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*ORIGINAL STUDY*

# Surgical options in the management of landmine blast injuries of lower limb: a randomised prospective study

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**Landmine blast injuries are high velocity shattering injuries that produce ghastly and gory wounds, presenting a dilemma to the treating surgeon, especially when the literature on this subject is limited. The aim of the present study is to enlist various surgical procedures that can be explored to treat such complex injuries. 60 cases having varied degrees of involvement of the lower limb from mine blasts were managed. Surgical treatment was tailored to the individual requirement depending on the extent and severity of injury. Serial surgical wound debridement was an integral part of all these procedures. Limb length preservation was possible in 70% cases. A combination of surgical approaches and procedures from fixation to different types of amputations can be employed for treating mine blast injuries to maximise residual limb function.**

**Keywords** *:* landmine blast ; amputation ; debridement ; flap.

## INTRODUCTION

Antipersonnel landmines are still widely used, an estimated 70 countries worldwide are believed to be infested by this menace causing a great number of causalities annually, however the exact number remains unknown because of strategic reasons. Most of these injuries are caused by accidental stepping over landmines and a few while handling them *(1)*. The former predominantly involves lower limb especially the foot and ankle whereas the latter causes predominant involvement of the upper limbs and chest. For the victim the anxiety and apprehension of being hit by mine blast is morally and psychologically devastating producing a morbid fear of losing the affected limb and even life. Very truly, it's the beginning of a long ordeal for him *(2)*.

We present our series of 60 cases of mine blast injuries managed at a tertiary care centre. The site of accident in all these cases was distantly located from the centre where definitive management was

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done. Hence the field paramedic was the first aid giver as he was the first point of contact between the casualty and medical care *(3)*. The field paramedic was the vital link in the evacuation chain. In our experience the field paramedic proved crucial to improving the overall outcome. Since a landmine blast causes tremendous panic and chaos, therefore the chances of missing concurrent injuries are high. The vital regions i.e. the head and neck including the eyes and ears, thorax and abdomen were quickly surveyed and reported for any injury. Since evacuation takes several hours, therefore the affected limb was splinted with locally improvised material and no attempt was made to remove the damaged shoe wear. When the casualty was evacuated to field surgical post (FSP) broken shoe wear and damaged clothing was removed and thorough wound inspection was done *(9)*. Initial wound lavage was done and broad spectrum antibiotics were administered, usually a combination of 3rd generation cephalosporin and aminoglycosides followed by generous bulky dressings. The casualty was evacuated to our tertiary care centre under opiate cover for adequate pain relief and sedation to allay fear and apprehension. It must be emphasised that the wound was only inspected at this stage and not explored *(15)*. The ETA was informed to the tertiary care centre along with the blood group of the casualty *(4)*.

## PATIENTS AND METHOD

The casualty was received in the Trauma centre and immediately the trauma team swings into action. The trauma team consists of anaesthetists, surgeons, radiologists, ORA (operation room assistants) and trained nurses. The vital parameters were assessed and monitored. Vital regions were again surveyed and radiographs of the affected limb, abdomen and thorax were taken. After this the dressings were removed in the OT only under anaesthesia *(5)*. Wound inspection was done and thorough wound lavage was done with high volume (at least 9 litres) low velocity normal saline solution. Surgical debridement was done wherein all the necrotic and charred tissues were excised till bleeding surface was achieved and care was taken to preserve major tendons for possible later use. At times quite substantial amount of tissues are excised including subcutaneous tissue, muscles, fascia, fat and comminuted bone fragments *(10)*. It was only after this, that the limb was assessed for classifying the injury and planning further surgical intervention *(6,7)*. Even though no universally accepted classification for landmine blast injuries exist, but with our experience we were able to classify these complex injuries into four types based on the extent and severity of involvement. This also helped in predicting the possible line of management and its outcome *(8)*. The study is a prospective randomised study. The duration of the study was 3 years from 2013 to 2016, with an average follow up of at least 2 years. 54 patients were military personnel with an average age of 32 years (range 26-43 years), all males. Remaining 6 were civilians with age ranging from 6 to 54 years. There was 1 paediatric case (06 years).

