The Comprehensive Care of Spinal Cord Injuries

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Summary

The following is an overview of the incidence, causation, and management of spinal cord injury in developed and industrialized societies. Rehabilitation of those with residual disabilities is outlined with an estimate of the disabled in the community and the problems arising in provision of residential care and employment. The author's experience derives from more than thirty years' reception of spinal injuries and seventeen years as Director of the Spinal Injuries in Perth, Western Australia.

Introduction

Spinal cord injury with paralysis was known more than two thousand years ago in ancient Egypt. It was described very accurately and recognized as a condition for which little could be done and was "... not to be treated". It inevitably resulted in early death from respiratory complications or later from renal failure and fulminating sepsis from decubitus ulceration. Survivors were doomed to a life of chronic invalidism and employment was not considered. Management of these unfortunate people remained with very little advance until the commencement of the modern method of management during and just after the World War II.

Advances in treatment were largely due to the pioneer work of the late Sir Ludwig Guttmann in Stoke Mandeville in England. This commenced with his setting up of a spinal centre in 1944. His results showed that pressure sores and chronic urinary infection were preventable. He emphasized rehabilitation and returned the majority of his patients to the community as citizens able once more to play a useful part in society. His example, together with work in other countries led to development of special spinal cord injury centres throughout industrialized nations with similar centres commencing in developing countries.

The Spinal Unit in Perth, Western Australia, was established in 1954 and was the first in Australia. More than two thousand patients have passed through this centre. All have been followed up since discharge from hospital; all medical records and X-rays have been retained; in those who died, either early or late, autopsy specimens of the vertebral column and spinal cord have been obtained in the majority of cases. Nearly three hundred such specimens are available for research together with the...
The records of the neurological status and management.

**Incidence and causation of spinal cord injury**

This varies in different countries through accurate statistics are not available in very many developed countries. It is essential that the incidence of this condition is known as with modern methods of treatment there is now developing a large number of disabled citizens within the community who have nearly a normal life expectancy. Numbers of spinal injuries occurring in each community will determine the number of spinal injury units required if the best treatment is to be obtained and the disability resulting from the injury minimized.

Australia has a higher incidence than many other European countries (27 SCI/mill/per annum). This is perhaps a reflection of the high motor vehicle ownership, the lack of public transportation in remote areas, and the vast distances covered by drivers often on gravel roads in the “outback”.

The incidence in Japan (20) is assumed to lie midway between European (Switzerland 16, Germany 13) and Australian statistics, and must be only an approximation in the absence of firm statistics. These figures demonstrate that the motor vehicle and industrial development are responsible for an epidemic which has produced an increasing reservoir of disabled in the community (Table 1). This is a disease of young people affecting those in the prime of life (Fig. 1). The male to female ratio is approximately four to one (4:1).

**Early management**

**1. At scene of accident**

Management at the scene of an accident and care in the transportation of a casualty to hospital is of great importance. Ambulance personnel must be trained to immobilize the spine where injury is suspected and to treat all unconscious casualties as though they were a spinal injury until proved otherwise. A fractured spine without paraplegia may displace and result in neurological complications by poor handling by those first on the scene of the injury.

**2. The first hospital assessment**

Careful neurological examination must be carried out. The site of a spinal cord injury can be determined from the dermatome and myotome level of defect. Obvious deformity of the spine will be noted. Care must be taken to notice swelling or deformity in the insensitive areas below the injured spinal cord segment.

**3. Radiological examination**

Radiological examination of the suspected area of the spine must include good quality AP, lateral and oblique views, tomography, CT scan, and MRI where available.

<table>
<thead>
<tr>
<th>Table 1 Causes of spinal cord injury</th>
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<tbody>
<tr>
<td>1. Road traffic accidents</td>
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<tr>
<td>2. Accident in industry and agriculture</td>
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<td>3. Falls (home or recreation)</td>
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<td>4. Sports (especially diving)</td>
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<tr>
<td>5. Penetrating wounds, i.e., GSW or knife</td>
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<td>6. Natural disasters (earthquake, cyclone)</td>
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</table>
Diagnosis of the lesion is now possible.

The neurological assessment will determine whether the lesion is a complete or incomplete cord injury. The complete lesion has a defined sensory and motor level compatible with the radiological evidence of trauma.

