SPINAL INJURIES WITH TETRAPLEGIA AND PARAPLEGIA

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Although the actual management is vital for success, the institution in which spinal injuries are cared for shares equally in importance. When responsibility is accepted by a multidisciplinary team, better restoration of function occurs whilst greater social and financial support is possible. The piecemeal care of spinal fractures with paralysis (Morgan, Wharton and Austin 1971; Botterell et al. 1975; Sussman 1978) is a practice endemic in every community and to be condemned. The creation of comprehensive units (Fig. 1) served by all specialties but co-ordinated by one—an emergent discipline—has allowed solution of fragmentary care (Guttmann 1977a, 1978; Botterell 1978) and has seen the emergence of new talents in seriously injured people (Guttmann 1968).

Covalt et al. (1953) and Talbot (1969) showed

![Fig. 1](image-url)
The comprehensive unit. Aerial photograph showing the hospital ward (1), the gymnasium (2) and the occupational therapy department (3) of the Royal Perth (Rehabilitation) Hospital; and the nursing unit (4), the hostel unit (5), the activity centre (6) and the workshops (7) of the Quadriplegic Centre.

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spinal injury to be costly. Such costs will escalate without comprehensive units (Young 1970; Charles et al. 1978). Munro (1943a) and Guttmann (1973) have long advocated such units. Meyer (1979) has reported such a cost benefit whilst Guttmann (1973), Pearman and England (1976) and Bedbrook (1976a) have shown a remarkable decrease in complications by multidisciplinary care.

An overall admission incidence of thirteen to twenty-seven per million per year, with figures of fifty to sixty-eight per million including sudden death, has been confirmed by the studies of Kurtzke (1975), Le Clair and Reswick (1977) and Spencer (1979). Most published reports on spinal paralysis are individual ones from orthopaedists, neurosurgeons and urologists on one aspect of care without co-ordination of other areas.

PREVENTION

Prevention of injury. Road safety measures, the constant use of seat belts and reduction in speed limits, have resulted, as Burke (1973) showed, in a reduction of 27 per cent in incidence. Trinca (1978) showed that 50 to 60 per cent of vehicular accidents are associated with alcohol, whilst water-sport accidents and football need more preventive measures adopted (Braakman and Penning 1976; Scher 1978). Education, improved rules, protective orthoses and eradication of psychogenic factors will help to lower incidence even further.

Prevention of complications. This is not impossible; their appearance is not inevitable. As advances were made by Thomson-Walker (1937) and by Munro (1943b) regarding life and management and then by Guttmann and Frankel (1966) on intermittent catheterisation and now the introduction of pressure flow studies and cystometry (Pearman 1976), so prevention has advanced. The advent of antibiotics was shattering in its benefit to treatment, and the control of infection by involving the microbiologist in the wards together with improved organisation of care has resulted in prevention of complications. When antibiotic combinations are used sparingly, bacterial insensitivity can be prevented (Pearman 1974) and the organisation of catheter and cross-infection teams (Guttmann 1954a, b; Lindan and Keane 1964; Pearman and England 1973) has had dramatic effects.

In the Spinal Unit at Perth, Western Australia, readmissions for urinary infection are rare (twelve per year) whilst those for decubiti have been reduced by 50 per cent. Total readmissions have fallen since preventive urological, pressure and wheelchair clinics were started, nursing staff visited patients in their homes and the patients were educated in the prevention of complications (Edmonds-Hill 1976).

Gingas (1973) reported decubiti as reasons for admission in 45 per cent; Fernie (1973) supported such figures, whilst Cox’s study (1975) confirmed how both prevention and treatment combined in cost effectiveness.

Spinal deformity in children with paraplegia is common (Burke 1976; Banniza von Bazan and Paeslack 1977; Hachen 1977; Hahn and Black 1977). Its prevention is difficult and as yet not well documented (Burke 1976; Bedbrook 1977b). Erect “stand alone” frames, prone trolleys instead of wheelchairs, the Milwaukee and Boston braces must all be considered. Correction should only be undertaken in comprehensive services and may be needed to prevent or correct ischial decubiti (Harrington 1963; Bedbrook 1977b).

ORGANISATION

Dick (1969) and Talbot (1969) aptly describe management of paraplegia as pre- and post-Guttmann. The historical saga is well summarised by Howarth and Petrie (1964), by Guttmann (1973) and in Vinkin and Bruyn’s Handbook of Clinical Neurology, Volume 25 (1976). “Organisation of Spinal Units” has been well discussed by many authors at the International Medical Society for Paraplegia in 1967. As to medical responsibility, clearly differing areas will have different ways of solution. The principles are clear: specially trained physicians or surgeons, full-time or maximal part-time, in comprehensive units with responsibility for extended care (Bors 1967; Bedbrook 1971a; Gutmann 1973; Bedbrook 1976a; Gutmann 1977c; Botterell 1978; Gutmann 1978). Recently Sussman (1978) criticised systems that do not provide properly for persons with spinal paralysis. Botterell (1978) showed the seriousness of the lack of comprehensive units, but did not emphasise the seriousness of passing a patient from one specialist to another. I find nothing to commend a system whereby the initial surgeon can “pass by on the other side”.

NEUROLOGY

Clinical neurological sequelae. The functional neurological sequences observed in 612 cases as recorded by Frankel et al. (1969) have become an accepted technique of review (Fig. 2). All methods (Cheshire 1969; Guttmann 1973; Michaelis 1976a; 1976b; Bracken, Webb and Wagner 1978) show that the observations of Sunderland and Bradley (1961) are confirmed: that motor function is more likely to improve than sensory function, particularly after initial sensory sparing.