Type I: only the heel was involved with comminuted fracture of calcaneum. The heel pad was well preserved. There were 6 (10%) cases of this type of injury. Fig.1 shows examples of type I injury.




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***Fig. 1.*** — A-C Showing examples of Type I injury with increasing severity

Type II: injuries involved only a part of the foot with one or multiple ray amputation. The rest of the foot including the heel pad was well preserved. There were 14(23.4%) cases of this type of injury. Fig.2(a)-(c) shows the examples of type II injury.

Type III: these were very severe injuries with a deep longitudinal lacerated wound extending from the heel to almost fore foot with charred soft tissue at the margins for e.g. fig.3(a). At times the main wound was transversely placed between mid and hind foot for e.g. fig.3(b,c1,c2). Wound exploration revealed complete loss of anatomical stratification, extensive soft tissue damage and bone comminution. The foot was flail with loss of anatomical integrity between fore-mid and hind



***Fig. 2.*** — (A)-(C) Showing examples of Type II injury

foot due to damage to joint capsules, ligaments and tendons. The tissues were deeply impregnated with vegetation, dust, cloth pieces, shrapnel, splinters and were grossly contaminated. Fig.3(a)-(e) shows the examples of type III injury. There were 27 (45%) cases of this type of injury.



***Fig. 3.*** — (A)-(D) Showing various examples of Type III injury with increasing severity

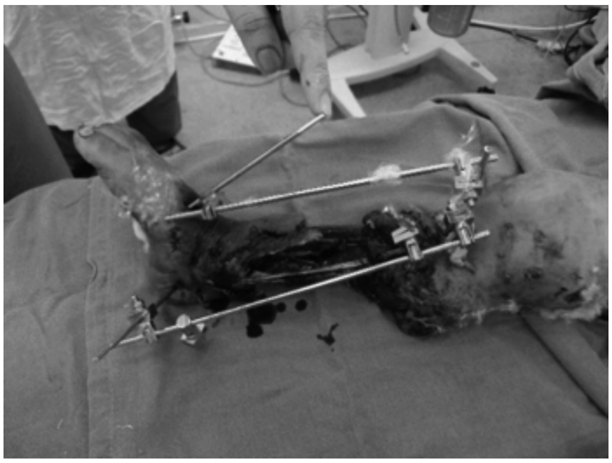
Type IV: type III injury plus complete traumatic amputation of the lower limb. Fig.4(a-b) shows an examples of type IV injury. Fig.5 shows complete traumatic amputation on left side. There were 13 (21.67%) cases of this type of injury.

***Fig. 4.*** — (A-B) Showing an example of Type IV injury with complete traumatic amputation

## MANAGEMENT

Type I injury cases were rather easy to manage. After thorough wound lavage, comminuted calcaneal fragments were manipulated using smooth Kirschner wires. It was attempted to restore the Bohler's angle under image intensifier as closely as possible. Delayed primary closure was done. Kirschner wires were regularly inspected for pin track care and were removed after 6 weeks. Good functional results were obtained and there was no need for any shoe wear modification.Fig.6 Shows pre and post-operative radiographs of management of case shown in Fig.1.(b) with 03 Kirschner wires. Fig.7 shows management of case shown in Fig.1(c) with single Kirschner wire. Fig.8 (A-B) shows management of another example of such injury.

Type II injuries entailed partial traumatic amputation of one or multiple toes, generally the lateral part of foot is involved. Management was therefore focussed on preserving as much foot structure as possible to permit efficient weight bearing. During surgical debridement partial amputations were refashioned to complete ray amputations and rugged margins are smoothened. Since there was degloving in many such cases, reconstructive procedures like split skin or full thickness skin grafting was often used *(13)*.Fig.9(a-c) shows management of case in fig.2.(a1-a2), full tickness skin grafting was done to cover the lateral