The incomplete lesion may be: (Fig. 2)

1. a central cord syndrome affecting mainly the...
upper limbs with sparing of the lower limbs with incomplete sensory loss and with hyperreflexia. It is more common in hyperextension injuries of the cervical spine in the older age group (Fig. 2A).

2 anterior spinal artery syndrome with complete motor loss but preservation of posterior column sensation (Fig. 2B).

3 a Brown-Sequard's syndrome with motor and sensory loss on the contralateral side of the trunk and lower limbs (Fig. 2C).

Radiological assessment

On inspection of the X-rays the vertebral injury may then be classified as described by Denis. A decision can be made whether the injury is stable or unstable (Fig. 3, 4).

In a stable lesion with minimal deformity conservative management may be commenced and continued. In an unstable lesion with deformity (e.g. fracture dislocation of cervical spine) treatment may be by manipulation under general anaesthesia with X-ray control (Fig. 5), by gradual reduction through traction applied by skull calipers or halo device, or by open reduction and internal fixation. In thoraco-lumbar injuries the same criteria will apply except that manipulation is replaced by postural reduction.

Indications for surgery (Table 2)

Penetrating wounds are rare in road traffic or
industrial accidents. They are seen in certain countries where assaults by firearms (Fig. 6), and knives are not uncommon. They are also more common in civil disturbance and in wartime. Through debridement and removal of missile fragments and clothing from the spinal canal is imperative.

Burst fractures of the thoraco-lumbar spine with large bony fragments in the spinal canal require removal by anterior or posterior approach and stabilization (Fig. 7).

In incomplete cases with early signs of recovery, and where the fragments occupy less than thirty percent of the spinal canal, conservative management may continue and resorption of the fragments and remodelling of the spinal canal may occur.

Table 2 Indications for surgery

1. Penetrating wounds with foreign body
2. Irreducible facet dislocation
3. Continued cord compression
4. Spinal instability
5. Late spinal deformity

Table 3 Incidence of selected complications (Perth)

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<tr>
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<th>16~30</th>
<th>31~45</th>
<th>46~60</th>
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Table 4 Incidence of selected complications (U.S.A.)

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<td>Heterotopic ossification</td>
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Early clinical management

A decision must be made whether to continue
treatment in the small provincial hospital or to transfer the patient to a spinal injury unit with physicians, surgeons, and nursing staff especially trained in spinal injury care. Delay in such transfer may produce complications which are avoidable. When allowed to occur they complicate management and prolong hospital stay.

This is well shown in the study carried out by Donovan, et al (1980), who observed the rate of complications in those admitted early or after to specialized spinal injury centres (Table, 3, 4).

### The role of the rehabilitation specialist (Table 5)

The rehabilitation medicine specialist should be involved in the early stage of management and liaise with his surgical colleague in planning the appropriate treatment. He should be the leader of the team in charge of early and late rehabilitation. He should supervise the program from admission to discharge from hospital and follow up as an outpatient.

### Respiratory management

In high tetraplegia early mortality occurs from respiratory failure. This may be from the level of the injury (above C4 vertebral level) or from cord oedema causing ascent of the paralysis of one or more segments. Tracheostomy and assisted ventilation with intensive physiotherapy are necessary.

### Urological management

An indwelling catheter is utilized for the first four to seven days until intravenous fluids are discontinued, paralytic ileus resolved, and fluid balance charts are stabilized. One must allow for a diuresis after initial spinal shock with fluid retention has passed off. Thereafter, six-hourly intermittent catheterization with full aseptic technique is utilized. In Perth every catheter specimen of urine is subjected to laboratory culture and significant bacteruria is treated by the appropriate antibiotics.

### Nursing

A trained nursing staff must maintain postural reduction in cases treated conservatively. There must be a program of regular turning at two to four hourly intervals to avoid decubitus ulcer developing. This must be carried out by a turning team supervised by a trained nurse or by use of a turning bed such as the Egerton bed developed in Stoke Mandeville.

### Physiotherapy

Intensive respiratory treatment must be undertaken to maintain clear lung fields. All joints of both upper and lower limbs must be mobilized with a full range of movement being obtained at least once a day. A motor chart of all myotome function should be carried out on admission and repeated regularly to assess the rate of recovery.
Occupational therapist

An occupational therapist should supply resting hand splints initially and functional hand splints later to prevent contractures, and to promote some degree of independence.

