Reconstruction in Warfare Injuries

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Abstract

Traumatic injuries, especially in the combat setting, stress the surgical team that may be sited in a remote forward area, battling against paucity of time, resources and infrastructure. The lone surgeon may be faced with the arduous challenge of saving life. There is seldom thought given to reconstruction in this high-pressure situation. If the patient survives, morbidity for want of reconstruction can be severe and quality of life can suffer significantly. Reconstruction after 3 to 5 days is fraught with complications and usually does compromise outcome in the post-operative phase. The reconstructive surgeon should be involved early in the management as he can provide coverage for large soft tissue defects after aggressive debridement with panache. If the patient is haemodynamically stable, he should be transferred urgently, preferably by air, to a higher centre with multi-specialty care, especially being equipped with an orthopaedic and trauma reconstructive surgeon. It has been proved beyond doubt that the healing improves significantly and there is marked decrease in morbidity if coverage of wounds is provided early, before colonized wounds get infected.

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Introduction

The understanding of reconstruction in trauma has undergone a sea change. Gone are the days when the patients and their wounds were subjected to daily dressings to allow healthy granulation tissue to form and then the wounds would be covered. Now the aggressive trauma reconstructive surgeon believes in urgent debridement and wound coverage. The traumatized tissue is radically excised and divided into critical and non-critical areas, the former being covered with flaps and the latter by skin grafts. The key to favourable result in these devastating injuries is to intervene before infection sets in.

The Armed Forces Perspective

A single surgeon-anaesthesiologist team in the peripheral military hospitals with meagre support and infrastructure treats most of our patients. The surgical team often focuses on saving life and practices damage control surgery for warfare injuries. If the life is saved and the patient is haemodynamically stable, he is evacuated by air to a large multi-specialty centre which can effectively deal with trauma reconstruction. Cutting down the time lag to reconstruction in trauma is of paramount importance.

General Considerations

The present day concept of debridement is the even

Fig. 1 : The reconstructive ladder.

more aggressive form called wound excision. This encompasses excision with a 2-3 mm margin around the contaminated and grit-laden tissues. For limb wounds, a pneumatic tourniquet and loupe magnification should be always used to reduce blood loss, to distinguish surviving from devitalized tissue and also to prevent inadvertent trauma to vital structures. The wound should then be washed with copious quantities of saline and soft tissue coverage planned.

Whether a clinical problem is simple or difficult, the rational approach has been to use the reconstructive ladder to guide surgical reconstruction (Fig. 1). The ladder provides a systematic approach to wound closure, selecting first simple and then complex techniques, depending on local wound requirements and complexity.

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However, currently the world is moving toward the concept of reconstructive 'escalator', wherein the best option is chosen and not necessarily the simplest.

For soft tissue defects that cannot be closed by direct suturing, skin graft remains a simple yet effective mode of coverage in the trauma setting. However, there are contra-indications to graft application, viz., bone without periosteum, cartilage without perichondrium and tendon without paratenon. These are indications for flap coverage.

Timing of Reconstruction

Providing cover, especially in the limbs after 5 to 7 days, even if performed before 10 days, delays bony union [1,2]. The International Committee of the Red Cross recommends an interval of five days from injury within which wound coverage should be attempted. Marko Godina, in his pioneering work, reported excellent results with regards flap failure, infection rate and bony union in a group of patients with limb trauma reconstructed within 72 hours. This compared with significantly inferior results in reconstructions done later [3]. Lister et al in 1988 introduced the concept of emergency free flaps that are performed within 24 hours of injury [4].

Regional Nuances

General considerations suffice for the body areas in general. However, there are some areas of the human body that have peculiar characteristics that have to be respected for reconstruction.

Head and Neck

The excellent blood supply to the face has facilitated the development of procedures not possible elsewhere in the body. Degloved, contaminated and infected fractures often heal uneventfully following immediate fixation [5]. There has been a move toward the early and total repair of facial injuries, often within the first few days or hours of injury [6]. Primary bone grafting can be done without increased infection rate. This is believed to result in much better functional and aesthetic outcomes. With long delays (around 14 days), soft tissues become adherent, making repair difficult [5].

