, weighs 0.85g and is composed of an alloy of PVC and metallic fragments[13].

There were 17 fatalities recorded with ten from the rubber bullet and seven from the plastic bullet[13]. Ten fatalities were from brain injury, two from cardiac injury, three from internal haemorrhage, and single cases of spinal shock and blood aspiration[13]. Again, their use against young males is highlighted, with 12 fatalities in the 10-19 age group with a mean age of 15. There was only one woman fatality aged 42. Non-lethal injuries were not discussed in the report.

As an aside, not all less-lethal projectiles are designed to control people or are sophisticated in design. A 12 gauge shotgun round called a 'Smack' round is made and marketed from a cattle property in Nebo, Queensland, and is a used in rounding up cattle.[14]. It is made by loading a cut off shotgun wad into a plastic case, inserting a piece of hydraulic hose and sealing the case.

CONCLUSION

Less-lethal projectiles are aptly named because, although they are designed to injure, they can kill if they hit vulnerable areas of the body, particularly the chest and head. They give law enforcement and military personnel an option, however, of using something other than lethal force. Training is required to prevent serious and fatal injuries.

The ADF has a need for such rounds where the use of lethal force is unwarranted or illegal, such as in peacekeeping or Defence Aid to the Civil Power. It has the weapons to fire these projectiles and, with proper training and rules of engagement, these rounds would be a valuable adjunct to military operations.

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Registered trademark names should be capitalised whenever used. Trade and trivial names should not be capitalised. SI units are to be used for all articles. Any normal ranges should also be included.

ILLUSTRATIONS

General Considerations. All graphics in the journal will normally be black and white. Colour pictures may be published for exceptional reasons, on application to the Editor.

All graphics must be created in digital format and included at their appropriate locations in the manuscript word-processor text file close to the point of first mention. In general, graphics should be copied from the graphics program window and pasted directly into the manuscript text file at the correct size. The author should make sure that the graphic is at the appropriate resolution (see below) before copying and pasting. If the graphics need to be resized later, they should be resized in the graphics program and then pasted into the manuscript; the original should be removed. The author should not resize graphics after they are pasted in Word or WordPerfect. This is true regardless of the graphic formats: cdx, tif, eps, pdf, etc. The author should not use the "insert" function in Word to place the graphics.

Quality

The quality of the graphics in the Journal depends on the quality of the originals provided by the author.

Figures cannot be modified or enhanced by the Journal production staff. The graphics files pasted into the manuscript word-processor file are used in the production of the Journal. Any flaws or non-uniform lines will be reproduced in the published article. Images produced from continuous-tone graphics such as photographs should have high contrast.

Size

Graphics must fit a one- or two-column format on the Journal page. *For efficient use of Journal space, single column graphics are preferred.*

Single (preferred)	**Double Width**
minimum 10.5 cm	
maximum 8.25 cm	17. 8 cm (7in.)
Maximum depth 24 cm	24 cm (9.5 in.)

For best results, submit graphics in the actual size at which they should appear in the printed edition. Original graphics which do not need to be reduced to fit a single or double column will yield the best quality. Lettering should be no smaller than 4.5 points. Helvetica or Arial fonts work well for lettering. Lines should be no thinner than 0.5 point. Lettering and lines should be of uniform density and the lines unbroken. If the submitted artwork must be reduced, larger lettering and thicker lines should be used so that, when reduced, the artwork meets the above mentioned criteria.

Avoid using complex textures and shading to achieve a three dimensional effect. Parallel or crosshatched lines should be used to fill enclosed areas with a pattern.

Resolution

Digital graphics pasted into manuscripts should have the following minimum resolution:

Black and white line art 1200 dpi
Grayscale art 600 dpi
Colour art 300 dpi

REFERENCES

References should be in accordance with the "Vancouver" system (see MJA 1991; 155: 197-202, or www.mja.com.au/public/information/ uniform.html). References in the text should be numbered consecutively as they are cited and should appear as superscript numbers (e.g. text[1,2]). References are collated at the end of the article. Annotation of the references should accord with the abbreviations used in Index Medicus. Where there are seven or more authors, list only the first three then use et al. Authors are responsible for reference accuracy. An example of the reference system is as follows:

1. Quail G. Asthma in the military. Aust Mil Med 2000; 9(3):129-137.
2. Bowden M. Black Hawk Down. New York: Atlantic Monthly Press; 1999.

REPRINTING

Reprinting of articles may be authorised by the Editor, with the author's consent, if an acknowledgment, quoting both the Journal and the original date of publication, is printed with the article.