Annals of the Royal College of Surgeons of England (1975) *vol* 56

Battle casualties

M A Melsom MBE FRCS, Lt Col RAMC

Consultant Surgeon, Royal Herbert Hospital, Woolwich

M D Farrar FFARCS, Major RAMC

Consultant Anaesthetist, British Military Hospital, Munster, BAOR

R C Volkers FRCS, Major RAMC(V)

Surgical Registrar, Brook General Hospital, Woolwich

Summary

Eighty casualties, mainly due to explosive devices, sustained over a period of 3½ months by the armed forces of the Sultan of Oman in counterinsurgency operations are analysed and their management by a British field surgical team is described. Of the 73 who reached the surgical centre alive, 56% had suffered major injuries, yet all but 2 survived, giving an overall survival rate of 88.75% (71/80).

The effects of first aid and rapid evacuation on survival and their influence on the surgical work load and on the facilities required for treatment are assessed, together with their relevance to the planning of military and civilian accident services.

Introduction

Her Majesty's Government provides certain military assistance to the Sultan of Oman. The main operational base for these forces is the airfield at Salalah in the province of Dhofar. The Sultan's forces are engaged in counterinsurgency operations in the surrounding province, and a field surgical team has dealt with casualties to the indigenous forces from this conflict as well as providing medical and surgical facilities for United Kingdom servicemen.

The team contained a surgeon, anaesthetist, and assistant surgeon, with 10 RAMC, 2 RAF, and 2 Omani medical auxiliaries. The operating theatre and resuscitation and recovery wards were in 2 air-conditioned huts and the laboratory and X-ray departments in tents. X-ray and transfusion facilities were good, but there were no facilities to estimate blood gas or electrolyte levels or to ventilate patients other than during operations. This was because equipment was reduced to minimum bulk and weight for air portability so that the team could be sited in the most suitable place to receive, resuscitate, and perform primary surgery on casualties prior to onward evacuation to a fully equipped base hospital.

During a 3½-month period (December 1972 to March 1973) 80 cases of wounding occurred. Seven men were killed in action (that is, died before reaching the surgical centre), 2 died of wounds (that is, after reaching the surgical centre alive), and 71 survived. Of the 80 casualties, 8 suffered miscellaneous trauma, 16 bullet wounds, and 56 injuries from explosive devices.

Miscellaneous injuries

Eight cases were classified under this heading. Four patients suffered burns (2 of 30% and 2 minor), 2 were concussed from a motor vehicle accident and a fall over a cliff, and 2 had minor injuries. There were no deaths.

Case 1 Thirty per cent burns of right chest, arm, and left hand from flare. Treated by resuscitation, dressing, and tangential excision and grafting on 3rd day. The latter was largely unsuccessful and 2 further skin grafting procedures were required.

Case 2 Thirty per cent burns of face, back, legs, and hands caused by ignition of loose powder in a trench by a cigarette. Treatment by resuscitation and exposure, with desloughing and split skin grafting at 10 d with satisfactory results.

Comment

Burns constituted 50% of cases in this group and are likely to constitute a significant element of casualties in most conflicts.

The various methods of treatment all have their advocates. Where casualties are numerous and staff and theatre time limited the exposure method has advantages in economy of manpower. In hot climates mosquito nets should be used to keep out flies and avoid infestation with maggots.

Bullet wounds

Weapons available to the insurgents varied from antique Martini-Henrys to Kalashnikov semiautomatic rifles. The series was a small one of 16 cases.

Observations and results

There were 2 patients with head injuries, 4 with trunk injuries, 11 with limb injuries, and only 1 case of multiple wounding. Three men were killed in action, one with a head injury and 2 with trunk injuries. No patient died of wounds. Thirteen patients (81.25%) survived.

Management

Penicillin and streptomycin were given routinely for 2 weeks or, when there was bony involvement, for 6 weeks. Tetanus toxoid was also given routinely. Surgical management was by wide laying open with primary wound excision and delayed primary suture.

Comment

Bullet wounds of the head, neck, and trunk have a high primary mortality. This is especially true for high-velocity missiles. Exploration of wounds from high-velocity missiles often reveals a large tract of contaminated and devitalized tissue around the missile track. Both are due to the release of kinetic energy from missile to tissues during the missile's passage, in a quantity proportional to the product of the mass and the square of the velocity. Increases in missile velocity lead to enormous increases in energy released and tissue damage inflicted.

Missile velocity and tissue damage cannot reliably be deduced from entry and exit wounds, and there is therefore no substitute for wide surgical exploration for assessment, with excision of devitalized tissue and delayed primary suture[1].

Injuries from explosive devices

Fifty-six cases of injury from explosive devices occurred. Five were due to antipersonnel mines, 5 to vehicle mines, 1 to a flare, and 45 to fragments from mortar and recoilless rifle shells.

Antipersonnel mines Three of the 5 casualties in this group had multiple injuries and one of these was killed in action. None died of wounds and 4 survived. Two of the survivors had eye injuries.

Case 3 (Plate II a–d) Mine triggered by right foot. The blast caused traumatic amputation of two-thirds of the right foot, a closed fracture of the left tibia and fibula, multiple soft-tissue wounds of both lower limbs, trunk, right hand, head, and neck, and multiple corneal foreign bodies. All wounds were grossly contaminated. Resuscitation and treatment were by infusion of Hart-

mann's solution, blood transfusion, tetanus toxoid, penicillin, and streptomycin. X-rays were taken.

Under general anaesthesia the wounds were scrubbed and extensively debrided and a provisional Pirogoff's amputation fashioned for the right foot. This was left open with a eusol dressing and the left leg was manipulated and placed in plaster. The corneal foreign bodies were removed and antibiotic ointment and eye pads applied. Partial amputation of the fingers of the right hand was performed. Operating time $5\frac{1}{2}$ h.