Medical social worker

Very many problems arise with the sudden transition of a healthy individual into one who is totally dependent upon care. Many financial obligations require assistance in the maintenance of family and dependents. The aid of a skilled social worker may be able to remove many of the anxieties which derive from sudden cessation of the role as a family member and of the income provider.

From the sixth to twelfth week after admission

Spinal shock should now have resolved and the patient’s physiological condition stabilised. Mobilisation from bed rest will now occur or earlier if surgery has stabilised the lesion, or in cervical cases if the lesion itself has been stabilised by use of a halo vest appliance. A wheelchair is supplied by the Bio-Engineering Clinic, as also are calipers, crutches and suitable orthoses. An intensive rehabilitation program now takes place in the gymnasium and in the occupational therapy department. Recovery in the incomplete case will have begun to demonstrate itself at this stage. In some cases recovery may be delayed and commence later, up to the twelfth week. If there is no motor recovery in cases with complete paralysis on admission, then at three months one must accept the fact that useful recovery is unlikely to occur, though some sensory improvement may still be possible.

It is at this stage that one can inform the patient and relatives with some degree of accuracy, that

![Cystometrogram showing wide fluctuations in elevated intravesical pressure and corresponding variations in urethral sphincter tone as bladder is filled. Detrusor and urethral sphincter inhibited in response to anal sphincter stretch.]

![Technique of anal sphincter stretch. One or two fingers gently inserted into anal canal. Sphincter Stretched in posterolateral direction and maintained during voiding trial.]

![Cystometrogram showing persistent high sphincter tone and little variation in elevated intravesical pressure as bladder is filled (failure of anal sphincter stretch). Patient requires intermittent catheterization and may be candidate for sphincterotomy (particularly if pressures remain above 80 cm H₂O).]

Fig. 8 Urodynamics
the future life will be confined to a wheelchair, plans towards return home and future employment may be commenced.

**Urological assessment**

Urodynamic studies should now take place to assess bladder function. In the upper motor neurone bladder voiding may be stimulated by tapping the abdomen or by utilizing the anal stretch reflex (Fig. 8). Abdominal straining supplemented by the Crede manoeuvre is indicated in the lower motor neurone bladder. Appropriate medication may facilitate relaxation of the bladder neck. Self-catheterization or bladder neck surgery may be indicated (Fig. 9).

**Home assessment and alteration**

At the twelfth week stage, it is time to plan towards discharge from hospital. If the patient is confined to a wheelchair and non-ambulatory, the home must be altered to allow of entry in the wheelchair and movement within the home to essential areas such as bathroom, toilet, et cetera. The rehabilitation counsellor will meantime have been in contact with the previous employer to enquire whether there is a possibility of his being re-employed in a wheelchair capacity. Failing this, then a program of retraining for alternative employment should be considered and commenced. It may be necessary to carry out a vocational assessment to assess the optimum areas for retraining according to the patient's attitude. Where the patient is a female and confined to domestic duties normally, then much time must be spent in the occupational therapy area to learn skills of running the home from a wheelchair.
Independence in the quadriplegic

Our aim in our rehabilitation program must be restoration of all possible independence. The well rehabilitated paraplegic should be expected to be completely free of all assistance in normal living and to be able to live alone. He or she should leave hospital with a driving licence after proper tuition in a vehicle with hand controls. In the quadriplegic, independence depends upon hand function. There is a place here for reconstructive surgery. Our treatment of the patient’s upper limbs must facilitate later surgery for reconstruction.

Independence in the tetraplegic may well be greatly assisted by tendon transfer surgery, which we find is best carried out some time after six months following injury. The requirements for this are that the patient be static in recovery, to have no contractures in the joints involved, and to have no pressure sores nor chronic urinary sepsis. Our priorities are to restore elbow extension, to give a key pinch grip to the fingers and thumb, and as much return of hand function as is attainable with the level of motor loss that is present. This is attainable in the high tetraplegic at C5 level by the procedures described initially by Eric Moberg of transfer of the deltoid to the triceps (Fig. 10), and by the tenodesis of the flexor pollicis tendon to achieve a key pinch grip to the fingers and thumb (Fig. 11), which aid greatly independence. Where the lesion is lower at C6 and C7 level, then other tendons are available to restore finger flexion.
It is important that the patients and relatives understand fully the problems in spinal injury. In Perth classes are conducted in the evenings for patients and for their relatives to explain the problems arising and how best to cope with them. An instruction manual is given to every patient to teach them self-care and how to avoid complications (Fig. 12, 13). Such manual has been available for more than twenty years and has been of great use in preventing re-admission for complications.
arising after discharge from hospital.

