Conflict Rehabilitation

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The Key Principles of Successful Rehabilitation of Patients with Ballistic Trauma

1. Early Assessment.
2. A multi-disciplinary team approach.
3. Active case management.
4. Evidence based to rehabilitation.
5. Rapid access to further specialist opinion and investigation.

32.1 Introduction

The rehabilitation of patients who have suffered multiple injuries is a critical element of the patient pathway. There is a duty to those injured either through military service, criminal act or terrorist attack. Providing the best possible care for these patients involves maximising their physical, psychological and social outcome. The aim is to take a casualty from point of wounding through surgical and medical management to rehabilitation and eventually return them to highest possible levels of function and integration back into military duty or society. Recent conflicts have challenged combat casualty care, military rehabilitation services and society as a whole [1–3].

Rehabilitation in this group of patients is complicated by a number of factors. There are frequently multiple injuries which include the musculo-skeletal, and neurological systems therefore it is not possible to compartmentalize treatment to one therapeutic approach. Psychological factors will be a major influence on long-term success of rehabilitation. Exposure to psychological trauma prior to injury, the death of colleagues, friends and family, the near death experience itself, disfigurement and

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perceived disability will complicate rehabilitation outcomes. Patients with similar injuries from similar circumstances may have widely different outcomes because of the individual's emotional response to the traumatic event. Similarly, mild traumatic brain injury can have devastating consequences—as it can impact on cognition and adaptability to life-changing events.

32.2 Early Assessment

Assessment of a patient needs to occur as soon after the point of wounding as possible to identify rehabilitation needs and to initiate earliest stages of physical rehabilitation This will include the intensive care unit. Psycho-social factors can be identified and peer support can be initiated.

32.3 Use of a Multi-Disciplinary Team

The medical consultant-led MDT is vital in these type of cases. The complexity and multi-system nature of these injuries means that they cannot be allocated to single therapy teams. A multi-disciplinary team might include:

- Medical staff
- Physiotherapists
- Occupational therapists
- Social work/welfare workers
- Exercise therapists
- Prosthetists
- Podiatrist/orthotists
- Mental health and psychology support

There must be regular multi-disciplinary team meetings with goal setting and treatment planning for each patient.

32.4 Active Case Management

Active case management means that a patient's care pathway is planned from injury, throughout their acute management until they are discharged from rehabilitation. Relying on multiple external agencies to coordinate their activities is unrealistic and frequently leads to failure of the pathway. The rehabilitation MDT is the key to facilitating the ongoing medical and social management of the patient. There is a need to coordinate medical care (including ongoing surgical review), investigations, equipment (e.g. wheelchairs) and social and welfare support. This may include planning for resettlement into supported living environments. If one tennet of this approach fails e.g. timely provision of equipement, then the whole effort is compromised.

32.5 Exercise-Based Rehabilitation

Exercise-based rehabilitation relies on the physical training of the injured body to enhance function, improve well-being and generate confidence. This relies on an understanding of tissue healing processes, exercise physiology and the ability to modify exercise programs to suit patients with multiple concomitant injuries. While trained physiotherapists should oversea this therapy, in the UK military, they are assisted by physical training instructors who have undergone additional training. This exercised based rehabilitation is typically delivered to groups of patients with similar levels and types of injuries.

32.6 Rapid Access to Further Specialist Opinion

Rapid movement along the treatment pathway from reconstructive to rehabilitation phases is desirable. However, this may mean that there is need for several follow-up surgical procedures including orthopedic, plastic and reconstructive surgery occurring during the rehabilitive phase of treatment. This may draw upon the skills of the original surgical teams or alternative specialist units with experience in, for example, neuro-urology and peripheral nerve injury. Psychiatric services and psychological support are essential.

32.7 Rehabilitation Process

The rehabilitation process will vary between services and what is outlined below are based on the principles used in the UK Armed Forces and is coordinated through the Defence Medical Rehabilitation Programme. This has at its core the main specialist rehabilitation unit at the Defence Medical Rehabilitation Centre. Supporting this are Regional Rehabilitation Units, which are supported by Primary Care Rehabilitation Facilities—physiotherapy-led departments. Not all trauma rehabilitation requires secondary care services and as patients spend more time at home and work they will rely on primary care support.

Rehabilitation is an interactive process with patients attending for 3–4-week periods of treatment, a period of recovery or consolidation at home or work, followed by readmission to provide further rehabilitation and a more intense level of therapeutic exercise or intervention.