Primary suturing or even local flaps give better colour and texture match for reconstruction of soft tissue defects than skin grafts which often impart an unnatural look to the reconstructed face. However, for smaller areas on the scalp, skin grafts may suffice.

Chest

Bony chest wall defects comprising a diameter greater than 5 cm or more than four ribs may result in flail [7,8] with paradoxical respiratory motion and abnormal

ventilation. Through proper skeletal reconstruction, chest wall flail may be avoided and respiratory function preserved. Skeletal reconstruction can be done by autogenous bone graft or alloplastic material. For soft tissue defects, flap coverage is superior to skin grafts. This is because underlying ribs can be readily exposed and also the mobility of the chest wall with respiration will hamper the take of a graft.

Abdomen

Reconstruction of the abdominal wall depends on the understanding of the forces on the abdominal wall that lead to hernia formation, prompt closure of open wounds and the conversion of enteric fistulae into ostomies, delaying definitive reconstruction until patients are well-nourished and have closed wounds. Early wound closure has multiple benefits, including patient comfort, ease of wound care and a decreased incidence of entero-cutaneous fistulae [9]. The most reliable method of wound closure is with skin grafts. The visual clue that the open abdomen is ready for skin grafting is that individual bowel loops are no longer discernible amidst granulation tissue. During the period that the wound is being prepared to take a graft, biologic dressings and even the Bogota bag can be used to prevent bare intestinal loops from dessication. Three to six months must pass for the wound to soften before definitive reconstruction [10]. An easy rule to remember is that if the hernia is expanding, it is ready to be fixed. Delayed reconstruction is by excision of the skin graft and closure either by mobilization by the component release or by using expanders at the edges of the defect and then advancing the expanded flaps to cover the defect. When both skin and abdominal wall are deficient in the midline, the procedure of choice is abdominal wall reconstruction using bilateral myofascial rectus abdominis flaps. Referred to as "components separation", the operation described by Ramirez moves the laterally displaced skin and rectus muscles toward the midline [11]. Loco-regional flaps such as the tensor fascia latae or the antero-lateral thigh flap can also provide coverage. A prosthetic mesh is the gold standard of repair for the abdominal wall.

Limbs

The peculiarity of limbs is that any trauma, especially with soft tissue loss, would expose the underlying skeleton. As skin is at a premium and cannot be stretched primarily for coverage, flap coverage often has to be resorted to. Today, the management of open fractures consists of early and thorough debridement of wounds, the avoidance of soft tissue closure under tension, the stabilization of fractures, the use of appropriate antibiotic prophylaxis and where indicated,

the application of free tissue transfers. Internal bony fixation in the presence of a well-excised and immediately covered wound does not increase the rate of infection [12]. The key to early bony healing is adequate debridement and early definitive skin and soft tissue coverage. A limb that is finally flail, painful, insensate and non functional will be inferior to amputation and prosthetic fitting. This is particularly true in the lower extremity where modern prosthetic appliances have proven to be effective in the restoration of almost normal function [13]. Exhaustive work done at Kleinert Institute, Louisville, USA, has conclusively proven that salvaged upper limbs are functionally better than the best available prosthesis [14]. The Indian experience suggests that patients prefer to retain their own limb, even though deformed, provided it is painless and retains function [12]. This is true even for the lower limb and therefore, all efforts should be made to salvage the injured limb.

Reconstructive Surgery in Burn Injuries

In the combat setting, an important and major component of traumatic injury is thermal injury. Like other trauma, burn injuries are also not generally considered for urgent reconstruction. While superficial burn wounds heal by epithelization within 14 days [15], the ideal treatment for the deep burn wound is early excision and coverage by autografts. This was propagated by the legendary Janzekovic four decades back [16]. Early excision and grafting results in increased survival, decreased infection rates, and decreased length of hospital stay. For patients who report late, either after 5-7 days or in overt sepsis, with raw areas that have or are not healing, the road to recovery is arduous. The sepsis has to be aggressively combated and wound coverage can be provided only after the patient has stabilized. In the recovery period, they develop functionally incapacitating contractures that need staged reconstruction.