Daily theatre dressings with hydrogen peroxide and eusol followed. Ketamine was used initially for these dressings but caused hallucinations, and pethidine and diazepam were substituted.

Split skin grafting and secondary suture of the amputation were carried out at about 10 days with good result.

Case 4 (Plate I) Mine triggered by right foot. The blast caused traumatic amputation of two-thirds of the right foot, a compound fracture of the left tibia and fibula with overlying soft-tissue injury, a large soft-tissue injury of the left thigh, scrotal injury with destruction of one and a half testes and partial transection of the penis and urethra, and a penetrating injury from the scrotum between the left inguinal ligament and skin into the abdomen, with 4 small-bowel perforations and with prolapse of a small-bowel loop into the scrotum.

Resuscitation and treatment were by infusion of Hartmann's solution, blood transfusion, tetanus toxoid, penicillin, and streptomycin. X-rays were taken. Under general anaesthesia laparotomy, peritoneal toilet, and closure of the small-bowel perforations were performed. The scrotum was debrided and partially excised and the right testicular remnant trimmed. The urethra and penis were repaired over an indwelling catheter. The left thigh and other limb wounds were scrubbed and extensively debrided with excision of a devitalized sartorius muscle. An open reduction without internal fixation was performed on the left tibia and fibula and a provisional Pirogoff's amputation fashioned for the right foot. All limb wounds were left unsutured for delayed primary suture or grafting. Initial operating time $7\frac{1}{2}$ h. He was evacuated to base hospital 24 h later, where he made an uncomplicated recovery.

Eye injuries

One patient in this group had multiple foreign bodies and made a good recovery. Another had a ruptured globe, which was overlooked initially, and did poorly. (A further case of ruptured globe, from a flare which exploded at arm's length, was noted on admission; the patient was transferred for ophthalmic care and made a good recovery.)

Comment

These injuries are typical for the victim detonating the device. In receiving the full force of the blast and fragmentation he may shield his companions, who thus receive less severe injuries.

Multiple injury is the rule and consists usually of loss of part of the triggering foot, extensive contaminated wounds of the lower limbs, perineum, and parts of the trunk, hand, and face in the line of the blast (Plate I). The opposite tibia and fibula were fractured in both cases described, probably owing to sudden angulation or rotation. Rupture of the globe of the eye, penetrating injuries, or corneal foreign bodies are not uncommon and should always be looked for. Rupture of the tympanic membranes also occurs frequently.

X-rays are helpful in assessment to show penetration of tissues by dirt or plastic explosive. The latter is radio-opaque (Fig. 1).

In grossly damaged limbs primary defin-

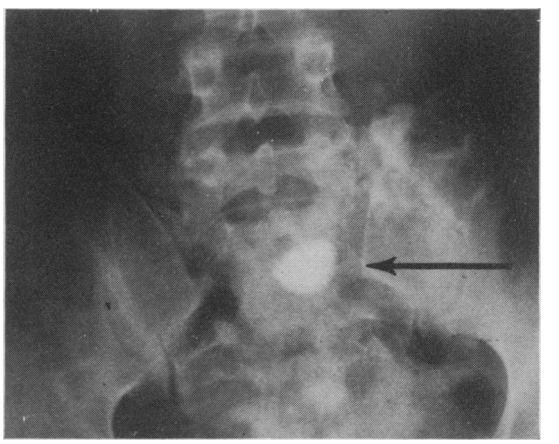


FIG. 1 *Intra-abdominal plastic explosive (Case 4). (Arrow indicates explosive).*

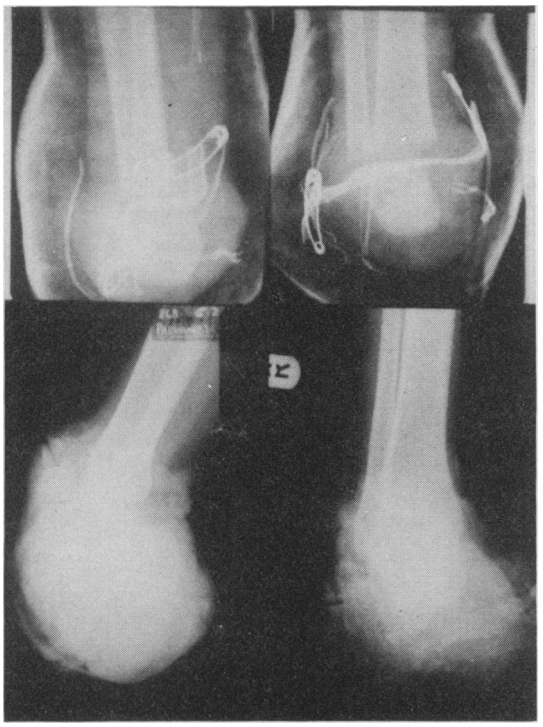


FIG 2 *Traumatic amputation of forefoot (below). Pirogoff's amputation (above).*

itive amputation, well above the damaged parts, may appear initially to be the only reasonable treatment. The extensive damage to skin and superficial tissues may, however, dictate very radical amputations and compromise stump healing with subsequent prosthetic problems. Conservative management, by extensive wound excision, daily dressings with hydrogen peroxide and eusol, and delayed primary suture or skin grafting, is well worth while (Plate II *a–d*). Ketamine was a very useful 'anaesthetic' for these procedures. Syme's or Pirogoff's amputation with delayed closure is well suited to such injuries, which destroy mainly the forefoot (Fig. 2). The option of a higher definitive amputation in consultation with the limb fitter is retained.

Vehicle mines Four of the 5 casualties in this group had multiple injuries; one of these was killed in action and one died of wounds (Case 5). The 3 others survived.

Case 5 Thrown from a vehicle blown up by a mine. The driver died instantly and 2 other passengers sustained less severe injuries.