The process comprises the following elements:

- Patient tracking
- Patient assessment
- Goal-setting
- Treatment planning
- Exercise-based rehabilitation
- Case management
- Discharge—readmission cycle

- Discharge planning
- Vocational rehabilitation
- Reintegration into society
- Follow-up

32.7.1 Patient Tracking

Effective rehabilitation depends on the ability to deliver the appropriate care package to the appropriate patient at the appropriate time. Identification of casualties who require rehabilitation may be challenging. The most seriously injured will pass through a hospital to undergo definitive reconstructive surgery and may require intensive care. The patient will be identified from the onset of trauma and a rehabilitation programme set in motion. Less seriously injured patients may have only transient periods in a secondary care facility and and be discharged to local physiotherapy services. The risk of this process is that apparently minor injuries with significant functional sequelae are passed to inexperienced services. These cases may be at greater risk of severe psychological disturbance than the more severely injured. There is a tendency to underestimate the severity of some injuries and the psychological consequences of even minor trauma may be significant.

To avoid the loss of patients from rehabilitation services the UK Armed Forces have developed a patient tracking system. The patient's journey through the pathway can be monitored and the appropriate medical service notified of the patient's whereabouts and needs. The experience of civilian trauma centres—particularly in moments of extreme demand—suggests that similar tracking systems need to be in place to ensure patients are correctly referred for rehabilitation.

32.7.2 Patient Assessment

The medical team play a critical part in the initial stages of the rehabilitation process when the patient may not be medically stable. Rehabilitation must commence on ITU but for the patient to be able to make significant progress he or she must be medically stable, free from serious infection and not undergoing frequent medical procedures which interfere with the continuity of rehabilitation. Wound or skin contamination with organisms such as MRSA does not exclude treatment but will alter how the patient is managed. Pain needs to be controlled and an understanding of pain management including neuropathic pain is vital.

32.7.2.1 Key Elements in the History

- Nature of wounding, single or multiple entry wounds
- Level of energy transfer
- History of impairment
  - Did impairment arise at the time of wounding or later in the course of the condition?

- History of loss of consciousness
- Pain quality and level
- Time on intensive care
- Nature of surgical and medical interventions
- Patient perception of injuries
- Social history
- Home support
- Past medical history
- Current medication
- History of psychological disturbance in particular nightmares, flashbacks, and intrusive thoughts. Changes of mood
- Cognitive deficits; word finding difficulties, memory, concentration, and executive skills
- Sensory deficits including tactile, visual, and auditory

32.7.2.2 Examination Skills

It is essential that the examiner has skills in both musculo-skeletal and neurological examination to diagnose deficits, record impairments, and monitor change.

32.7.2.3 Multi-Disciplinary Assessment

A multi-disciplinary assessment is vital. Assessments by medical, physiotherapy, occupational therapy, social work, exercise therapy, and nursing staff inform the rehabilitation plan. After a multi-disciplinary assessment good communication in an MDT meeting will produce a problem list from which goals are set and a treatment plan derived.

Goal Setting is an important element of the rehabilitation program. Goals need to be set over the long (6 months), medium (2–3 months) and short term 3–4 weeks. The SMART (Specific, Measurable, Achievable, Realistic, and Time bound) model is frequently used. Critically, they need to be set in discussion with the patient, although frequently patients—particularly service personnel—need to be given guidance so as to avoid setting unattainable goals in unrealistic time frames. Alternatively, their goals may be very general and therefore difficult to extrapolate a treatment plan from—'I want to return to running'. Once long-term goals are set the shorter goals can be developed. Goals must be set in accordance with the patient's wishes and personal aims.

For example:

Long term goal	In 6 months I will return to part-time sedentary work
Medium term goal	In 3 months I will be walking on my prosthetic for 1 km using one stick
Short term goal	At the end of this 1 month admission I will be wearing my new prosthesis for 3 h/day.

It may be necessary to determine goals over even shorter periods, such as week, in order to demonstrate to the patient measurable improvement in their function when they are sceptical of their progress. Alternatively, patients may need short-term goals in order to rein-in their over-enthusiastic activity detrimental to their

outcome. Patients may need encouragement and support to improve their performance but many cases require limitation to be placed on their activity—particularly in high achieving military or sporting personnel.