If the patient with deep wounds reports late after hideous hypertrophic scarring and grotesque contractures have set in, the contractures have to be released and the resultant soft tissue defects covered with either split thickness skin grafts or with flaps. The timing of surgery is also important as most are released once the scars have matured, roughly 9-12 months after healing of the raw areas has occurred, to minimize wound-healing complications. However, if the function is grossly compromised, especially in patients with incapacitating microstomia, eyelid contractures threatening exposure keratitis and, severe neck and hand contractures, they can be released even through immature scars.

Recent Advances

The concept of negative pressure dressings was

introduced by Argenta [17]. It was found that negative pressure on a wound would decrease edema and bacterial count, promote contraction of the wound, and promote granulation. Many wounds that were difficult to manage could be tackled with simpler reconstruction, often a skin graft. The vacuum dressing gives the patient and surgeon time to transform a hostile wound into a manageable one [18]. It is of considerable value in the Armed Forces, especially if the patient cannot be transferred early to a trauma centre due to logistic problems or inclement weather.

Patients with extensive burns leave few available donor sites for autologous skin grafting. Over the past two decades, the concept of cultured epithelial autografts (CEA) was developed, wherein a small skin biopsy of the patient is used to culture and expand keratinocytes in the laboratory into stratified layers of cells that has allowed for the development of pure epidermal replacement. However, apart from taking long (3 weeks) to be produced, which is a major drawback as the patient combats severe sepsis during that period, the retarded formation of basement membrane structures using CEAs alone results in high rates of culture loss and infection. As a result, CEAs have fallen into disrepute. In the past few years, the introduction of an autologous cell suspension (spray-on skin) introduced by Wood has rekindled interest in the subject. Cell Spray is a cultured epithelial autograft suspension that is sprayed onto injured skin in order to provide a rapid epidermal cover within 5 days [19].

Dermal replacement provides a more formidable challenge. The complex acellular dermal structure and the inability of dermis to regenerate have prevented the development of cultured dermis. A number of products such as Integra, Alloderm, TransCyte and Dermagraft have been developed over the past three decades that can serve as dermal replacement in combination with a thin split-thickness autograft. Though effective, especially in small areas, the cost of these products remains prohibitively high.

Trajectories of the Future

Recent developments in the field of robot-assisted microsurgery (RAMS) have promised encouraging results with this technology. RAMS allows performing high dexterity microsurgical operations with the help of robotic arms. The surgeon actually does a better, more precise, dexterous and highly controlled microsurgical procedure under high magnification resulting into optimal microsurgical outcome [20]. This not only means less strain on the surgeon but also may excitingly increase the surgical life of the trauma reconstructive surgeon. No longer does he have to retire if he develops tremors;

the robot can dampen the quivers effectively.

Though the NASA played an important role in early development of telemedicine [21], reconstructive surgeons have been slow to embrace it. Through the technology, trauma reconstruction can be given a shot in the arm with medical care providers getting opinions from experts across the country or the globe, especially in managing the challenging patient.

The stem cell boom, especially the embryonic stem cells in science has engendered global controversy [22]. If legislatively allowed, this can bring about a revolution in tissue engineering, especially in the field of trauma reconstruction. A horde of skin substitutes, blood vessel and neuronal conduits, polymer scaffolds for soft-tissue defects, skeletal muscle tissue, cartilage and bone can be swiftly produced for replacement of the lost tissue.

Conclusion

Managing the injured survivor in combat is indeed a formidable challenge, especially as such patients are treated quite often by single specialist surgical teams. Owing to paucity of time and resources, often reconstruction for the traumatized patient is not forthcoming. For the patient who is heroically saved, this can spell doom in the form of serious morbidity and poor quality of life in the after-years. There is a need for early evacuation to a trauma centre and reconstruction for these patients before the contaminated wounds get infected.

Conflict of Interest

None identified

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