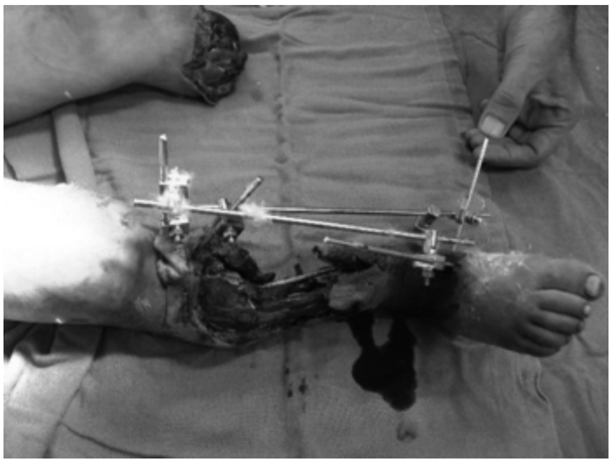


***Fig. 5.*** — (A-B) Showing bilateral involvement of lower limbs with complete traumatic amputation on one side



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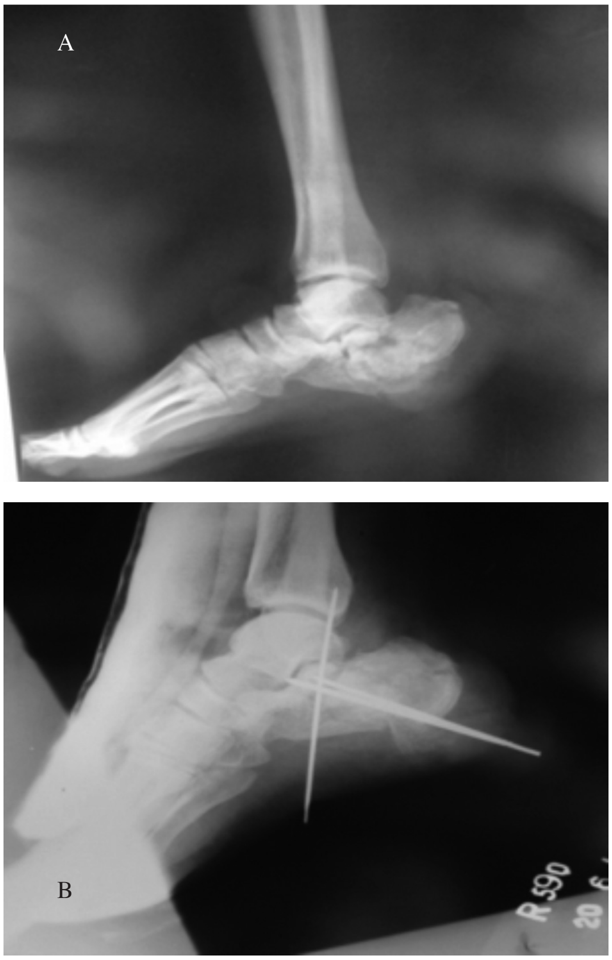