Goal setting should focus on occupational outcomes when dealing with people capable of returning to functional employment. A lack of focus on this aspect of rehabilitation will limit overall vocational outcome. Returning patients to work demedicalises them and reaffirms their usefulness to society and family.

32.7.3 Treatment Planning

Treatment goals are set after discussion between the therapy staff, doctors, and the patient. Patient involvement is critical to success and may require involvement of the family and their employer. Ideas, concerns, and wishes may need to be explored and an explanation of the treatment and the prognosis improves a patient's concordance. A joint treatment plan is produced which includes the timelines for treatment, and indicates the external agencies to be involved, including employers and social services. Decisions should be recorded on a shared MDT document and actions identified for individual therapists and doctors to perform.

Once rehabilitation has commenced regular MDT planning meetings are essential and progression recorded and discussed with the patient. Regular review of the patient is essential and planning for discharge should take place as soon as the patient is admitted.

At discharge, there is readmission planning and a selection of goals to be carried out whilst the patient is at home, which allows for continued progression and improved progression on return.

32.7.4 Delivery of Exercise-Based Rehabilitation

In UK military, rehabilitation is undertaken over short periods—up to 4 weeks at a time and much of the structure of rehabilitation focuses on exercise which is frequently delivered in a group setting.

32.7.4.1 Group Therapy

Exercise therapy is usually delivered in groups with each group being composed of patients having similar injuries and level of function. All groups complete a varied daily program of 5 h of exercised-based activity that includes: Class Therapy, Hydrotherapy, Postural Re-education, Walking/Running and Gait Re-education, Recreational Therapy with individually tailored treatment programs. Many of the outcomes rely on the training benefits of exercise and therefore dependent on the intensity, frequency and duration of exercise.

Peer support is important in overcoming the psychological consequences of this trauma and group therapy is a major contributor to this. Being surrounded by injured patients from similar backgrounds and experiences aids concordance with treatment and improves recovery. External social interactions are vital at an early stage in the rehabilitation to improve long-term social integration.

32.7.4.2 Physiotherapy

Physiotherapy is a key component of the rehabilitation service provided for patients with severe physical injury. Treatments typically take place on a one-to-one basis. Core skills include manual therapies such as mobilization, manipulation, soft and deep tissue massage, and scar tissue mobilization. Physiotherapists will provide orthotics, correct gait abnormalities and muscle imbalances, provide stretches, exercise therapy, and advice on progression. They supervise the exercise therapy and may use acupuncture and a number of electrotherapy modalities particularly for pain relief.

32.7.4.3 Social Work

Specialist medical Social Workers play a key role in the rehabilitation process and should have expertise in health-related issues that individuals or families may experience following trauma or illness. They offer the following services:

- Assessment and Counseling
  - Guiding the patient and their family along the process of adjustment, providing support and assisting the individual and their relatives to plan for change.
- Care and Discharge Planning
  - Providing information about resources such as, resettlement and retraining opportunities, housing, welfare benefits and access to legal advice.
- Advocacy
  - Representing the patient view at clinical meetings and with outside agencies such as Housing Departments or welfare agencies.
- Resettlement
  - The Social Worker, in conjunction with the Occupational Therapist, will advise patients on opportunities for vocational assessment and retraining.

32.7.4.4 Occupational Therapy

Occupational Therapy enables patients to be as independent as possible in activities of daily living, their chosen occupations or leisure.

They provide the following services:

- Education and practical advice about the nature of the injury and how to deal with its effects on their lives. Advice on work, personal care, and leisure activities.
- Activities of Daily Living
  - Assessment and treatment of limitations of personal care. This may involve home visits to advise on equipment or adaptations that are required to improve safety and aid independence.
- Provision of Equipment
  - Specialized equipment to solve the problems of temporary or permanent disability e.g., wheelchairs, bathing aids, pressure garments, and cushions.
- Community Living Skills
  - Assessment and training in community living skills such as traveling on public transport, shopping, and accessing local community facilities. Driving assessments and advice on equipment and adaptations to enable individuals to return to driving.

- Emotional Support
  - Practical support and coping strategies to help patients adjust to their limitations and explore their concerns.
- Cognitive Rehabilitation
  - Assessment and treatment of the functional impact of cognitive problems such as memory, concentration, and processing in brain injury.
- Work Skills
  - Assessment of skills and advice on strategies and adaptations that can be implemented to improve return to work. Through a graded program of work hardening, individuals can be gradually introduced back to their trade. If they are unable to work, recommendations can be made regarding future employment, training, or rehabilitation.