Clinically he had a fractured pelvis (right ilium, ischium, and pubis on X-ray) and an extensive wound of the right popliteal fossa down to the femur but no chest or abdominal signs. Lacerations of face and neck were also present.

Treatment with penicillin and streptomycin, tetanus toxoid, and infusion of Hartmann's solution followed by blood was commenced, but his blood pressure continued to fall in the X-ray department. Laparotomy was decided upon.

Under general anaesthesia laparotomy with extension into the right chest was performed. A severe burst injury of the right lobe of the liver with about 8 lacerations and brisk bleeding was present (Plate II *e* and *f*). The lacerations were satisfactorily sutured over Sterispon (absorbable gelatin sponge). A blood clotting deficiency occurred during the operation. Fresh blood, calcium, and fibrinogen failed to achieve coagulation, and fibrinolysis was assumed. Treatment with epsilon-aminocaproic acid followed by more fresh blood and fibrinogen was successful. Nineteen units of blood were transfused in all. Closure with an underwater seal chest drain was performed, the head and neck wounds cleaned and sutured, and the popliteal fossa debrided and left for delayed primary suture.

Renal function was satisfactory on completion of the operation and subsequently. Postoperative recovery was satisfactory initially, but after 36 h he began to develop clinical and radiological signs of post-traumatic pulmonary insufficiency. Inability to estimate blood gases and electrolytes and to commit the anaesthetic machine to full-time ventilation of this patient complicated management. After 48 h he suddenly deteriorated and died, probably owing to acid–base and electrolyte imbalance.

Comment

Vehicle mines produce blast waves, rapid acceleration with ejection from the vehicle, and trauma on hitting the ground. Multiple injuries to several people may occur and present simultaneously. The clinical problems of

major multiple trauma occurring in Case 5 are discussed with the management of liver injuries below.

Mortar and recoilless rifle shell fragments Eighteen (40%) of the 45 casualties in this group had multiple fragments in more than one region of the body, the limbs, the trunk, and the head and neck each constituting one region.

Two men (4.4%) were killed in action. One had an entry wound on the lateral aspect of the neck at the level of the second cervical vertebra with probable spinal cord damage. The other had a large entry wound of the root of the neck with possible major vascular damage. Postmortem examination was not possible. One man (2.2%) died of wounds, which were from penetrating skull and trunk fragments (Case 6).

In 13 cases (28.9%) the head and neck were involved, in 17 (37.8%) the trunk, and in 28 (62.2%) the limbs (41 limbs). Three men with head and neck injuries died, 2 being killed in action and 1 dying of wounds (Case 6); this last man was also the only one with trunk injury who died, while none with limb injury died.

Major injuries occurred in 29 cases (64.4%). They were classified thus if they were killed in action or had multiple wounding or a major injury to one region.

Six head and neck injuries were major, 2 men being killed in action and 4 needing craniotomies, 1 of these dying of wounds. Five trunk injuries were major, 4 men having liver wounds and 1 dying of wounds. Seven limb injuries were major, 3 being fractures, 1 a nerve injury, and 4 vessel injuries. Eighteen cases were major on account of multiple wounding.

Head and neck

Case 6 Entry wounds of the right parietal region and right lower chest. The patient was hypotensive and semiconscious and one of 29 casualties in a mass casualty situation. Intravenous infusion was commenced but his prognosis was judged poor. He was consequently given a low priority for surgery and died 30 min after arrival.

Case 7 A single fragment in the left temporal region. X-ray suggested that the fragment was embedded in the outer table. Exploration showed a compound depressed fracture with dural tear and local brain damage. Wound and brain toilet, dural repair, and elevation of the fracture were performed. Penicillin and sulphadimidine were given for 3 weeks. Recovery uneventful.

Case 8 Multiple fragments entered the right posterior parietal region and passed medially and

---

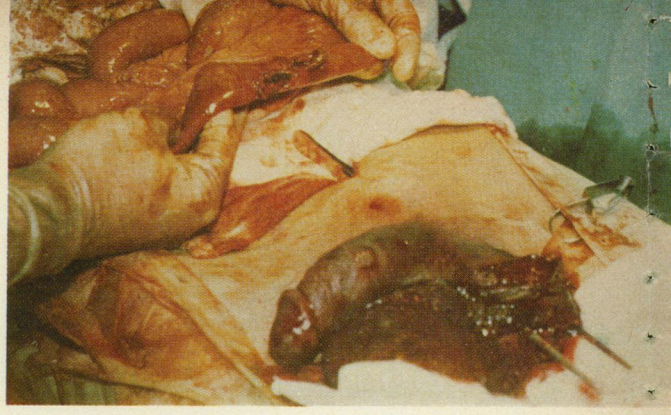
Legends for Plates I and II (pp 294–295)

PLATE I *Case 4. Typical antipersonnel mine injuries. (a) Thigh and scrotal contamination and wounding. Hand also involved. (b) Scrotal–abdominal perforation with small-bowel ruptures. (c) Injury to left thigh and leg (with undisplaced fractured tibia and fibula). (d) Wide laying open of thigh wound and excision of sartorius. (e) Injury to right forefoot and leg. (f) Right foot after wound excision, toilet, and fashioning of provisional Pirogoff's amputation (bone ends left exposed in wound).*