***Fig. 6.***— (A-B) See text.

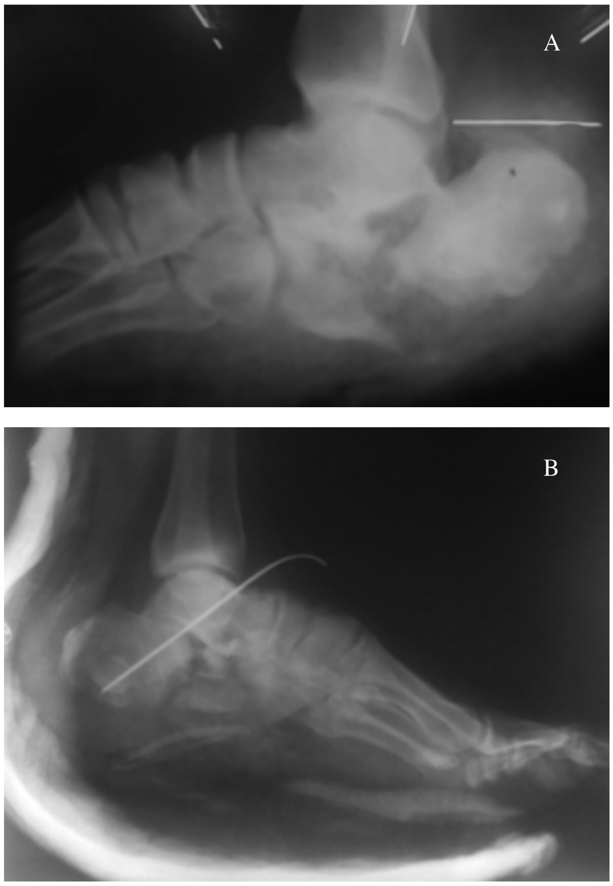


***Fig. 7.***— (A-B) See text.


***Fig. 8.***— (A-B) See text.

raw aspect of foot. Fig. 10 Shows management of case shown in fig. 2(c) with partial amputation of great and second toe.

Type III injury cases required radical surgical debridement. 6 cases were managed with surgical debridement alone and delayed closure was possible. However, persisting sinus was a problem in these


***Fig. 9.***— (A-C) See text.

***Fig. 10.***— See text.

cases which was managed with re-exploration and antibiotic impregnated beads were used. Fig.11 (a-c) shows one such example managed this way.

During radical debridement a substantial part of the foot structure was removed and limb salvage than depended on whether the heel pad was preserved or not. Cases where the heel pad was well preserved it was attempted to perform a Lisfranc's or a Chopart's amputation. Dorsal tendons were preserved and tenodeses to talus was done, this restores the balance between plantar flexors and dorsiflexors of the foot *(11)*. This step is valuable in preventing a late stage equines deformity. Fig.12 shows technique for attachment of tibialis anterior tendon through talus using ethibond suture. The plantar skin is very valuable and preserved as much as possible. Flaps are raised using this plantar skin and rotated dorsally. Only loose tagging sutures were applied initially and once the wound discharge settles delayed closure is done using monofilament suture. This type of flap cover best preserves the vascularity of the stump and gives tough durable




***Fig. 11.***— (A-C) See text.

***Fig. 12.***— See text.

skin cover to the stump to permit efficient weight bearing. This procedure was highly successful in averting a high level amputation and preserves limb length. Patients only required a shoe wear modification at a later stage for ambulation.

Fig.13 Shows management of case in fig.3(e) with a Lisfranc's level amputation with preservation of plantar flap that is rotated dorsally to provide wound cover. Fig.14 Shows managemnt of case in fig. 3(c)-(d) with a chopart's level amputation.

Cases where heel pad was preserved but the talus and calcaneal were severely comminuted, a stable


***Fig. 13.*** — (A-C)


***Fig. 14.*** — (A-B)

hind foot for weight bearing couldn't be created. Hence, the bone fragments were meticulously excised and the heel pad was mobilised carefully preserving the vascularity. A Syme's amputation was than done. Since the foot was badly contaminated we performed a modified two stage procedure. In the first stage ankle disarticulation was done with preservation of tibial articular surface and the malleoli. The wound was kept open and regular dressing with wound inspection was done. Once the wound becomes clean the second stage is performed. We performed Sarmiento's modification of Syme's amputation where the bones are resected 1.3 cm above the ankle joint, hence the malleoli are removed and closure was performed over a suction drain. This produced a less bulbous stump. The tough, durable skin of the heel flap provides normal weight bearing skin. Fig.15 (a-c) shows management of case in fig.4 with a staged Syme's level amputation and a suction drain in situ.

There were still other cases where the lower third of the leg was severely shattered with relative sparing of the foot-ankle complex. Since the distal vascularity is well preserved an amputation is effectively ruled out. General wound debridement is done followed by careful application of a joint spanning external fixator application followed by a hybrid Illizarov's ring external fixator. Vacuum assisted closure techniques were most helpful in these cases. Fig.16 (a-d) shows management of one such case with radiographs showing bony union.

Type IV injury cases involved complete foot with varying degrees of involvement of the distal tibia, such cases were managed with a below knee amputation. Again a two stage operation was done, the first being open amputation (12). This made the procedure more planned and predictable. This also prevented a revision amputation at a higher level. We used the general rule "one inch of stump length for one foot of height" and at the same time avoided distal third of leg for amputation. A long posterior or a skew flap depending on condition of skin was used (14).