In my own reviews of 1959 and 1965, figures for cervical injuries showed that 10 to 15 per cent of complete lesions became incomplete, whilst about 5 per cent of complete lumbar lesions showed improvement (Table 1). Guttmann’s figures for thoracolumbar lesions were higher at 25 per cent. All the authors who have reviewed their results (Meinecke 1964; Benassy, Blanchard and Lecq 1967; Bedbrook 1976a; Burke
Table I. Percentage of spinal injuries with incomplete or complete neurological lesions on admission and discharge

<table>
<thead>
<tr>
<th></th>
<th>Admission</th>
<th>Discharge</th>
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<tbody>
<tr>
<td></td>
<td>Incomplete</td>
<td>Complete</td>
</tr>
<tr>
<td>Cervical</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td>Thoracic</td>
<td>22</td>
<td>78</td>
</tr>
<tr>
<td>Thoracolumbar</td>
<td>35</td>
<td>65</td>
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</tbody>
</table>

Bedbrook 1959, 1965

and Murray 1976; Hardy 1977; Meyer 1979) have shown that 40 per cent of incomplete cervical injuries show useful recovery. Burke and Murray (1976) and Hardy (1977) showed that 80 per cent of incomplete thoracolumbar lesions usefully improved whilst only 11 per cent of complete lesions showed any neurological change while in hospital (Table II). Real neurological deterioration is rare (Frankel 1969) and causation unknown. A two-segment cephalic deterioration is usually temporary.

Using Frankel's grid method Young and Dexter (1978) showed that the cases treated totally conservatively at Stoke Mandeville on the whole fared better than the South-West Regional cases, although no statistical difference was found between the cases in the latter group who were treated conservatively or by operation. The differences in the two centres and the difference in results of centres were multifactorial and included the time on admission; the time of early adequate care (Gregg and Wilmott 1964; Gregg 1967); the organisation; the experience in the various centres; and the methods of management including procedural methods. Late neurological recovery. This has been suspected by Guttmann (1973) and Michaelis (1976a). My own observations (in press, Paraplegia) show that over twenty years fourteen of seventeen complete lesions developed sensation to conscious levels via alternate pathways including the autonomic nervous system, and that this recovery was of value in habilitation.

Table II. Neurological sequelae of spinal cord injury

<table>
<thead>
<tr>
<th></th>
<th>Per cent of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cervical lesions</strong></td>
<td></td>
</tr>
<tr>
<td>Useful recovery</td>
<td>41</td>
</tr>
<tr>
<td>Useful recovery in incomplete cases</td>
<td>48</td>
</tr>
<tr>
<td>Useful recovery in complete cases</td>
<td>18</td>
</tr>
<tr>
<td><strong>Thoracolumbar lesions</strong></td>
<td></td>
</tr>
<tr>
<td>Useful recovery overall</td>
<td>36</td>
</tr>
<tr>
<td>Useful recovery in incomplete cases</td>
<td>80</td>
</tr>
<tr>
<td>Useful recovery in complete cases</td>
<td>11</td>
</tr>
</tbody>
</table>

Data from Burke and Murray (1976) and Hardy (1977)

**PATHOLOGY**

This remains the basis of all care. Ever since Sommering (1793) drew attention to the severity and the gross macroscopic damage in complete cases, efforts have been made to reduce or contain the process. The macroscopic three-dimensional appearances and the observed three-dimensional clinicopathological sequence (Guttmann 1969a; Kakulas and Bedbrook 1976; Kakulas, Jacobsen and Bedbrook 1977) show the known difficulty of early correlation of the radiological appearances and the clinical state. Such studies emphasise how rare is a pathological state that can be assisted by surgical intervention. Jellinger (1976) indicated the complex microscopic changes which are dynamic in time and space. Ducker (1976) and Yeo (1976) discussed the experimental model and indicated the continuing chemical changes whilst little is yet known of the pathodynamics as far as the cord is concerned.

The biomechanical studies of White, Panjabi and Thomas (1977) have clarified, by observation of pathological changes, our concepts of stability in their emphasis of clinical instability. In human material the late changes are mostly manifestations of scarring—cysts, dural adhesions, pachymeninigitis haemolytica and gliosis have been well described by the above authors. Included in these areas are abortive attempts at
regeneration (Wolman 1964) of no significance, yet not dissimilar in type to those described experimentally by Ramon Y Cajal (1928) followed by Puchala and Windle (1977) and others.

CLASSIFICATION
Classification of all injuries including gunshot wounds must, as Guttmann (1969a) pointed out, give a three-dimensional pathological picture (Bedbrook 1975, 1977a). The simple classification first developed by Holdsworth (1963, 1970), which has served me well, is shown in Figure 3.

A consideration of biomechanical and pathological facts shows that stable injuries include crush fractures, extension fracture-subluxations and flexion-rotation injuries with less than one-third displacement. Flexion-rotation injuries with greater than one-third displacement in either plane are, however, unstable.

MANAGEMENT
Early. Good first-aid and initial care have been stressed by many (Gregg and Wilmott 1964; Guttmann 1965; Cheshire 1970; Botterell 1978) as undoubtedly being able to prevent a number of incomplete cases becoming complete. Sussman (1978) shows how poor initial care may jeopardise the entire future. All of the speakers at the 1973 Combined Conference at Scottsdale, Phoenix stressed the importance of effecting postural control immediately after the accident and maintaining it until admission to a comprehensive unit (Eisenbeiss 1977; Hardy 1977; Harris 1977; McSweeney 1977).
Clinical assessment. A detailed neurological examination by an experienced clinician followed by an accurate record of the neurological state is fundamental (Michaelis 1976a). The Medical Research Council scales are used entirely; any sensory perception in an otherwise completely "paralysed" area carries better prognosis, as is shown by the work of Tarlov (1972) on the greater resistance of sensory axons. All reflexes should be sought and, after catheterisation, the scrotal, anal and bulbocavernous responses whose presence indicates a reduction in spinal shock. Blood for gas analysis is helpful at all levels of injury, particularly the high cervical. The bony and neural clinical features must correlate and if they do not then multiplicity of lesions such as occurs in at least 5 per cent of cases should be suspected (Griffith, Gleave and Taylor 1966; Kewalramani and Taylor 1976; Calenoff et al. 1978). Radiography to include anteroposterior, lateral and oblique views with tomograms as necessary to achieve the three-dimensional picture of the total pathology must be obtained (Boyloston 1957; Beatson 1963). In cervicothoracic and basi-occipital fractures, careful radiography is necessary to visualise all the bony elements. Gas or water-soluble myelography may be useful but the value of computer-assisted tomography has yet to be proven (Rossier et al. 1977).