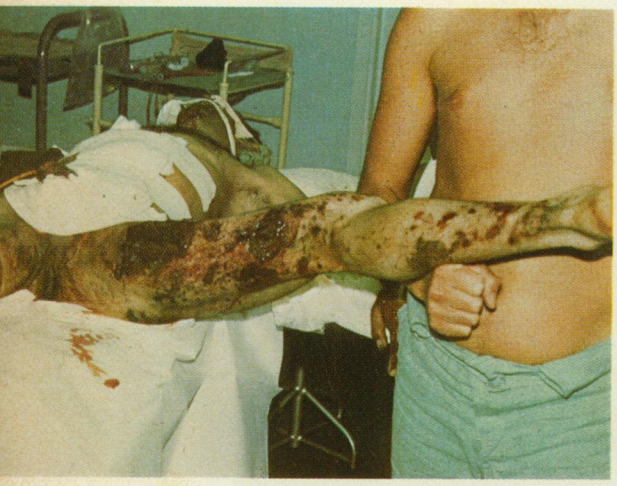
PLATE II *Case 3. Similar injuries to Case 4. (a) Eleven days after injury. Primary wound excision and daily hydrogen peroxide and eusol dressings under ketamine have led to clean granulation tissue. (b) Split skin grafting and completion of Pirogoff's amputation at 11 days. (c) Right leg 4 weeks after injury. (d) Left leg 4 weeks after injury. Further skin grafting to foot and immobilization for fractured tibia and fibula were required.*

Case 5. Multiple injuries from vehicle mine. (e) Multiple liver lacerations. (f) Postoperative picture. Note the extension of laparotomy into chest for access and generous drainage of both wounds, chest, and subdiaphragmatic space.

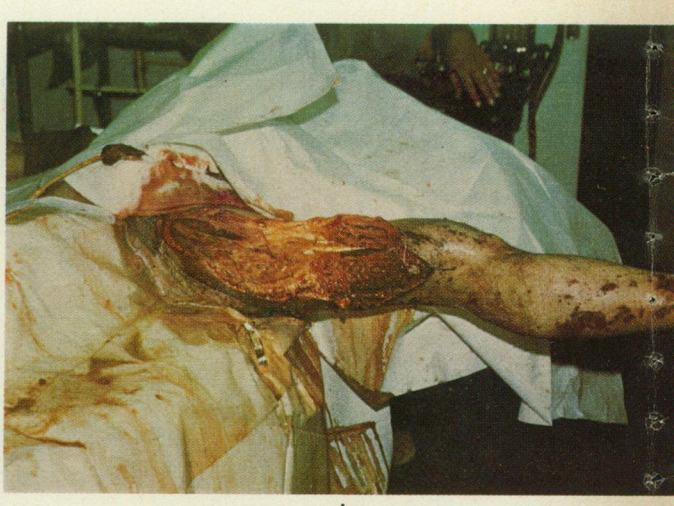
a



b



c

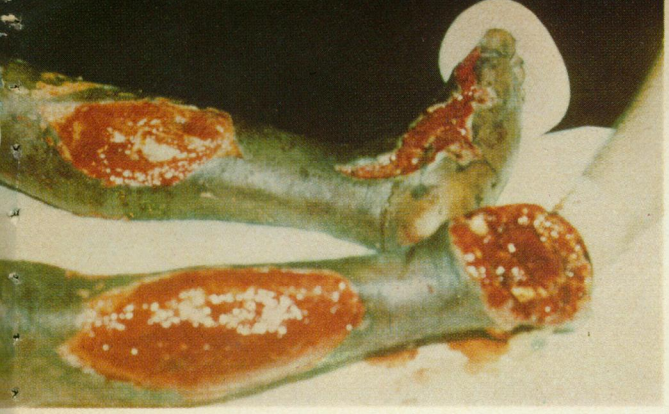


d

e

f

Plate I

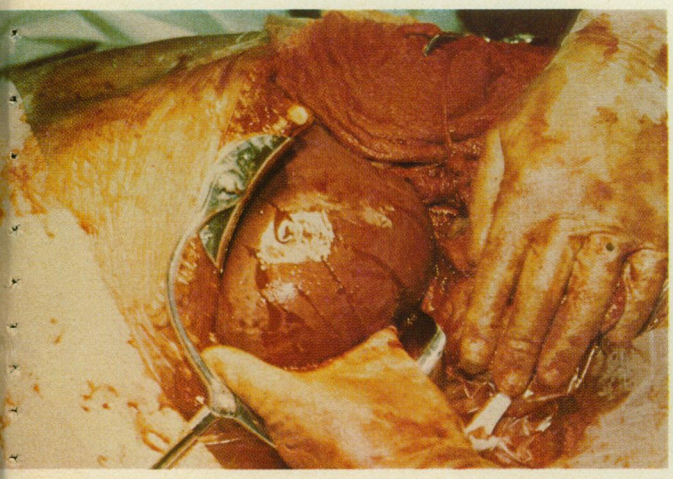


a

b

c

d



e

f

Plate II

downwards to be arrested at the falx. Exploration with removal of bone and metallic fragments and damaged brain tissue as far as the sagittal plane was performed, together with gentle saline irrigation. A pericranial dural patch was applied and penicillin and sulphadimidine given for 3 weeks.

Postoperatively he had a left hemiplegia which was recovering well after 2 months.

Thoracoabdominal injuries

Case 9 A small entry wound was present posteriorly below the right 12th rib. X-ray showed a small fragment in the region of the right lobe of the liver. A laparotomy with oblique enlargement to the costal margin was performed. The fragment was embedded in the inferior surface of the liver. It was removed and the laceration sutured over Sterispon. A hole was present in the hepatic flexure of the colon, and right hemicolectomy was performed. No other injury was apparent and the wound was closed with drainage to site of anastomosis and liver repair.

Postoperative recovery was prolonged and complicated. A biliary leak occurred through the drainage hole after 3–4 d and was treated conservatively. A severe haemorrhage occurred through the drainage hole at 1 week and was treated by transfusion. The biliary leak persisted and increased and local liver breakdown was thought likely.