32.7.4.5 The Nursing Team

A named nurse is responsible for a nursing care plan for the patient and for supporting the patient through his rehabilitation. The nursing team requires nurses knowledgeable in orthopedics, neurological rehabilitation, amputee care, spinal injury, sexual dysfunction, mental health and continence care. Of particular importance is tissue viability expertise for multiple wounds, split skin grafts, reconstruction flaps and burns. Nursing staff assist patients with activities of daily living in order to promote and encourage independence.

Nutritional support is critical in enhancing the recovery of patients who have been in a highly catabolic state for many weeks and who need nutritional support during a period of intense physical activity. PEG feeding may be required in more dependent patients.

32.7.5 Case Management

At all times, the rehabilitation program should focus on reintegration of the patient into society at work or home. There requires coordination of external agencies involved in this, including Social Services, the Health Service, the employer, and housing agencies. On-going specialist medical investigations and treatments may be required, for example urodynamics to inform bladder management in the spinal cord injured patients or bone infection management. The consultant which leads the MDT is responsible for the case management of these cases and must ensure the rehabilitation process is a smooth as possible.

32.7.6 Discharge: Readmission Process

The scheme below demonstrates a program for serial admissions to a complex trauma rehabilitation team. Patients are admitted for approximately 4 weeks at a time. Within 10 days the goals for that period are stated, agreed, and written in the MDT summary. At discharge Readmission goals are set for the patient to achieve while they are away and for the first 10 days of their admission. At the end of the

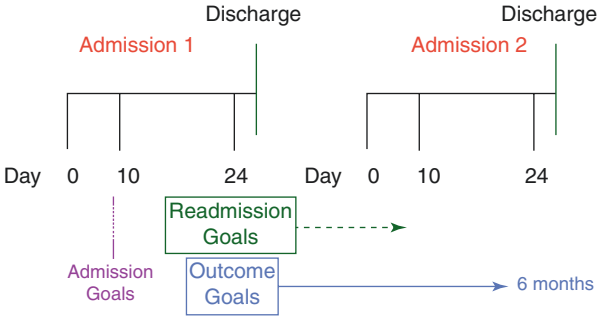

Fig. 32.1 The discharge: readmission process

first admission long term Outcome goals are set to determine what is expected to be the clinical outcome after 6 months. In this way a series of admissions are conducted with greater periods of time away on sick leave, or later, back at work (Fig. 32.1). This system allows for a greater throughput of cases.

32.7.7 Discharge Planning

The MDT must work closely with the patient, their family, and outside agencies to co-ordinate a package of care that meets the needs of the patient. This often involves liaising with Health Authorities, Social Services, and other external organizations to negotiate the appropriate level of support for the individual. A main focus of rehabilitation is on returning to work and to facilitate this vocational Occupational Therapists can liaise between the MDT, the patient and their employer to ensure that the maximum number of patients return to gainful employment. Where appropriate the patient will be sent to their workplace for a period of work assessment; if this is not possible patients will be supported with further neurological and/or vocational rehabilitation.

Reintegration into society may be difficult and will depend on a number of factors including, the physical, mental, and cognitive status of the patient, the family support the individual receives, and the support from society itself.

32.8 Measuring Outcome

Outcomes can be measured in a number ways:

- Success of the team in accurately predicting goals, using goal attainment scaling
- Repeated measurements of standardized physical tests e.g., 6 min walk test, multi-stage fitness tests
- Patient Reported Outcome Measures e.g. SF 36, Reintegration to Normal Living Index (RNLI)

- Validated questionnaire-based therapist completed outcome measures e.g. SIGAM, AMP Q, Mayo-Portland Adaptability Inventory 4 (superior to FIM FAM in this patient population [4])
- Return to work data

32.9 Specialist Rehabilitation Issues: Amputee Rehabilitation

32.9.1 Considerations

Rehabilitation of the patient who has sustained an amputation as a result of a ballistic injury requires special consideration. The majority of cases of amputation in the developed world affects the older population, over the age of 50 with diabetic or vascular causes of limb loss. The population affected by trauma is younger and has higher levels of physical function and expectation of recovery [5]. The increase in disabled sport, particularly in response to the Paralympic movement, has demonstrated the high level of functional outcome attainable from these patients and has set the bar higher for clinical success. However, as described in Chap. 31, following ballistic injury residual limbs may be irregular and have more scarring [6] providing a greater challenge to the prosthetist compared to a more typical elective dysvascular amputee.