Bladder distension must be urgently relieved and, if intravenous infusion is being used, a temporary indwelling catheter be used to avoid overdistension and infection (Pearman and England 1973, 1976). Finally, the classification already detailed is applied.
Spinal cord injury in children. Beware the flaccid baby, particularly after breech presentations (Allen 1976). The paediatric incidence of cord injury is 0.75 per million per year (Burke 1976) and such children should be admitted to comprehensive units; characteristically 50 per cent are not associated with radiological bony damage. Kilfoyle, Foley and Norton (1965) stress the long-term care needed and the major problem of spinal deformity.
Cervicothoracic injuries
Compression–dispersion injuries (Tables III and IV). Pathological examination shows that with intact ligaments these injuries are stable and constitute 26 per cent of cervical injuries (Bedbrook 1977a).

| Table III. Cervical fractures and fracture-dislocations (Perth, Western Australia) |
|----------------------------------|----|---|
| Compression                      | 63 | 26 |
| Flexion rotation                 | 121| 48 |
| Extension                        | 63 | 26 |
| **Total**                        | 247| 100|

(236 of these cases were assessable)
1976). Those in Group II are to be considered unstable only after maintenance of reduction for at least six weeks (Bedbrook 1969a, 1971b, 1977b). The latter are more often associated with complete tetraplegia.

Early reduction in both groups is by traction, either slow traction using a head caliper such as the Crutchfield (1933) or halo (Nickel et al. 1968), first in flexion to unlock and finally in rotation and extension; or by rapid Hyperextension (or retroflexion). This not well-recognised group accounts for a fifth of cervical injuries (Table IV) often in the older age group with cervical spondylosis and incomplete lesions (Schneider, Cherry and Pantek 1954; Frankel 1969; Braakman and Penning 1976; Bedbrook 1977a). The incomplete cases (85 per cent) have a 40 per cent chance of useful recovery but in the upper limb this can be poor. The

### Table IV. Collected figures of cervical fracture-dislocations with tetraparesis

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Dall</th>
<th>Frankel</th>
<th>Cheshire</th>
<th>Bedbrook</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression</td>
<td>Stable</td>
<td>22</td>
<td>48</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flexion rotation I</td>
<td>Stable</td>
<td>25</td>
<td>129</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>9</td>
<td>0</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Flexion rotation II</td>
<td>Stable</td>
<td>22</td>
<td>25</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Extension</td>
<td>Stable</td>
<td>6</td>
<td>16</td>
<td>66</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Unstable</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total number of stable injuries</td>
<td>75</td>
<td>218</td>
<td>224</td>
<td>236</td>
<td>753</td>
</tr>
<tr>
<td>Total number of unstable injuries</td>
<td>13</td>
<td>2</td>
<td>12</td>
<td>17</td>
<td>44</td>
</tr>
</tbody>
</table>

### Table V. Cervical fractures and fracture-dislocations (Perth, Western Australia). Neurological state on admission and discharge

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Admission</th>
<th>Discharge</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Per cent</td>
<td>Number</td>
</tr>
<tr>
<td>Compression (63)</td>
<td>Complete</td>
<td>30</td>
<td>47.5</td>
</tr>
<tr>
<td></td>
<td>Incomplete</td>
<td>33</td>
<td>52.5</td>
</tr>
<tr>
<td>Flexion rotation I (75)</td>
<td>Complete</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Incomplete</td>
<td>58</td>
<td>77</td>
</tr>
<tr>
<td>Flexion rotation II (45)</td>
<td>Complete</td>
<td>25</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Incomplete</td>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>Extension (53)</td>
<td>Complete</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Incomplete</td>
<td>44</td>
<td>83</td>
</tr>
</tbody>
</table>

reduction using a similar mechanism but under anaesthesia, full relaxation and intubation. When this has been carried out within forty-eight hours no neurological deterioration has been reported (Walton 1893; Burke and Berryman 1971; Cheshire 1969, 1977) and complications of the use of skull calipers are very rare (Weisl 1972)—in my own observations, once in 500 cases.

complete cases are due to crushing of the cord and the prognosis is poor (Table V).

**Initial management.** The immediate management of cervical injuries (and of thoracolumbar injuries) is a matter of contention between the protagonists of conservative care and those who advocate early operation. Those who advocate conservative management (Cheshire 1969; Frankel 1969; Dall 1972;
Bedbrook 1976b; Guttmann 1976a) indicate that whilst compression and extension injuries may be regarded as stable, 6 to 10 per cent of cervical flexion-rotation injuries may displace after eight to ten weeks of conservative treatment and may then require stabilisation by anterior fusion. No neural deterioration has been noted in the series treated conservatively. Those who advocate early operations (Cloward 1961; Verbiest 1962; Perret and Greene 1968; Raynor 1968; Goran 1969; Verbiest 1969; Norrell and Wilson 1970; Cloward 1971; Myers and Buckley 1971; McNab 1972; Cloward 1973; Paul et al. 1975; Cornish 1976; Selecki 1976; Riska 1977) have, in most centres, abandoned wide laminectomy which confers no neurological benefit and runs the risk of producing a complete unstable lesion (Holdsworth 1965; Morgan et al. 1971; Guttmann 1976a). The survey of 356 cervical cases by Heiden et al. (1975), the series by Clawson et al. (1971) and 645 cases by Geisler, Wynne-Jones and Jousse (1966), all prove conclusively the lack of neurological improvement by anterior or posterior technical methods. Munro’s (1961) advocacy of conservative methods in his series has been substantiated.

The use of steroids (Meyer 1979), of mannitol and Decadron (Eisenbeiss 1977; Ranshoff 1977), of cooling of the spinal cord (Albin et al. 1968) and of hyperbaric oxygen and alpha methyltyrosine (Yeo, Stabbback and McKenzie 1976), have all been tried without success in cervical injuries either within or without comprehensive units.