A further severe haemorrhage then occurred. A coagulation defect was suspected and fresh blood and fibrinogen were transfused. Laparotomy to establish the cause disclosed a fistula of the second part of the duodenum. The liver was well healed and not the cause of the bleeding or biliary leak. The source of bleeding was not apparent. The fistula was repaired and the abdomen closed with drainage. Postoperative management was by nasogastric suction and intravenous fluids.

Initial progress was satisfactory, but the fistula reopened after 3 d, and 2 weeks postoperatively was discharging vast quantities of fluid daily. Diversion of duodenal contents was decided upon to allow the fistula to close. Partial gastrectomy and gastroenterostomy with a Roux-en-Y anastomosis was performed. This was technically difficult owing to adhesions of the jejunum to the site of the previous right hemicolectomy. No attempt was made to close the duodenal fistula. Postoperative recovery was uneventful and the fistula closed within a week. The pathological specimen showed a previously undiagnosed posterior gastric ulcer, the cause of the earlier haemorrhages.

Case 10 A solitary entry wound 1 in (2.5 cm) in diameter was present in the mid-axillary line of the lower right chest. X-ray showed a large fragment in the upper left abdomen. Laparotomy with right thoracoabdominal extension was performed. The fragment was found to have traversed the chest wall, pleura, lower edge of the right lung, diaphragm, and right and left lobes of the liver, ending deep to a star-shaped laceration in the left lobe. The hole in the right lobe of the liver was closed with deep chromic catgut sutures tied over Sterispon. The left lobe of the liver was incised to remove the fragment and similar haemostatic sutures inserted. Blood loss was brisk and coagulation was impaired. Haemostasis was restored by the use of fresh blood. The diaphragm was repaired and closure with chest and abdominal drains and tension sutures was performed. On reflection, the liver substance should have been drained. However, he made an uneventful recovery.

Limbs

Case 11 Fragments had entered the left arm and forearm causing a compound fracture of the left humerus with radial nerve palsy and soft-tissue forearm damage with division of the radial artery. The wounds were laid open and the radial artery ligated. Delayed primary suture achieved skin cover. Union of the humerus was awaited before exploration of the radial nerve.

Case 12 Multiple entry wounds of the chest wall, arm, and left thigh. Those of the anterior left thigh were minute, but swelling indicated vascular damage. Exploration revealed perforations of the femoral artery and vein below the profunda origin and a perforation of the anterior branch of the profunda. The vein was repaired and the arteries ligated. Peripheral circulation remained adequate and vein graft was not therefore performed as a primary procedure.

Multiple injuries

Case 13 Multiple injuries from mortar fragments. It was necessary to explore wounds of both legs, both thighs, both buttocks, trunk, right arm, and scalp. Luckily none penetrated body cavities. All were laid open and, since infection occurred,

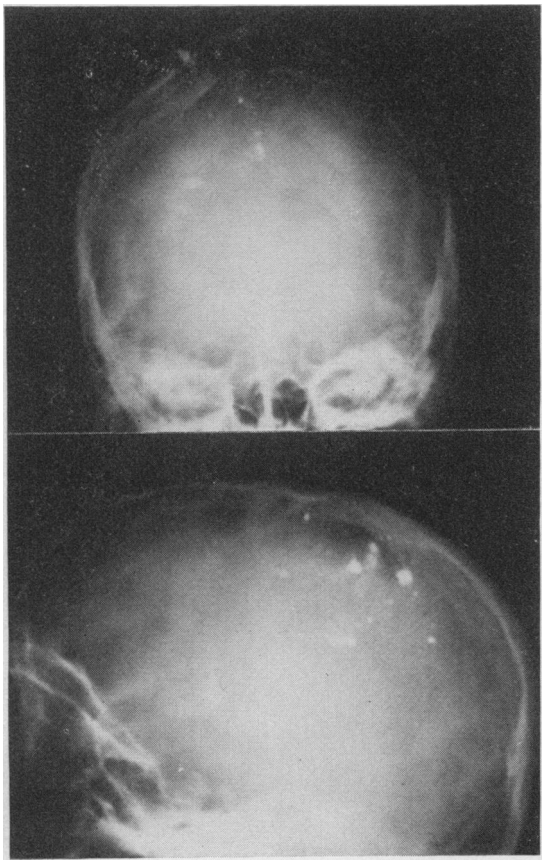


FIG. 3 *Anteroposterior and lateral X-rays of penetrating skull fragments (Case 8).*

regular eusol dressings under ketamine followed by secondary suture were performed.

Comment

Fragmentation injuries are frequently multiple and often cause penetrating wounds needing major surgical procedures, the latter more commonly in those sustained by the head, neck, and trunk regions than by the limbs. Men killed in action usually have damage to some vital structure. The missiles are mainly of low velocity and damage is localized to the missile track, in contrast to high-velocity bullet wounds.

Assessment was clinical and by X-ray examination in 2 planes (Fig. 3). X-rays were often time-consuming owing to multiplicity of injury but essential, since from the entry wound and missile's point of arrest the track and likely damage to important structures could be inferred (Fig. 4).