In cases where the lower limb was severely affected with no scope for a below knee amputation a knee disarticulation was done. Disarticulation of the knee results in an excellent end-bearing stump. Here a long anterior flap was fashioned. The patella was mobilised and brought in the intercondylar notch with the patellar tendon being sutured to the remnants of the cruciate ligaments and the gastrocnemius muscle. Closure was done over a drain. Fig.17 shows pre and post-operative radiographs of one such case managed with bilateral knee disarticulation.

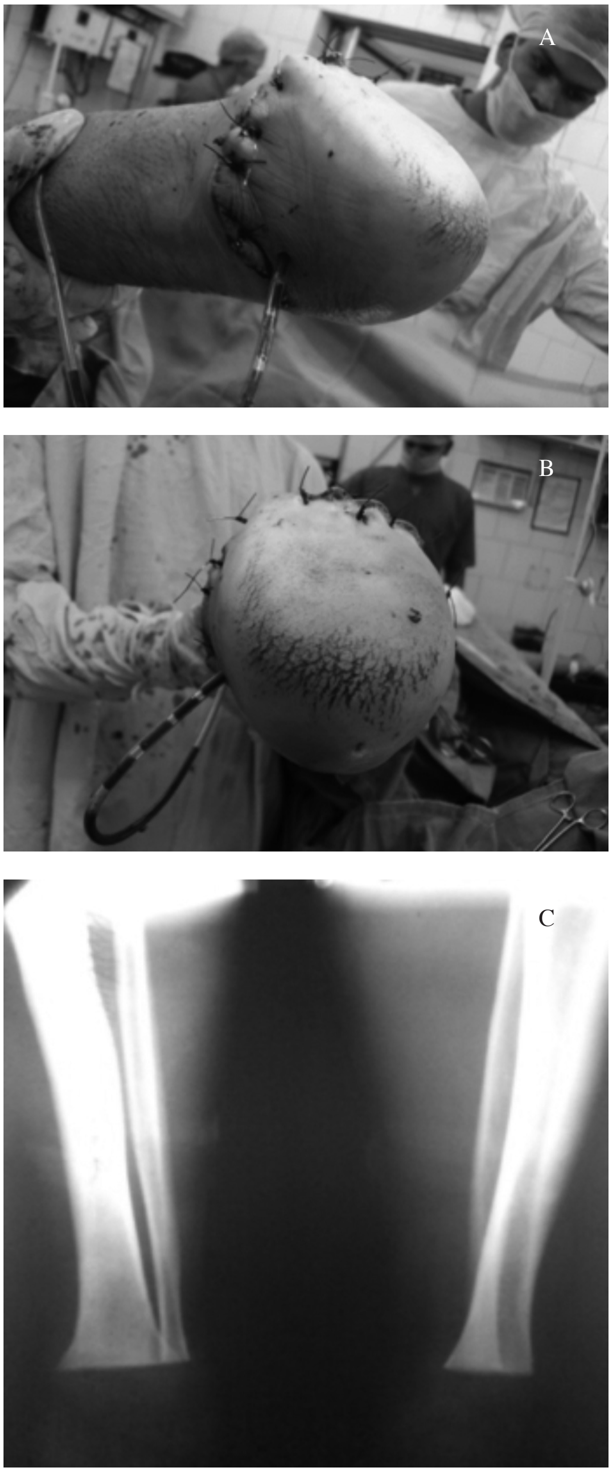


***Fig. 15.*** — (A-C) See text

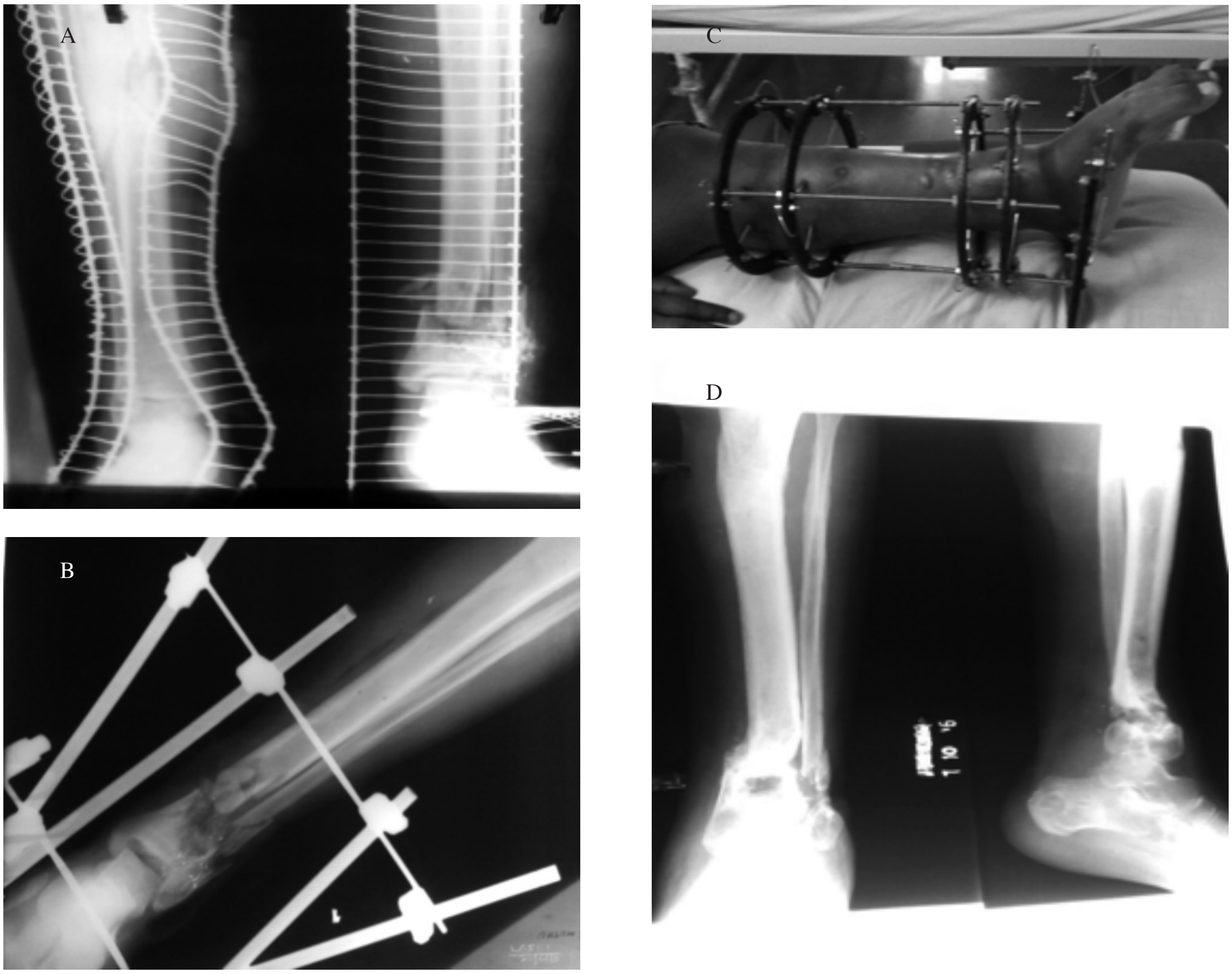


***Fig. 16.*** — (A-D) See text

## RESULTS

Type I injury patients recovered very well. No shoe modification was required for these patients. Among type II injury patients, medial 2 or 3 digits were preserved in all the patients. Only an infitting in the shoe was required. Patients with only two medial digits had difficulty in "toe off" part of the stance phase. Two patients in this group required revision of reconstructive procedure *(13)*. Out of 27 patients with type III injury, 16 underwent partial foot (Chopart's or Lisfranc's) amputation *(11)*. The calcaneum and talus were preserved in all the patients with varying degrees of mid and fore foot amputation. This provided them with an excellent end bearing stump. 5 patients in this group had Syme's amputation. This proved to be an excellent option with high patient acceptance. These patients required a Syme's prosthesis for ambulation *(16)*. In spite of all the necessary surgical precautions wound dehiscence occurred in 2 patients and they required multiple wound debridements and vacuum assisted closure. Of the 13 patients with type IV injury, 10 had below knee amputation and the remaining 3 had knee disarticulation. In all below knee amputations the junction of middle and distal third of leg was taken as the level of amputation *(12,14)*. There was one patient with bilateral knee disarticulation.