The maintenance of posture and continuous traction for six to eight weeks remain core therapies. Early mobility has been advocated even for the cases where instability is possible but such moves, in cervical injuries, may present difficulties for nursing and maintenance of reduction (Munro 1965; Pierce and Nickel 1977). Stauffer and Kelly (1977) studied the use of the anterior approach and concluded that all cases with recurrent displacement had disruption of posterior elements; and that early anterior fusions were contra-indicated in cases where only the anterior longitudinal ligament had survived, as in Group II fracture-dislocations. Surgical fusion should be reserved for those few cases (Table IV) of true late instability (Bedbrook 1969b, 1977a), but neurological recovery (Table IV) can only be achieved by long-term repetitive sensory stimulation and isometric muscle retraining.

Special groups. Injuries of the atlas and axis are not uncommon but are only rarely seen with neural injury which is usually incomplete, for patients with complete lesions do not survive (Wood-Jones 1913; Cornish 1968; Williams 1975). For those who have symptoms after reduction, due to joint disruption or non-union, Gallie (1939) described an excellent posterior fusion. Fried (1973) showed poor results of early operation whilst Fielding, Hawkins and Ratzan (1976) showed how rare is non-union. The transoral approach of Fang and Ong (1962) has not found wide application. Rogers (1938) McSweeney (1973) and Griffiths (1974) have commented on a small group of children in whom the damage to the ring epiphyses resulted in severe kyphosis and recurrent paralysis. Early recognition calls for early fusion.

Thoracolumbar injuries

Holdsworth (1970) reviewed 1000 cases and emphasised that diagnosis, bony and neurological, was fundamental—a message which still needs stressing and re-emphasis; that the neurological level in thoracolumbar fractures and dislocations may vary with similar radiological lesions; that patients frequently had mixed cord and root lesions; that stable injuries included fractures and subluxations classified as wedge, bursting or extension injuries; and that unstable injuries were fracture-dislocations and dislocations of the thoracolumbar spine, usually due to rotation. This was confirmed by Roaf (1964). One cannot agree with Holdsworth’s statement that “operative reduction is always necessary in dislocations”, or that “serious damage to cord may be produced easily during management by constant turning”. Such statements have not been confirmed by the passage of time or by the experience of many authors (Guttmann 1954b; Meinecke 1964; Guttmann 1973; Bedbrook 1975, 1976b; Burke and Murray 1976; McSweeney 1976). These authors stress positive postural methods using muscle power and visceral controls and urge a balanced approach using multifactorial methods of care.

Immediate surgical care. Immediate care is frequently less than ideal but until early immediate admission to comprehensive units is possible, early management will continue to show fragmentation. Compression (or axial) injury of the thoracolumbar spine (Holdsworth 1970) continues, in most centres, to be managed by non-operative methods, although Dickson, Harrington and Erwin (1978) advocate the use of distraction rods to assist the longitudinal ligaments to reduce the bony fragments exactly. De Oliveira (1978) recently described the hyperextension or retroflexion injury of the lumbar spine, a very uncommon lesion, occurring only three times in the 180 cases of the author’s experience.

Controversy on early care continues unabated after 150 years. At one extreme are those who advocate early surgical intervention in unstable cases (Roberts 1969; Holdsworth 1970; Erickson, Leider and Brown 1977; Ranshoff 1977; Meyer 1978). At the other extreme are those such as Armis et al. (1977) in Indonesia and the Stoke Mandeville group who use no surgical help. Burke and Murray (1976), Hardy (1977), McSweeney (1977) and the present author advocate less surgery than previously, indicating the rarity of need.

Management is related to pathology, natural history (Tables I and II) and questioning the term...

Chahal traction and Norrell and Wilson 1970; Dickson, Harrington and Erwin 1973; Guttmann 1973; Harrington and Dickson 1973; Lewis and McKibbin 1974; Bedbrook 1976b; Burke and Murray 1976) but no one has yet shown that any method has favourably affected neurological recovery although some have attempted so to prove (Lewis and McKibbin 1974; Paul et al. 1975; Eisenbeiss 1977; Ransohoff 1977; Young and Dexter 1978), or that methods of splintage or internal fixation have so improved care as to justify the risks and complications of such operations. Improved rehabilitation is reported but the criteria used (Bradford et al. 1977; Dickson et al. 1978; Meyer 1979) are open to criticism since no details are given about the other systems needing coincident care, for example the urinary tract. Getting a patient out of bed, in the author's experience, is not a criterion of success, for seriously ill and debilitated patients may be mobilised before adequate physical retraining. Averages of twenty to thirty days before mobilisation are quoted. Early mobilisation out of bed has little to commend it, since, in well-disciplined units, mobilisation and physical restoration can be practised equally well whilst the patient is in bed. Non-technical methods, such as posture turning or the use of exoskeletons, have resulted in tragedies.

Conservative methods. Exoskeletal orthoses have been described by Yamada and Ikata (1969) and by Dollfus and Maury (1978 personal communication). By regular turning, and changing of inner vests as for scoliotics, satisfactory results are claimed. Polypropylene jackets, as used for scoliotics, are helpful (Bradford et al. 1977; Dickson et al. 1978). Halo-femoral or just femoral traction has been used by Dommsie (1972) and Chahal (1975a). In 1970 in Western Australia, a conservative method of reducing thoracolumbar fracture-dislocations with locked facets was introduced: under general anaesthesia traction is first applied in flexion, and then, after unlocking the dislocation, in extension. This has proved successful in ten cases where simple postural reduction was unsuccessful. Deterioration of neural function after conservative methods has been described by Rogers (1938) but such has not been seen personally where conservative methods are carefully carried out.

Surgical techniques. Guttmann (1969b), Lonstein (1977) and Whitesides (1977) have stressed the deformity after laminectomy, particularly in children. Whitesides' studies led him to condemn laminectomy completely. His criticism of conservative methods cannot be substantiated, whilst his report on reduction in time in hospital from 500 days to 90-120 days cannot be mainly due to the initial methods of treatment. Time spent in hospital depends on many factors, and is not an appropriate index of the success of early care. Whitesides agreed that such fractures could be conservatively treated.