The improvements in the technical provision of prosthetic components have revolutionized the prognosis for patients with amputations. In particular socket-suspension system developments have significantly improved comfort and practical function.

32.10 Principles of Prosthetic Fitting

There are seven elements to a prosthetic prescription depending on the level of amputation [7].

32.10.1 The Structure

In developed medical societies the usual structure is the endoskelatal form of prosthesis, which consists of metal or composite materials (e.g. carbon fibre) strut attached to the end fittings which may be covered by a cosmesis. The structure holds the socket in the correct linear and angular orientation.

32.10.2 Socket

Transmits the forces between the residual limb and the prosthesis;

- Vertically for weight-bearing in the stance phase and some suspension in the swing phase

- Horizontally and rotational about the long axis. To stabilize the socket and energize the prosthesis.

The socket shape is usually a modification of the residual limb shape as it has to take into account the contained skeleton, the consistency of the soft tissues, the limb volume and pressure sensitive areas. It is possible with the development of osseointegration as discussed in Chap. 31 that traditional sockets may become unnecessary in some cases.

32.10.3 Suspension

This may come from the socket shape and material or additional belts. More commonly in this patient population the use of silicon suspensory sleeves with ratchet or vacuum suspension systems the gold standard. These systems give the patient more freedom of movement, greater comfort, are well-tolerated and are robust. Their selection is usually based on personal preference and tolerance [8]. They allow good suspension particularly for high performance amputees where residual limb shape or scarring is less than optimal. They may increase sweating, but this frequently adapts, can be corrected by better fitting or can be treated with aluminum based deodorants or botulinum injection.

32.10.4 The Ankle and Foot

Are usually considered as one unit and have to transfer forces between the prosthesis and the ground but also have to modify this transfer in the gait cycle. This may be provided by a mechanical uni-axial joint providing movement in one plane only or a flexible bush allowing multi-axial movement, an assembly of spring components producing multi-axial movements or compression wedges at the heel. High performance limbs for running may use a spring system like the carbon fibre Flex-run® or Cheetah® systems.

32.10.5 Knee Joint

These joints may be uniaxial or polycentric and whereas there are many knees, including the simplest locked systems only released for sitting—the patient population in this situation usually require high performance prosthetics.

The most significant innovations of recent years for the trans-femoral amputee have been the introduction of microprocessor controlled knees such as the C Leg® or the Genium® These systems have revolutionized knee control, particularly where stability is critical in such as the bilateral trans-femoral amputee.

These systems use a knee-angle sensor to measure the angular position and angular velocity of the flexing joint. There are moment sensors, using multiple strain gauges, to determine exactly where the force is being applied to the knee from the

foot and the magnitude of that force. Measurements are taken 50–100 times a second. A microprocessor receives signals from each sensor and determines the type of motion and phase of gait of the amputee. The microprocessor directs a hydraulic cylinder to control the knee motion accordingly.

These systems can provide a close approximation to an amputee's natural gait and increase their walking speeds. Variations in walking speed are detectable by the sensors and communicated to the microprocessor, which can alter the swing through stance phases of the prosthesis. The knee system will allow the amputee to walk down stairs with a step-over-step approach, rather than the one step at a time approach used with mechanical knees and it can deliver additional stability in other contexts—including recovery from stumbles.

The microprocessor, however, are expensive, are limited by battery time, susceptible to water damage and require a lot of patient training. The price may be outside the range of most developing nations and may not be funded by health commissioners, even in developed countries. Nevertheless, they can dramatically help the bilateral trans-femoral amputee, significantly increasing their physical activity during daily life and an improved quality of life [9].

32.10.6 Hip Joint

In the event of hip disarticulation or trans-pelvic amputations a hip joint is required. Fortunately, this is a relatively rare phenomenon [6] as the functional limitation on such patients may be severe. The hip joint will need to be mounted onto the anterior inferior surface of the socket, in order to allow the patient to sit. It may be uni-axial, polycentric or may incorporate one of the microprocessor joints described for use in the knee. Given the severity of the injury, initial mobilization is relatively straightforward as the shallow nature of the hip disarticulation socket means that the patient, for all practical purposes, 'sits' on the socket when walking.