Bio-engineering clinic

Supplies each patient with an individual wheelchair and especially sculpted cushion to avoid pressure sores. The introduction of this clinic over the past sixteen years or more has reduced dramatically the anticipated rate of re-admission for pressure sores since being established (Fig. 14). It is obviously far better not to develop pressure sores than to treat them once established.

Home visiting service

Over the past twenty years, a home visiting nursing service has been established in Perth. This is conducted by two experienced trained nurses who follow the patient through in his or her home after discharge from inpatient care. The two nurses involved in this program travelled 62,000 km in 1986–87 and were able to treat very many complications in the home before they became severe enough to warrant re-admission to hospital (Fig. 15).

Residence and employment for disabled

Approximately ninety per cent of patients treated in Perth are able to be discharged to their home, and many of those, especially paraplegics, return to normal employment in the community. However, certain patients are unable to return home. This may be because their disability requires ongoing nursing care. In Perth we have developed our residential area termed “The Quadriplegic Centre” on the same campus as our rehabilitation hospital (Fig. 16). This has residential facilities for more than one hundred patients. We have also developed industrial areas adjacent to the residential complex, where some two hundred clients are employed, all with disabilities, though not all of them of a spinal nature. This is very similar to the work of the late Yutaka Nakamura, who developed “Sun Industries” in Beppu, Oita, so many years ago.

Sport

Sport as a mean of rehabilitation was initiated by Sir Ludwig Guttmann (Fig. 17) and has become well recognized as a mean of restoring health, activity, and self respect. The figures of those disabled athletes now competing at international level are indeed impressive (Seoul Para-Olympics 1988—3,000 disabled athletes). One great value of sport is that it does demonstrate to prospective employers that a wheelchair athlete may still be able to travel internationally and become a useful employee if given certain facilities to utilise their skills.

Life expectancy

With better treatment the life expectancy of a paraplegic and quadriplegic is now not much less than the normal population (Table 6). The figures quoted are taken from an assessment carried out in Australia in 1987. It is estimated at this time that we have in Australia more than 6,000 wheelchair citizens. The cost to the community is increasing year by year (Table 7). With our greater medical expertise early mortality will go on diminishing and life expectancy must increase.

Prevention program

There is now developing in the USA and in Australia, a program which we hope will succeed in reducing the incidence of spinal injury in the community. Our programs are directed towards the younger and older children at school and our lecturers are themselves confined to wheelchairs. If we cannot yet cure spinal injury, we should do all we can to prevent its occurrence by better education of the public, by better road design, and by better vehicle construction (Table 8).
Research

Research should be both retrospective and prospective. In retrospective research we should analyse our results of past treatment and try to assess how successful our treatment has been. We are fortunate in Australia in that we have the facility of obtaining autopsy specimens of our patients who succumb both early in the acute stage and later, sometimes in the community. A study of these nearly three hundred specimens combined with our medical and X-ray records give very valuable information on the exact pathological process and how best these cases should have been managed.

Prospective research should be directed to all means of reduction of the degree of the disability on first admission. This may be by use of:

① A "bolus" steroid usage in the first six to twelve hours following injury.

② Functional electrical stimulation to enhance motor recovery.

③ Further research into nerve tissue regeneration.

④ Possibly the usage of embryonic tissue implantation, which seems to have had some success in certain cerebral conditions.

To conclude, one should remember that some forty five years ago the treatment of spinal injury with paralysis had advanced very little from that description given by the Egyptian physician more than two thousand years ago. We have now reached the stage where the majority of our patients survive with a life expectancy not far from that of normal but with a very major disability. We must continue to direct our efforts towards prevention, improved management, and making a life for those disabled in our community more productive and fulfilling.