Laminectomy and plate fixation have been replaced by anterolateral decompression (Paul et al. 1975; Riska 1976, 1977) or by fixation by posterior devices such as Weiss springs (Meyer 1975), Zadek clips (Hardy 1977), Morag Williams plates or the excellent devices designed by Harrington for scoliosis (Dickson et al. 1973; Hannon 1976; Bradford et al. 1977; Yosipovitch, Robin and Makin 1977). A number of authors (Breg 1972; Paul et al. 1975; Whitesides and Shah 1976; Riska 1977) have advocated an early anterior operation to clear out debris after early posterior fixation but such series are small and represent only a small percentage of the total cases. Breg (1972) and Paul et al. (1975) have advocated transthoracic decompression in incomplete thoracic lesions in which a good chance of recovery already exists (Table 1). Harrington (1962, 1967) instruments, the Dwyer cable (Dwyer, Newton and Sherwood 1969; Dwyer 1970) and improved grafting techniques have all gained advocates as wire and plate were discarded, so far with no improved results. As indicated by Guttmann (1949, 1973), and Bedbrook (1975), such methods are rarely needed; probably in less than 5 per cent of all fractures and only after conservative measures fail.

Most authors who advocate surgical methods (Flesch, Leider and Bradford 1975; Bradford et al. 1977) intervene during the first three weeks, by which time pathological examination shows that early healing is well advanced. They combine their interventions with postural methods (Kaufer and Hayes 1966; Armstrong and Johnston 1974; Lewis and McKibbin 1974; Bradford et al. 1977; Yosipovitch et al. 1977), including exoskeletons. Failure of plates and failure of postural methods (Guttmann 1954b; Frankel 1969; Leidholt et al. 1969; Bedbrook and Edibam 1973) usually occur in the first three weeks. Yosipovitch and his co-authors (1977) and Yocum, Leatherman and Brower (1970) advocate fixation in all cases of “unstable” injury and indicate increased deformity (really failed posture) as their indication for intervention. Large series are now accumulating on the use of Weiss springs (Meyer 1975; Weiss 1978) and Harrington rods (Dickson et al. 1973; Bradford et al. 1977; Dickson et al. 1978). The early complications and long-term problems do not yet appear to be fully documented. Bradford et al. (1977) and Dickson et al. (1978) stress the need for perfect technique. I fully agree, but feel such procedures for spinal injuries must be carried out in a comprehensive unit, and then only after adequate assessment and consideration, not only by the surgeon, but principally by the overall physician whether he be surgeon, physician or paraplegist.

Indications. For fifteen years I treated all cases without
operation to evaluate the results. Eleven per cent of thoracolumbar fracture-dislocations had locked facets, and united, but un-reduced fracture-dislocations had good spinal function. A review in 1969 and again in 1975 indicated that some 5 per cent were individuals for whom technical fixation might be considered. There is no absolute indication for such when one considers all the other problems of traumatic paraplegia, the visceral paralysis, the associated injuries, the problems with the skin and the respiratory difficulties. There may be relative indications in specific cases such as gross irreducible fracture-dislocations with complete column disruption and scoliosis; bilateral locked facet dislocation after the failure of conservative care; gross injury due to gunshot wounds; and, rarely, neurological deterioration.

Pain after the injury, ease of nursing and early mobilisation are three factors that are debatable. The latter is certainly not an indication, as good mobilisation, including isometric activity and recreation such as indoor volleyball, can be started in bed after the first or second week and constitutes the graded mobilisation required (Guttmann 1976b). Lewis and McKibbin (1974) and Bradford et al. (1977) indicate that pain is less after operation whilst Guttmann (1973), Chahal (1975a), Bedbrook (1976a) and Burke and Murray (1976) find that pain disappears quickly, certainly within ten days of the injury. Ease of nursing was first discussed by Holdsworth and Hardy (1953) and continues to be discussed. I have attempted to evaluate this but, like pain, it is a very subjective matter and does not lend itself to easy study. In comprehensive, well-disciplined units ease of nursing should not usually be a factor. Care must be taken to maintain posture in the first four to six weeks. The use of a log-rolling technique with maintenance of posture by lumbar pillows does not allow major movement at the fracture site, whilst the Stoke Mandeville bed has further eliminated such movement. Particularly is this so if isometric movement of the erector spine is maintained, for its innervation is preserved below the lesion.

A question to be asked again and again, particularly when prognostic features are considered, is “Are surgical methods really needed?” (Michaelis 1976a). Urinary infection will be high unless preventive methods (Pearman and England 1973) are effectively carried out, whilst incomplete cases will not recover if inhibited by urinary infection, poor surgery or poor nursing (Guttmann 1973; Young and Dexter 1978).

Few authors disclose the actual percentage of cases undergoing surgical treatment; figures vary from 21 per cent (Meyer 1979) to 50 per cent (Riska 1977 and personal). Neural changes from continuing compression anteriorly are unknown in the pathological series of Wolman (1965), Hughes (1966) and Kakulas and Bedbrook (1976), yet such is claimed clinically by Riska (1977) and others. In my own series, eight cases of 100 were reduced openly after gross dislocation or locked facets. So far I am not convinced, after retrospective study, of the value of such operations.

Long-term care. Guttmann (1969b) shows that mobility problems are greater in operated cases. Less than 1 per cent need fusion for non-union (Bedbrook 1976b). Bony stenosis has been reported (Landau and Ransoff 1968; Stern 1972). Great emphasis on isometric activity and posture must be continued until the patient has been mobilised.

Sacral and pelvic injuries with neural damage

Injuries to the lumbosacral joint, pelvis and sacrum with neural damage are rare. Authors such as Lam (1936), Bonnin (1945), Patterson and Morton (1961), Goodell (1966), Purser (1969), Bucknill and Blackburne (1976) and Fountain, Hamilton and Jameson (1977) reported the occurrence of such injuries as being between 1 and 11 per cent. Diagnosis is difficult and can be made only after repeated clinical examination. Isolated fractures of the sacrum are not common and no classification of such fractures has yet been offered. Reviewing the collected cases, the following groups can be recognised clinically: transverse fractures with kyphosis, with or without displacement; shearing oblique injuries confined to one or other side of the sacrum; gross avulsion injuries of the sacrum distal to the body of S2 and double vertical fractures. Huittinen (1976) published detailed studies on neural injuries in fractures of the pelvis. His post-mortem studies emphasised an incidence of 9 to 12 per cent in pelvic injuries, which may be low in reality. The neural injuries varied from avulsion to rupture of the cauda equina, to traction or compression injuries to the lumbosacral plexus. All authors (Furey 1942; Goodell 1966; Huittinen 1976) stress the expected difficulty in relating neural damage to bony damage and the variability of the neural lesion. Since pathologically it is rarely a compression lesion (only four in forty) the futility of surgery is obvious, particularly as spontaneous recovery will occur after neurapraxia and will usually occur after axonotmesis.