32.10.7 Miscellaneous Units

Axial units will allow rotation about the long axis of the prosthesis against resistance—provide greater freedom of action and reduce the torque applied between the socket and residual limb. This is of particular use in high functional end patients for example in those who wish to play golf where a rotational motion would aid the swing.

The successful provision of a prosthetic limb to an amputee relies on close interdisciplinary working with all members of the team. The prosthetists, prosthetic technicians, and physiotherapists must work closely to provide equipment which fits and which the patient knows how to use. The particular prosthetic skill is in the provision of a comfortable well aligned socket.

Residual limb volume rapidly changes in the earliest stages of rehabilitation and may continue to decrease for up to 2 years after amputation. Early use of

compression socks such as the Juzo® will aid this and reduce healing time. The rapid loss of volume will lead to a need to use additional socks to ensure a comfortable fit with the prosthesis. When the volume has changed significantly a socket change should be done as rapidly as possible so that time is not lost from rehabilitation and the patient does not become frustrated or disillusioned. This can be expensive and time consuming as sockets may need to be changed every 6 weeks.

32.11 Neurological Rehabilitation

Ballistic injury can affect any aspect of the peripheral and central nervous system. The most devastating are the consequences of traumatic brain injury as described in Chap. 14. The neurological rehabilitation team at the Defence Medical Rehabilitation Centre provides comprehensive assessment, rehabilitation, and management of neurological illness and injury for a range of conditions including brain injury, stroke, and neuro-degeneration. The majority of cases are acquired brain injury as a result of road traffic accidents and assault—the same principles apply for treatment whether there has been a closed or open injury to the brain.

The aim is to provide an intensive program of rehabilitation including vocational assessment, which is delivered by a specialized and experienced multi-disciplinary team. The structured program of therapy addresses the physical, cognitive, communication, psychosocial, vocational and daily life issues. Involving families and carers in the patient's recovery is essential.

The principles of management are identical to other areas of rehabilitation but the length of treatment required is longer and the pace of treatment slower. It is good practice to assign a key worker to each patient to co-ordinate their treatment and to liaise with the patient and their family, about any areas of concern.

Cognitive deficits frequently overshadow physical deficits as the cause of difficulties in social adaptation, independent living, family life, and vocational activity. Without appropriate intervention, cognitive deficits can lead to frustration, anxiety, depression, and social withdrawal. Cognitive rehabilitation is provided by specialist occupational therapists. It focuses on regaining those cognitive skills, which are lost or altered as a result of neurological trauma or illness. The process includes gaining skills through direct retraining, learning to use compensatory strategies and education about cognitive skills.

32.11.1 Mild Traumatic Brain Injury

Recently there has been increased awareness of mild traumatic brain injury. This has fallen out of the observation that a number of soldiers, particularly from US deployments, have displayed cognitive deficit after exposure to blast, in the absence of evidence of other ballistic trauma, and a causative relationship inferred. This has generated a significant degree of medical controversy [10, 11], not least because of confusion over terminology. A severe brain injury may leave a patient with major

cognitive impairment and other impairments—but the outcome is highly unpredictable. For example, there is a poor correlation between Glasgow Coma Scale at time of injury and prognosis. It is possible that a severe acute injury leaves a patient with only mild functional impairment; conversely a minor injury can produce socially devastating consequences.

32.11.2 Lessons Learnt in Rehabilitation from Recent Conflicts

32.11.2.1 Injury Severity at Presentation Is Not Associated with Long Term Vocational Outcome

Injury severity scores such as the ISS and GCS should not be considerd predictive of long-term prognosis, quality of life or employability therefore frontline military clinicains should be encouraged to actively intervene and treat patients with severe traumatic brain injury in the knowledge that recovery is possible. Ninety-three percent of those patients with brain injury and an ISS of 75 were capable of returning to work 4 months after the completion of rehabilitation [12].

32.11.3 Attempt Limb Salvage

As described in Chap. 31 the decision regarding limb amputation or salvage is challenging. It is reasonable to try and preserve an injured limb if possible and allow further surgical interventions and rehabilitation to try and maximise function and minimise pain. Painful limbs of limited function can be removed at a later date if necessary. Most patients are glad to have the opportunity to make an informed decision for themselves later. The literature is inconclusive about whether limb salvage or amputation is more effective in terms of hospital stay, pain and functional outcome [13]. But data from our group has shown that patients with unilateral amputations can walk further in 6 min than a limb-salvage group and those patients with limb salvage were less capable of running independently than amputees. The unilateral amputation group demonstrated a significant functional advantage over the limb-salvage group. Those electing for below knee amputation later, still achieved superior functional gains compared to limb salvage cases and experienced no functional or mental health disadvantage compared to those who had an immediate amputation [14].