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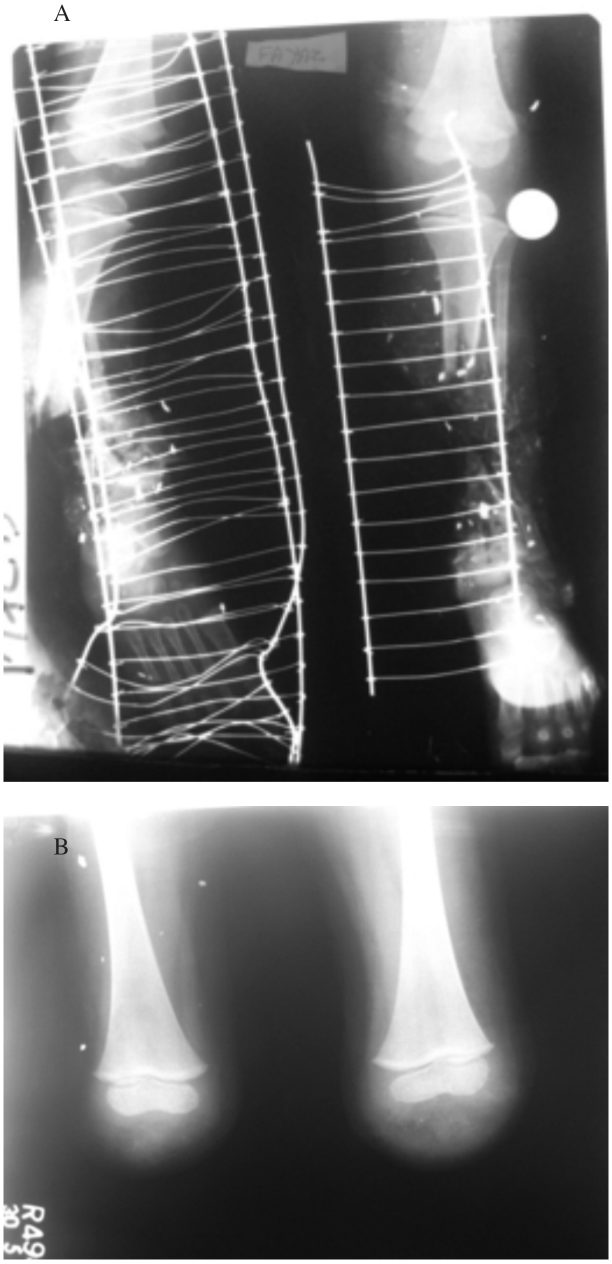

*Fig. 17.* — (A-B)

## DISCUSSION

In our study of 60 cases the incidence of multiple injuries involving anatomic areas other than lower limbs was 12 cases i.e. 20%. Other such studies show much higher incidence of multiple injuries ranging from 47%-73% *(7,15)* (Table 1). One reason for such discrepancy is that military personnel predominantly formed part of our study (about 90%) and had better protective gears to defend themselves than civilians in general. The percentage of amputation in our study was 56.67%. Other studies show a highly variable incidence of amputation ranging from 24% to 100% (Table 1). The reasons for these wide fluctuations are many.

The explosive power of land mines used in different parts of the world varies widely *(2)*. This can produce trauma ranging from relatively low velocity to extremely high velocity shattering wounds causing traumatic amputation of limbs in many cases *(1)*. Secondly, the chain of evacuation of casualty and the terrain in which it is being done has a great bearing on the eventual outcome. While in our case the evacuation chain was professionally trained and competent, the geographical terrain was hilly and rugged. This added to the time consumed in transporting the casualty to the tertiary care centre loosing the precious "golden hour".