Regular clinical assessment will give the surgeon help in prognosis whilst the bladder and bowel must be cared for as in other neural injuries causing visceral paralysis. Fountain et al. (1977) have advised early exploration for compressive lesions to allow precision in diagnosis, but at present little is to be gained by such operations. My personal cases have developed satisfactory but not normal bladder and bowel function with the aid, in one case, of bladder-neck surgery. Treatment should be aimed at preventing aggravation by avoiding long periods on operating tables when pressure can be a factor; a careful clinical follow-up of the lesions; preventing bowel and bladder retention and complications; and establishing visceral function and encouraging physical restoration of the surrounding musculature.

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COMPLICATIONS

Genito-urinary infection
The greatest single advance in the management of spinal injury over three decades was started by the pioneer work of Guttmann (1954a, 1973) in preventing and treating urinary infection. Intermittent catheterisation, which he advocated, is the early treatment of choice. General acceptance (Walsh 1968) has resulted in the precipitous falling off of complications, helped considerably by the organisation of catheter teams and the control of cross-infection (Lindan and Bellomy 1971; Pearman and England 1973). Between 17 and 50 per cent of cases remain sterile, the others experience one to four episodes of bacteriuria yearly (Ott and Rossier 1973; Pearman 1971, 1976; Donovan et al. 1978). Provided that overdistension and chronic infection is avoided, a balanced bladder can be achieved (Pearman and England 1973; Pearman 1976). Pyelonephritis can be treated aggressively by bactericidalis and then by bacteriostatic agents. Methenamine mandelate is of great use regularly, but only when catheters have been dispensed with and the residual urine measures more than 80 millilitres. Vesico-ureteral reflux, due to infection (Donnelly, Hackler and Bunts 1972; Wein, Raezer and Benson 1976), will disappear whilst hydronephrosis almost disappears and is rectifiable by removal of the urethral obstruction (Guttmann and Frankel 1966; Pearman and England 1973; Rosen, Nanninga and O’Connor 1976). Calculi can be prevented (Pearman 1976) and with them the need for surgery. Complications of the indwelling catheter, such as epididymo-orchitis, stricture, diverticulum and fistulae, will also disappear.

Detrusor-urethral sphincter dyssynergia
In normal voiding as the detrusor contracts the bladder neck opens and is drawn up into the shape of a funnel while the pelvic floor relaxes (Tanagho 1971). After spinal cord injury, this synergistic action is altered in patients with upper motor neuron lesions. Andersen and Bradley (1976) have shown that occasionally the detrusor remains hypotonic but more often the bladder neck and the urethral sphincter either fail to relax as the detrusor contracts, or the urethral sphincter (less often the internal sphincter) contracts clonically, resulting in an interrupted urinary stream (Yalla et al. 1977). As more patients with spinal cord injuries become free of catheters, the problem of dysynergia has become more apparent. The current methods to optimise urine storage and bladder emptying are well summarised by Wein et al. (1976). The attack upon the outlet obstruction is by bladder-neck resection and inhibition of the alpha adrenergic smooth muscle fibres with phenoxybenzamine (Krane and Olsson 1973) if the obstruction is at the bladder neck. If it be at the pelvic floor urethral sphincter then external sphincterotomy (Ross, Damanski and Gibbon 1957), stretching of the anal sphincter (Donovan et al. 1977), pudendal nerve blocks or crushing and pharmacological manipulation are indicated. Dilatation of the anal sphincter causes inhibition of both the detrusor and urethral sphincter; voiding is effected by strain. Some success has been reported both with the centrally acting Lioresal (Rousan et al. 1975) and diazepam (Perkash 1975), and the peripherally acting dantrolene (Herman, Freedman and Mayer 1974).

Other complications
Osteoporosis, hypercalciuria and heterotopic ossification are now much relieved but still significant. Neurological complications include spasticity, hyperreflexia, post-traumatic syringomyelia, pain and late neurological deterioration. Treatment now includes prevention of the former two and neurosurgical assistance for the latter.

Decubitus ulcers, unfortunately, still present major problems and are the cause of much morbidity necessitating costly and expensive care. Preventative measures include intermittent relief of pressure from weight-bearing surfaces, by wheelchair push-ups and a night-time turning schedule together with good cushions (Guttmann 1976a, 1976c; Noble 1977); visual inspection twice daily by a hand-held mirror, or by an attendant in the case of tetraplegics; maintaining good health habits and a dietary intake adequate in protein and vitamins while avoiding high-calorie foods and excess of alcohol or other drugs which will result in inattention or neglect of the skin; and the avoidance of tight clothing and material that will not absorb moisture. Experimental ulcers appear three to four days after application of pressure in rats (Kosiak 1959, 1961) whilst factors enhancing the effect of pressure include ischaemia (Husain 1953) oedema and cellular infiltration, anaemia and venous thrombosis (Kosiak 1961).

Despite the use of preventative methods operation may be indicated. Early intervention includes debriement and antiseptic sterilisation, for surgical repair must only be considered after infection has been eradicated. Reparative surgical procedures (Griffith 1963; Herceg and Harding 1978) can assist the healing of large trochanteric or sacral sores. Great caution must be exercised to overcome sources of bacteraemia such as loculations, whilst postural care must be practised both before and after operation. Alert conscientious and competent nursing staff are essential to achieve good results. Such care can reduce the time in hospital by half.

Respiratory problems abound in early and late stages, needing adequate care (Cheshire 1964; Meyer et al. 1971; Bellamy, Pitts and Stauffer 1973; Quimby, Williams and Greifenstein 1973; Burke 1977).