Treatment was by blood volume replacement, with central venous pressure monitoring as required. Penicillin, streptomycin (or sulphadimidine for head injuries), and tetanus toxoid were administered in all cases. All penetrating head wounds were explored for wound and brain toilet and dural repair. All other head wounds were explored in a manner that allowed craniotomy to be proceeded with if a depressed fracture became apparent for the first time at operation. With abdominal wounds laparotomy was performed. Clinical signs or reasonable suspicion of major damage determined the urgency of exploration. All missile wounds were laid open and dead and devitalized tissue excised. Serous cavities and joints were closed if pos-

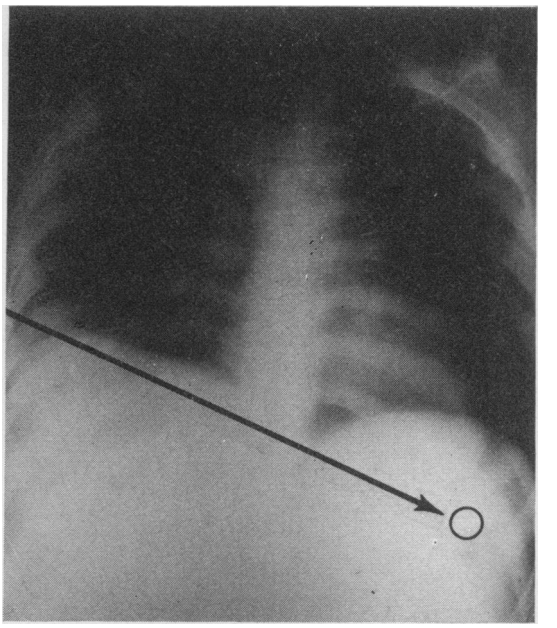


FIG. 4 *Fragment (ringed) in left hypochondrium. Arrow shows missile track (Case 10).*

sible following wound toilet, but skin and soft tissues were closed 3–5 days later by delayed primary suture or skin grafting.

Of the 45 casualties with injuries of this type, 43 (95.6%) arrived alive and 42 (93.3%) survived.

Liver injuries

Both blunt and penetrating liver injuries are prevalent in injuries from explosive devices in this series and from bullet wounds in larger series. Experience with management and full reviews of the literature have been reported by Little[2] and Walt[3].

Diagnostic delay may still contribute to mortality. Clinical awareness, history, and examination are the most important diagnostic tools. Peritoneal infusion of normal saline with reaspiration for macroscopic and microscopic examination has a place, particularly in unconscious patients. Its results should not be allowed to cloud clinical judgements. A negative laparotomy is safer than delay in treatment.

Access plays a large part in achieving control of haemorrhage. The patient should be positioned and towelled so that thoracotomy can be performed without delay when required. This applies particularly to lacerations of the upper and posterior surfaces and the hepatic veins. The abolition of intrathoracic negative pressure also reduces the possibility of air embolism.

Surgical procedures are proportional to the severity of the injury.

Haematomas should be deroofed.

Lacerations should be left alone if small, explored digitally if large, with debridement of damaged tissue and individual ligation of large vessels. Closure may be by tension sutures tied over Sterispon or mattress sutures. In either case they should be inserted well away from the edge to avoid cutting out. Alternatively the laceration may be left open, with interlocking sutures parallel to its edge to achieve haemostasis. This is appropriate when there is much tissue damage and may prevent collections of blood and bile leading to pressure necrosis, abscess, or haemobilia.

Segmentectomy or lobectomy may be required occasionally when the circulation is impaired distal to the laceration or when the hepatic veins or intrahepatic vena cava are damaged.

Control of blood loss can be assisted by occlusion of the porta hepatis for periods of 10 min at a time. This can be increased to 30–40 min following peritoneal cooling with chilled Hartmann's solution or normal saline to an oesophageal temperature of 33°C. Ligation of lobar vessels at the hilum and cannulation of the inferior vena cava to isolate the hepatic veins may be required for resections. Ligation of the portal vein is safe. Ligation of a branch of the hepatic artery may sometimes be tolerated but may cause ischaemia to a degree dictating resection. Postoperative hypothermia, hyperoxygenation, and antibiotic cover are required to prevent anaerobic and other infections. Packing is a last resort since it is subject to secondary haemorrhage, necrosis, and liver abscess but it may save a life.

Drainage is an important part of treatment and when introducd routinely in World War II coincided with a reduction in mortality from 30% to 17%. Drainage of the supra- and infrahepatic spaces, liver substance, and chest may be required. Drainage of the biliary tract is more controversial, but after resection or when intrahepatic collections or necrosis are anticipated cholecystostomy or insertion of a T tube is a valuable safety valve and permits radiological studies prior to removal.

Two complications common to major liver injuries, major trauma, and other conditions

requiring massive transfusion occurred in Case 5, and both contribute significantly to mortality in such cases. These are coagulatsion difficulties and pulmonary insufficiency.

Coagulation difficulties

Abnormalities of clotting factors and fibrinolytic factors have been detected in series of fully investigated cases, but this complication often presents to the surgeon at times or places where such investigations are not feasible.

We have found the following empirical method of treatment of value: (1) Replace clotting factors with 2 bottles of fibrinogen, calcium supplements, and 2 bottles of fresh blood. Fresh frozen plasma may be added if available. Observe for improvement and, if maintained, complete the operation using more fresh blood as required. (2) If oozing recurs assume that fibrinolysis is present. Treat with epsilon-aminocaproic acid and subsequently repeat replacement as in paragraph (1), continue maintenance doses of epsilon-aminocaproic acid, and use fresh blood to complete the operation. These items should be kept convenient to the operating theatres, and a donor panel for such emergencies should be maintained.

Post-traumatic pulmonary insufficiency

Clinically this presents as a progressive impairment of gaseous exchange accompanied by diffuse opacification of the lung fields on X-ray developing over the 48 h following injury or surgery.

The pathological changes are interstitial pulmonary oedema, fragmentation, and haemorrhage and occlusion of precapillary arterioles by microemboli.