32.11.4 The Ideal Stump

The technology now available for fitting limbs in this patient population allows a wide degree of flexibility in stump length, quality and scarring. Healed split skin grafts will usually tolerate the silicon sleeves and suspension systems well.

In the trans-tibial amputation an optimal range would be 12–16 cm when measured from the medial joint line and in trans-femoral 14–21 measured from the crotch, or 23–30 cm measured from the tip of the greater trochanter. Ideally, the optimal stump length should be proportional to the overall stature of the patient. An

'ideal' length of 16 cm in someone with short legs may not leave enough ground clearance to fit in the total length of the modular components in the prosthesis. This may be particularly critical in the high performance amputee where the prosthetic componentry may need to be longer. In a trans-tibial amputee an approximate guide is for 8 cm of stump length per metre height. Anything shorter than 7 cm in a trans-tibial is very difficult to fit. In the trans-femoral patient a gap of 15 cm above the medial tibial plateau is described as ideal for fitting a knee joint system in place whilst retaining a sufficient lever arm. Often of greater difficulty is the management of a bulbous residual limb. A residual limb with a distal circumference greater than that measured at the level of the patella tendon can be difficult to fit. In the case of complex trauma choice of the residual limb length may not be open to the clinician—the prosthetist will have to deal with what they are given.

Post-operative oedema can be reduced with stump shrinkers and early mobilisation with PAM- aids (Pneumatic aid to mobilization). But excess muscle bulk is the main source of the problem. This more commonly occurs in a posterior flap rather than a skew flap technique which produces a more conical shape which allows better prosthetic fitting. However, these are deliberate decisions that should not be made in the first surgical episode and over-long or badly scarred stumps can be revised at a later date.

32.11.5 Through-Knee (Disarticulation) Can Be a Very Effective Amputation

There is considerable bias against the use of knee disarticulation as a surgical option in trauma. This is based on poor experience of the procedure in civilian practice and reflects real concerns but ones which are not always applicable to military practice [15, 16]. The main advantage of the through knee amputation is an end weight-bearing stump. Once the prosthesis has been fitted then the patient can make rapid progress to high-level weight-bearing activity and a level of function, including running, in excess of that expected from a trans-femoral amputation. Disadvantages are mainly cosmetic, as the knee system will sit at a level below that of the contralateral knee. On sitting the knee joint on the prosthetic limb will protrude further forward than the non-affected side. Lowering the centre of rotation of the joint may produce a minor biomechanical disadvantage but this is more than compensated by the stability and control gained from the long lever arm, deep socket and polycentric knee joint combined with hydraulic swing phase controls.

32.11.6 Concomitant Injuries May Be the Factor Limiting Recovery Rather than the Amputation

The functional performance of the lower limb prostheses in many of our amputees is so good and the socket/stump interface so effective in many that the main limitation to mobilisation is frequently the concomitant injury. Fractures have a rate of healing considerably slower than prosthetic fitting and multiple fractures in a

contralateral limb, particularly the foot can have a considerable slowing effect on the rehabilitation process. This frequently leads non-amputees with protracted rehabilitation due to delayed fracture union to request an early amputation. This requires careful counselling.

32.11.7 Aggressive Treatment of Neuropathic and Phantom Pain Is Critical: Non-Pharmacological Methods of Pain Control Are Important

Anecdotal evidence would suggest the importance of early, aggressive treatment with analgesics to prevent the development of neuropathic pain. This includes the use of opiates, and drugs such as gabapentin, amitriptylline and pregabalin. There should be no hesitation in using maximum doses of all this medication to obtain complete control of pain. Audit of our practice shows that, once in the rehabilitation setting, the requirement for analgesic rapidly diminishes and very few of our patients require long standing medication for phantom pain control. Education, reassurance, peer support, and physical distraction all play a part in this. Wearing the socket and physical activity often dramatically improve the pain. Other modalities such as mirror therapy and acupuncture can be very effective in certain cases although carry over can be limited.