Other complications such as thrombo-embolism, hypotension, autonomic hyperreflexia and arrhythmias are of importance, but cannot be considered in this review.
REHABILITATION

Vocational
The Rehabilitation International meeting in Teheran in 1970 declared that medical rehabilitation, social rehabilitation, vocational rehabilitation, and educational rehabilitation were indivisible parts of care. Hoover (1977) states the goal of vocational restoration as the "return to a useful participating place in society" and emphatically states rehabilitation to be incomplete if vocational rehabilitation is excluded. Goldberg and Freed (1973) noted in their short study on the vocational adjustment, interest, work values and career plans of persons with spinal cord injury, that the pre-disability vocational development and educational level was a far better predictor of vocational adjustment than the severity of the disability (Meincke 1964; Guttmann 1973; Forner et al. 1976). The establishment of sheltered workshops has enabled the disabled worker to return to productivity up to the full capacity his physical disability permits, and to supplement his welfare payments by his own earnings. In a study in Perth, Griffiths (1979) described the Para-Quad Industries which have made a major contribution towards employment of the disabled in Western Australia (Tables VI and VII).

Social
The psychosocial aspects of management of the patient with spinal cord injury are defined differently in many centres, and are carried out by a variety of specialists including psychiatrists (Stewart 1977), psychologists (Hohmann 1975; Braakman, Orbaan and Blaauw-van Dishoeck 1976; Karney 1976), occupational therapists (Mann, Godfrey and Dowd 1973), nursing staff (Pepper 1977) or by the whole rehabilitation team guided by the medical staff (Cibeira and Liendo 1972; Harris et al. 1973). The practical aspects of social management may be carried out by social workers, welfare officers or welfare assistants.

Although the personnel responsible for the psychosocial aspects of patient care may not be uniform, these needs of the patient are related to areas of psychosocial pathology. The restoration of social functioning is a very wide subject. It is important for those working with the patient to know what aspects of life were significant before the injury and to assist the patient regain satisfaction in these areas (Richards 1975a; Boatwright 1976; Shipp 1976; Weller and Miller 1977).

The most frequently documented areas of social pathology where action in social management of the patient with spinal cord injury is regularly required are: psychosocial history, patient's personality, the process of adjusting to the disability, marital and family support, economic security, accommodation and access, and community resources.

Sexual function. This is a specialised area of rehabilitation needing increasing attention as emphasised by Tarabulcy (1972), Guttmann (1973), Verkuyl (1976) and Burke (1977), and requires discussion and review beyond the scope of this review.

Extended care
A sophisticated environment for acute care can only be justified in terms of a comprehensive after-care programme. The timing of discharge from hospital should be seen as the initial stage in the after-care programme and not as the final stage of rehabilitation (Rowlands, Jaeger and Gregg 1968; Francis Jones and Jones 1975; Richards 1975a). The value of a continuous follow-up where disability is irreversible but not static lies in the prevention, early detection and relatively inexpensive treatment of complications. In spinal injuries, this is supported by evidence from a pilot study by Thompson and Murray (1967) and subsequent reports from Meine (1970), Francis Jones (1972), Middaugh et al. (1974), Doss, Miller and Rhodes (1975) and Steinberg (1975). Continuous follow-up helps to maintain a high level of health, prevents social and economic disruption to the patient and releases hospital beds for the care of the acutely ill (Wilcox, Stauffer and Nickel 1970).

### Table VI. Production in the Para-Quad Industries, 1970–77

<table>
<thead>
<tr>
<th>Year</th>
<th>Production S</th>
<th>Disabled employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>10 763</td>
<td>10</td>
</tr>
<tr>
<td>1974</td>
<td>133 073</td>
<td>81</td>
</tr>
<tr>
<td>1977</td>
<td>522 297</td>
<td>190</td>
</tr>
</tbody>
</table>

### Table VII. Employment of patients with traumatic injuries

<table>
<thead>
<tr>
<th>Cervical lesion</th>
<th>Thoracolumbar lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete</td>
<td>Incomplete</td>
</tr>
<tr>
<td>Working</td>
<td>5</td>
</tr>
<tr>
<td>Not working</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
</tr>
<tr>
<td>Percentage working</td>
<td>13</td>
</tr>
</tbody>
</table>
outpatient clinics, and the results from Western Australia since 1970 confirm this: in 1971 fifty-five new patients were admitted with 232 readmissions while in 1977 new cases totalled eighty-three but readmissions only 143.

On discharge, patients with spinal cord injury require some alteration to their homes, some aids, suitable means of transport and often adaption of facilities at work (Deyoe 1972; Francis Jones 1972; Grant 1972; Richards 1975b). However, there are people with severe disability where such community living does not provide the optimal life. For them the best environment is that of the hostels and nursing facilities found at the Thistle Foundation in Scotland, Het Dorp in Holland and Stoke Mandeville in England and in Perth, Western Australia (Brattgard 1972; Frederickson 1972; Loring 1972; Guttmann 1973; Kirksey 1973; Dorricott 1974; Shearer 1974). Such accommodation does not always pretend to be integrated but provides an independence not otherwise possible (Fig. 1). More importantly, such areas provide a continuum of care.

**Engineering.** This is a new discipline in medicine where professionals give service in prevention of pressure sores and provide better wheelchairs and patient support systems, communication systems and various types of beds (Scales 1961; Scales, Winter and Bloch 1966; Keane 1970; Stewart 1970; Guttmann 1976c; Reswick and Rodgers 1978).

Based on the work of Brand (1972), the services of the bioengineering staff of the Royal Perth Hospital, Western Australia, have been extended to a Pressure Clinic (Cox 1975). All such activities, with others, such as stimulators to help control spastic responses and bladder evacuation, aim at providing greater independence (Davis and Gesink 1974; Reswick and Rodgers 1979). Expansion of this field is planned in most rehabilitation centres (LeClair and Reswick 1977; Garrett 1978; Robertson 1979). Meyer (1979) reports on the use of orthoses for certain spinal cord injuries as judged by the level of neurological involvement. The addition of new designs and materials such as aluminium alloys, polyethylene, polypropylene, ABS and copolymers has stimulated rapid development (Rubin and Dixon 1974; Stills 1979).