The causes are direct trauma, including blast, and emboli of platelet aggregates from banked blood. The microemboli appear to be preventable by use of a 40-μm filter (Ultipor) in the transfusion line; this was not in use with field surgical teams when this series was

Effects of wounding in different conflicts

	Evacuation time	*Killed in action**	*Died of wounds†*	*Survivors†*	*Died of wounds**
		(per 100 casualties)			*(% of cases)*
Crimean War	12 h	18.6	13.8	67.6	16.7
American Civil War	12 h	20	11.6	70.4	14.1
Boer War	12 h	20	6.9	73	8.6
World War I	12 h	20.9	6.0	73.1	7.6
World War II	6–7 h	20.3	3.5	75.8	4.5
Korea	6 h	21.2	2.2	76.6	2.5
Vietnam (7000 casualties)[6]	40 min	15	1.6	83.4	2.1
Salallah (80 casualties)	30–40 min	8.75	2.5	88.75	2.7
Bullet wounds		18.75	0	81.25	0
Antipersonnel and vehicle mines		18.8	9.4	71.8	11.1
Mortar and recoilless rifle shell fragments		4.5	2.2	93	2.3
Miscellaneous		0	0	100	0

*Figures from official reports
†Figures derived from above

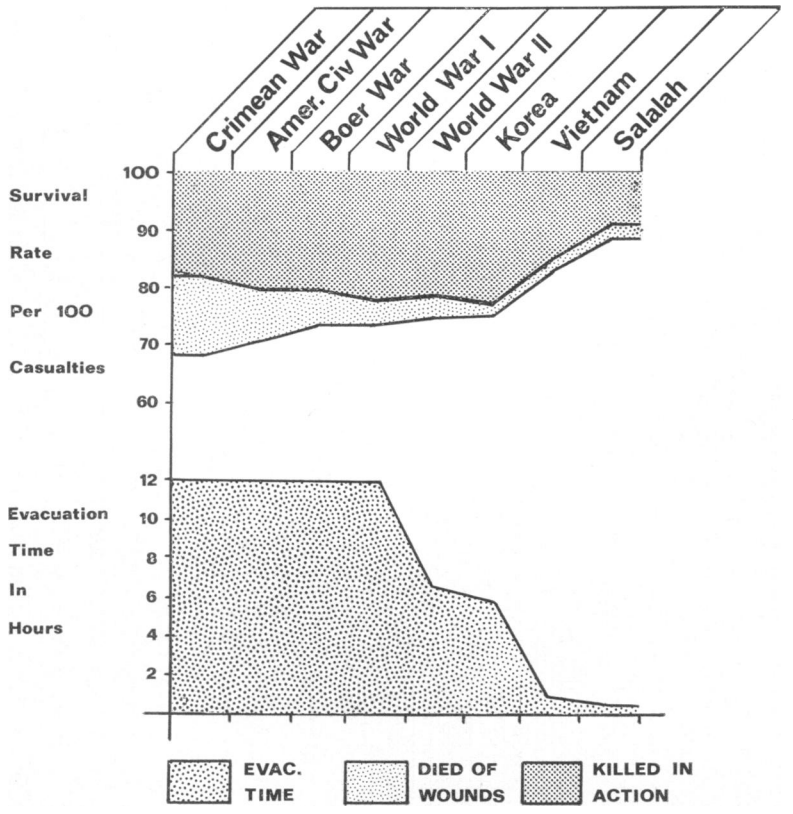


FIG. 5 *Effects of wounding in different conflicts.*

treated. Reul *et al.*[1] have reported a reduction of incidence from 41.3% to 7.4% with its routine use for massive transfusion.

Management of the established case is by oxygen therapy progressing to intermittent positive pressure respiration, then positive end-expiratory pressure respiration with room air or oxygen mixture, the percentage being varied in relation to blood gas measurements. When respiratory assistance is necessary it should be continued until the condition resolves, often for about 10 d. In these circumstances early tracheostomy is often desirable[4,5].

Discussion

The effects of wounding in different conflicts are shown numerically in the table and graphically in Fig. 5. Overall survival rates appeared almost to have reached their limit in Korea at 76.6% since all but 2.2% of the balance were killed in action. Experience in Vietnam and Salalah shows that within the 'killed in action' group further lives can be saved.

The two prime factors in achieving this are first aid and rapid evacuation. Good first aid was available in Salalah from medical orderlies on the ground and from helicopter crewmen during evacuation. A medical officer was present only where evacuation time was long (1 h) and evacuation delay by tactical isolation possible. Rapid evacuation was assured by radio communication and a helicopter and crew on 24-h standby, able to be airborne in 2-3 min., and the ability to place

surgical facilities forward of the base hospital.

At the surgical centre in this series 73 out of 80 casualties (91.25%) arrived alive and those salvaged above the Korean figure of 78.8% were necessarily major cases. Weaponry 'advances' ensure that more casualties have major injury overall — 60% of the total in this series and 56% of those arriving alive.

Analysis of the wounds of the 7 men killed in action, the 2 who died from wounds, and the 12 other most seriously injured casualties who it was felt would not have survived longer evacuation shows 12 multiple injuries, 4 trunk and 5 head and neck injuries, but no solitary limb injuries.

Analysis of the 52 cases requiring surgery before further evacuation but not of an immediately life-saving nature shows 15 multiple injuries, 5 trunk, 5 head and neck, and 27 limb injuries.

The 7 remaining casualties required minor surgical procedures that could well have awaited evacuation to a base hospital.

Thus the pattern of work presenting at a surgical centre with prolonged evacuation, where approximately 50% of those admitted have solitary limb injuries and the most severely injured have died, alters radically with rapid evacuation, when almost every additional case is of multiple injuries or of major head, neck, or trunk injury.

Rapid assessment, resuscitation, and surgery were the most valuable aspects of treatment and were made possible by calling out the surgical team at the time of casualty notification. Postoperative management of the major cases demanded nursing supervision and laboratory and life support aids to intensive care standards. These needs are not currently allowed for in field surgical team staffing and equipment scales, but such casualties are often unfit for evacuation to the better equipped base hospital.

Results, however, at 2.5 deaths from wounds per 100 casualties, were only slightly worse than the Vietnam and Korean figures of 1.6 and 2.2 and the overall survival rate of 88.75 per 100 casualties compares favourably with the Vietnam and Korean figures of 83.4 and 76.6 respectively. This overall improvement in survival is largely attributable to those factors which prevent death between injury and arrival at the surgical centre.