32.11.8 Early Assessment of Peripheral Nerve Injury with Surgical Repair Will Reduce Pain and Limit Disability

It is important to avoid a nihilistic approach to peripheral nerve injury. Early expert assessment is important following primary repair and follow-up vital. Persisting pain following brachial plexus or peripheral nerve injury warrants consideration of surgical exploration and repair or grafting if needed. Monitoring progress of nerve re-growth allows interventions to be carried out rapidly if the graft or repair is failing. There may be a later requirement for tendon transfer to return function, which further demands the need for expert follow-up [17].

32.11.9 The Psychological Component to Rehabilitation Has an Influence on Outcome

It is evident that the psychological status of the patient has a major influence on physical outcome. Self efficacy is associated with good outcomes in spinal rehabilitation and probably this complexity of injury also. Depression, persistent adjustment reactions, and PTSD are all detrimental to recovery. What is remarkable is the low level of psychological morbidity detectable in these patients [18]. Peer support is an important factor in this, as is the patient having a clear sense of the long term pathway for recovery. Many patients have mild psychological morbidity in the early stages of their rehabilitation but the long-term outcomes are unknown.

32.11.10 Concomitant Traumatic Brain Injury Is a Major Prognostic Determinant of Polytrauma Outcome

In assessing outcome from polytrauma and amputation there is a tendency to dwell on the surgical and physiological factors which determine outcome. Additional injury—particularly brain injury may not be apparent at review but could have a major effect on physical outcome including donning and doffing the prosthesis, ability to understand rehabilitation instruction, balance, and return to work.

32.12 Outcomes

The recent conflicts in Iraq and Afghanistan have helped develop and test the systems described above. Enhanced survivability on operations as a result of improved combat casualty care has, by increasing the number of "unexpected survivors," resulted in considerable rehabilitation challenges. The multidisciplinary clinical teams of the Defence Medical Rehabilitation Centre at Headley Court in Surrey have worked to enhance the outcomes of severely injured UK battle casualties.

Retrospective reviews of polytrauma patients at discharge showed that, 95% (n = 62) of the complex trauma patients were independent in all activities of daily living with an aid or adaptation. Over 90% (59) of amputees, around half with multiple limb loss, walked independently over all terrains, and 75% (6) of triple amputees did not require a wheelchair for daily activities [18]. Amputees show an average walking speed and energy expenditure comparable to a normal, age matched, healthy population. Only for bilateral transfemoral amputees was the walking speed significantly slower (1.12 ms vs. 1.29 m/s, $p = 0.025$) and cadence reduced. Oxygen costs of walking for unilateral trans-tibial amputees were the same as controls and only 60% greater for bilateral transfemorals compared to controls.

From a mental health perspective combat amputees had PHQ-9 (patient health) scores compatible with moderate to severe depression in 3.1% of cases, compared with 1.6% of the general population. GAD-7 (anxiety and depression test) scores indicating severe anxiety and depression were present in 1.5%, compared with 1.3% of the general population [18].

Of 91 patients with moderate to severe brain injury 79 (87%) were living independently, and 92% (84) were in some form of employment 4 months after discharge [19]. Most of those with the worst possible ISS and GCS injury scores at presentation were able to return to work [12].

These outcomes are encouraging and indicate high quality trauma care, including specialist rehabilitation. This has significant implications for the lifelong physical, mental and vocational outcomes of these patients and will have major economic benefits for the individual person and the nation. To determine the long-term outcomes of these cases and, in particular the long-term cardiovascular risk of trauma UK Defence Rehabilitation will determine the 20 year outcomes of this cohort with the Armed Services Trauma Rehabilitation Outcome (ADVANCE) Study. This study will investigate the 20 year outcomes of battlefield casualties from the Iraq

and Afghanistan campaigns. The medical, physical, and psychosocial outcomes of this cohort will be compared with service personnel who did not sustain injuries during operations.

Conclusion

Patients injured through military service, criminal act or terrorist attack undoubtably deserve the highest quality of care available. Despite perfect resuscitation and reconstruction, without high-quality rehabilitation, patients will not achieve their full potential in terms of maximal physical, social, functional and psychological recovery.

This requires a skilled, consultant-led, multidisciplinary team with rapid access to modern rehabilitation technologies. It requires systems in place to identify and track the patient through the care pathway and needs a focus on a high expectation of functional and work-related outcome.

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