Thirdly, there is little mention of the type and classification of amputations performed in these studies. Limb length preservation is relatively a new and evolving concept in traumatology *(11)*. In our study, of all the amputations done, we were able to preserve limb length in 47.05% of cases by performing a Lisfranc's or a Chopart's amputation (Fig.18, Table2). Patient acceptance of these type of surgical procedures is higher than a below or through knee amputation because a prosthesis is not required for ambulation *(14).* Moreover the patient is spared of the psychological trauma of amputation. Even a Syme's level amputation has high acceptance because short distance ambulation is possible without using prosthesis *(16)*. Lastly, most of these studies are quite old; surgical techniques, antibiotics, dressing materials have undergone a sea change since then. Wound management techniques like vacuum assisted closure (VAC) are versatile techniques for handling such complex wounds.

## CONCLUSION

1. In our series of 60 patients with lower limb mine blast injury, limb salvage and limb length preservation was possible in 70% patients.

Table I. — Showing comparison with other studies on landmine blast injuries (8).

| War Zone/Country | Year | Study size | Amputation (%) | Mortality (%) | Multiple Injuries | Population (%) |
|---|---|---|---|---|---|---|
| Kurdistan | 1991 | 1652 | 24 | - | - | Mixed |
| Afganistan | 1991 | 757 | 39 | 0.8 | 757 | Mixed |
| Jaffna | 1996-97 | 328 | 23 | 29 | 60% | Civilian |
| Sri Lanka | 1990-92 | 191 | 75 | - | - | Military |
| Thailand | 1981 | 120 | 93 | - | 47% | Military |
| Angola | 1995 | 94 | 56 | 2 | - | Civilian |
| Thailand | 1981 | 40 | 100 | 0.0 | - | Military |
| Afganistan | 1985 | 20 | 60 | - | - | Mixed |
| Afganistan | 1985-87 | 11 | 73 | - | - | Military |
| Mozambique | 1994 | - | - | 48 | 73 | Civilian |

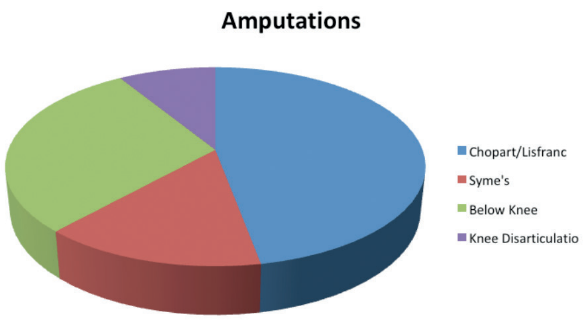


***Fig. 18.*** — Pie chart showing distribution of various levels of amputations

Table II. — Showing distribution of various types of injuries and amputations levels.

| Type | No. (%) | Amputation (%) |
|---|---|---|
| I | 6(10) | Nil |
| II | 14(23.40) | Nil |
| III | 27(45) | Lisfranc/Chopart=16, Syme's=5 (35) |
| IV | 13(21.6) | Below Knee=10, Knee disarticulation=3 (21.67) |
| Total | 60(100) | 34 (56.67) |

2. Meticulous surgical debridement should be done in all cases. Every attempt should be made to identify anatomical structures and compartmentalise them, after that the type of injury can be classified.

3. Thick plantar flaps should be preserved as far as possible as they provide the best cover for weight bearing stump. Preserving the heel pad is of crucial importance as it is the most important determinant of the level of amputation.

4. Open and staged amputations significantly improves the result of surgery and prevents revision amputation at higher level.

5. Various combinations of surgical procedures must be utilised to optimise outcome and maximise limb function. External fixators can also be judiciously used in some cases where lower leg is involved. Reconstructive surgical procedures should be employed to cover raw areas.

6. Surgical procedures for partial foot amputation like Chopart's and Lisfranc's can be used for limb length preservation.

7. Every effort should be made for limb salvage since the stigma of amputation is demoralising for the individual. Even today amputation is a taboo in our society and impedes normal intercourse of the individual.

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