Conclusions

Certain guidelines in management of civil and military trauma may be derived from these results.

1) First aid A) *First line* Positioning for airway control, control of external blood loss, and occlusion of chest wounds should be performed by the first person to reach the casualty. In the Army each and every combatant is trained to perform this service for his friend. In civil life universal knowledge of such first aid is the goal.

B) *Second line* Suction, intubation, infusion, immobilization, analgesia, and rarely tracheostomy or intercostal intubation for pneumothorax may be required.

The skilled first aider, strategically positioned, with ambulance or air ambulance mobility and adequate equipment, has this role and requires training and experience in these skills. They must be exercised to the minimum requirement lest delay in evacuation results, which in itself may be detrimental to survival.

2) Rapid evacuation A) *Radio communication* Links between surgical centre, ambulance control point, and ambulance play an essential part in reducing evacuation time and providing information for and advice from the surgical centre. Peripheral medical officers also require to be in radio contact in case of need. In the military context there is usually the added benefit of a direct link with the incident point.

B) *Method of evacuation* Time rather than distance is the important parameter and every reduction in injury-to-resuscitation time has benefits in survival. No two situations are the same and flexibility is essential.

Ambulances are ideal where roads are good; strategic prepositioning saves valuable time. Helicopters greatly increase the distance that can be covered within a reasonable time scale and are important where a drainage area is large or road communications poor.

Decentralization of primary accident care may have a role if evacuation time cannot otherwise be reduced and adequate services can be provided peripherally.

3) Surgical centre The effect of good first aid and rapid evacuation is to bring a greater percentage of all casualties to the centre alive but with severe injuries. The types of casualty saved by this policy are likely to be those with multiple injuries or severe trunk and head and neck injuries. Their management requires the best of modern facilities and skills.

A) *Accommodation* i) A resuscitation room should be spacious and well equipped, with ready access to laboratory and X-ray facilities.

ii) An operating theatre should be constantly available and not committed to routine lists.

iii) Intensive care and minor care wards are required for postoperative management.

iv) In military and disaster situations tents are by no means ideal for complex surgical cases. Portable buildings have a role where mobility of the surgical facility is essential. This does not exclude the use of tents in all circumstances but a lowering of standards and turnover must be accepted.

B) *Staffing* i) *Trauma teams* Trauma pays no respect to specialist boundaries but requires rapid assessment and action for good results.

There are intangible benefits in the use of teams who are (*a*) immediately available for rapid resuscitation and surgical management of cases of trauma and not committed to other duties; and (*b*) able to take on the management of patients as a whole, incorporating advances from various disciplines but seeking specialist advice, equipment, or expertise for exceptional cases rather than as a routine.

(ii) *Resuscitation staff* The skills required by ambulance attendants and resuscitation room staff who assist the resuscitation room doctor and trained nurse are the same. Rotation of such staff through ambulance and resuscitation room duties would provide initial and continuing in-service training.

In the Army the medical assistant is well suited to this role, in which air ambulance attendant skills should be included.

iii) *Crash team and general practitioner resuscitation services* On-site medical assistance additional to that of the ambulance attendant is sometimes required. Provision of such standby services are further roles for both the surgical centre and peripheral practitioners.

iv) *Nursing staff* First aid, rapid evacuation, and surgery lead to larger numbers of seriously ill postoperative patients. Staffing to intensive care as well as minor care standards is required.

In military conflicts the number of cases in each group is about 50%.

C) *Equipment* In the ambulance equipment to effect resuscitation and preserve life in transit is required.

At the surgical centre full laboratory services and life support aids are required for management.

In the service context forward deployment of surgical teams and rapid evacuation have increased this need, and miniaturization of diagnostic and treatment aids is required to fulfil the requirement for mobility.

Many of these guidelines are well known

and in use variously in different centres. The comparison of statistics from military conflicts emphasizes the effect of first aid and a short injury-to-surgery interval on survival. This can best be achieved by joint consideration of evacuation methods and deployment of surgical and ancillary staff.

We are indebted to the supporting services of 2 Field Hospital, Royal Army Medical Corps, and Headquarters United Kingdom Land Forces, the Defence Medical Equipment Depot Cyprus, the Pathology Department, Princess Mary's RAF Hospital, Akrotiri, RAF Masirah and Salalah, and the Dhofar Brigade, Sultan of Oman's Armed Forces.

To all members of the team and the Station Warrant Officer Salalah, who worked so well together, and to the crews of the Sultan of Oman's Airforce Helicopter Squadron for their efficient, selfless, and hazardous work.

To Professor A J Harding Rains, to Major-General A P Dignan, Director of Army Surgery, and to Professor W C Moffat, Professor of Military Surgery, who gave valuable advice and criticism, to Pall Biomedicals Ltd, Kabi Pharmaceuticals, and Parke Davis Ltd for assistance with publication costs, to Mrs Beryl Smith for much uncomplaining typing, and to Lt P Basford, Royal Army Medical Corps, for preparation of the chart.

This paper is published by kind permission of the Director General Army Medical Services.

References

1 Hopkinson, D A W, and Marshall, T K (1967) *British Journal of Surgery,* 54, 344.

2 Little, J M (1971) *The Management of Liver Injuries.* Edinburgh, Livingstone.

3 Walt, A J (1969) *Annals of the Royal College of Surgeons of England,* 45, 319.

4 Reul, G J, Beall, A C, and Greenberg, S D (1974) *Chest,* 66, 4.

5 McCaughey, W, Coppel, D L, and Dundee, J W (1973) *Anaesthesia,* 28, 2.

6 *U.S. War Department Survey* (1970), Vol III, Appendix C, p. 6.