**SPORT**

**In rehabilitation**

Restoration of function, physical and psychological, is the ultimate goal in all therapy. Robert Jones (1921), Girdlestone (as quoted by Trueta 1971) and Watson-Jones (1943) emphasised this goal in their continual development of the application of the physical therapies for physical rehabilitation. Watson-Jones's rapid development of rehabilitation services in 1940 for the Royal Air Force only emphasised the pioneer work well reported by Sir Arthur Keith in *Menders of the Maimed* (1919). Discharge from hospital is but an event in the overall programme which goes on for much longer. Therefore, to estimate success in rehabilitation by the time spent in hospital, as is done by those who advocate early operative care (Eisenbeiss 1977; Yosipovitch *et al.* 1977; Dickson *et al.* 1978; Meyer 1979), is not valid. Any one method can only be judged when the whole is looked at within the comprehensive structure of a spinal unit. Detailed methods of functional restoration are well reviewed in texts and papers already used in this review.

**In therapy**

A review of the material in Guttmann's monograph on *Sport for the Disabled* (1976d) shows the extraordinary

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**Table VIII.** Medical classification of paraplegic and tetraplegic sport, showing neurological levels and points

<table>
<thead>
<tr>
<th>Cord level</th>
<th>Class</th>
<th>Class characteristics and points</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4</td>
<td>IA</td>
<td>Triceps 0–3</td>
</tr>
<tr>
<td>C5</td>
<td>1A</td>
<td>1B Triceps 4–5, wrist flexion and extension</td>
</tr>
<tr>
<td>C6-</td>
<td>1C</td>
<td>Finger flexion and extension</td>
</tr>
<tr>
<td>C7-</td>
<td>1B</td>
<td>Finger flexion and extension</td>
</tr>
<tr>
<td>C8</td>
<td>1C</td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td></td>
<td>No useful balance</td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>No useful abdominals</td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td>No lower intercostals</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T6</td>
<td></td>
<td>Some balance</td>
</tr>
<tr>
<td>T7</td>
<td></td>
<td>Upper abdominals</td>
</tr>
<tr>
<td>T8</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>T9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T11</td>
<td></td>
<td>Good balance</td>
</tr>
<tr>
<td>T12</td>
<td></td>
<td>Good abdominals and spinal extension</td>
</tr>
<tr>
<td>L1</td>
<td>IV</td>
<td>Some hip flexors and adductors</td>
</tr>
<tr>
<td>L2</td>
<td></td>
<td>Points: 1–20 traumatic</td>
</tr>
<tr>
<td>L3</td>
<td></td>
<td>1–15 polio</td>
</tr>
<tr>
<td>L4</td>
<td>V</td>
<td>Points: 21–40 traumatic</td>
</tr>
<tr>
<td>L5</td>
<td></td>
<td>16–35 polio</td>
</tr>
<tr>
<td>S1</td>
<td>VI</td>
<td>Points: 41–60 traumatic</td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td>36–50 polio</td>
</tr>
</tbody>
</table>

*Not eligible*

Traumatic 16 points and above
Polio 51 points and above
development in this area and more importantly that neural plasticity (Bach-Y-Rita and Collins 1972) is a fact. Keith (1919) gives us a glimpse of the use of sport by physicians in the seventeenth, eighteenth, and nineteenth centuries, as they followed the ancient hippocratic traditions. As quoted by Keith (1919), Nicholas André (1741) used hydrotherapy, John Shaw (1825) emphasised gymnastics as a therapy, whilst Delpech (1827-28) developed a large outdoor gymnasium for many restorative activities including sport. European development of sport for the blind, for amputees and for cardiac invalids predated its use for spinal injuries and yet the latter has now outstripped them in the development of organised Sports’ Associations outside the hospitals (Guttmann 1976d). Watson-Jones’s use of volleyball, soccer and cricket for spinal fractures, whilst in exoskeletal casts, was to have great significance. In 1944, when working with paraplegics, Guttmann undertook early experiments with skittles, polo, punchball and snooker. Later we find the use of archery (Guttmann 1973) as a method of preventing and indeed relieving, spinal deformity, as hinted at by Delpech in Keith’s book. The development of basketball, archery and individual sports such as weight-lifting, and throwing the javelin have had a far-reaching significance. More emphasis is needed in their professional application in comprehensive units managing spinal injuries.

Such activities reveal areas where spinal paralytics are less disabled than the able-bodied (Jochheim and Strohkendl 1973; Weiss and Beck 1973; Guttmann 1976b, 1976d). Muscle development and co-ordination are developed whilst motivation, so easily lost (as Robert Jones mourned), is maintained and improved. By July 1948, the Stoke Mandeville Games Movement was started and by 1952 the now great International Stoke Mandeville Games was a reality. Sport is useful as much for incomplete lesions as for complete, hastening restoration. Competitive sport has an international neurological classification (Table VIII), emphasising function.

CONCLUSIONS

Detailed analysis of results (Bedbrook 1965; Guttmann 1973; Kurtzke 1975; Bedbrook 1976a) all show immense progress over nearly four decades. This progress is closely linked with the development of comprehensive spinal injury services. In these centres urinary infection is reduced to a manageable figure of 8 to 10 per cent (Pearman and England 1973); decubiti can be prevented (Guttmann 1976a, 1976c) whilst the quality of life is immeasurably improved. Yet many patients with spinal injury are still managed away from such services and this is at tremendous cost to the patients themselves and, ultimately, to the community.

The future, as regards reduction in the incidence of spinal injuries, is bleak. More energy must be put into the development of more long-term extended care services which, in the author’s hands, have resulted in a reduction in the need for expensive hospital beds. The emphasis must be placed on care in the community at large, not just on hospital care. Such was the goal that Robert Jones (1921) sought and achieved in other areas of musculoskeletal medicine.

Management of spinal paralysis has become a responsibility shared by a group of professionals although one always has the final responsibility. Assistance was given in this review by Mr E. R. Griffiths, Director of Spinal Injuries, Western Australia, in cervical and dorsal injuries; by W. H. Donovan, Assistant Professor and Specialist in Rehabilitation Medicine, in complications and neurology; by Mrs M. Furphy, Social Worker, in social care; by Mrs G. Sedgley, Nurse-in-charge, Outpatient Department, in extended care; by Mr E. Scull, BioEngineer, in rehabilitation engineering; and by Mrs C. Barrow in library research.

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