SPINAL CORD INJURY IN VIETNAMESE COMBAT

By S. A. JACOBSON[1] and E. BORS

Spinal Cord Injury Service of the Veterans Administration Hospital, Long Beach, California, and the Department of Surgery, University of California, School of Medicine, Los Angeles, California

THIS report deals with the experience gained by observation and treatment of 114 Vietnamese combat injuries from December 1965 to April 1969. The report covers all aspects of rehabilitation, medical, physical and socio-economic.

METHODS AND MATERIALS

The data presented were collected via examination of charts only (both in-patient and out-patient) in 60 instances. In 54 instances charts were utilised and the patient was also interviewed. Correspondence was used when appropriate to fill in data or bring them up to date. No patient's record was so unsatisfactory as to preclude inclusion in the study. All of these patients are service connected with government compensation. Their paraplegia demanded close medical supervision which was carried out in this government institution.

Since December 1965 about 250 new patients with spinal cord injury considered 'Vietnam conflict' have been treated at the Long Beach Veterans Administration Hospital. This survey concerns itself only with the actual combat injuries as the non-combat do not differ from peacetime civilian paraplegics. The combat injuries differ in (*a*) severity of injury (often multiple wounds); (*b*) problems regarding first aid and evacuation; (*c*) they have been shown to behave differently in regard to complications and course (Bors, 1951; Comarr *et al.*, 1962) in previous studies.

Age distribution of patients is shown in the following Table I.

TABLE I

Age	Number
< 20	15
20-22	40
22-24	25
24-26	12
26-28	7
28-30	4
> 30	11

As can be seen, 80 patients were under 24 years of age (70 per cent.), and only 11 were over 30 (9·6 per cent.). In the latter group were patients who were injured in supervisory positions (bunker building: two), or were non-combatants (chaplain: two; mail delivery: one), etc.

[1] Permanent address: Jewish General Hospital, Department of Urology, Cote des Neige and Van Horne, Montreal 25, Canada.

Table II illustrates the level distribution.

TABLE II

Level and Extent of Lesion

	Complete	Incomplete
C	10	5
T1-T6	19	7
T7-T12	27	9
L-S	23	14

The level indicated refers to the neurological level found on neurological admission examination. The lowest normally functioning segment is designated as the patient's 'level'. Functionally only the segmental level is important rather than the vertebral level which is still often quoted. As has been pointed out (Michaelis, 1968; Bunts, 1967) a fracture of T10 to T12 may produce a complete or incomplete lesion below T9 or a cauda equina lesion with or without an epiconal lesion below L3 or L4. The orthopaedic classification fails to clarify the lesion. This statement may be extended in view of the act that we have seen lesions as high as T6 with complete distal flaccidity. This is believed to be on a vascular basis.

The mechanism of injury is indicated in Table III.

TABLE III

Mechanism of Injury

	Bullet	Shell fragments	Blast	Vehicle crash	Other
C	9	4	1	1	
T1-T6	20	6	1		
T7-T12	12	16	5	1	2 (bunker collapse)
L-S	16	7	6	5	1 (elevator sabotage)
					1 (hit by helicopter)
					1 (parachute jump)

Shell fragment includes pieces of metal from landmine, mortar, grenade or booby traps. Blast injury with the victim thrown for a varying distance and landing on back, buttocks, or feet often led to compression fractures as did vehicle crashes. 'Vehicle crash' referred to helicopter in five instances.

OBSERVATIONS

The majority of these patients had multiple system injuries and accompanying shock was common. Evacuation was rapid to a well-equipped field hospital or hospital ship. Often more immediately vital injuries than the spinal cord involvement were by necessity first treated. Table IV presents data on these major injuries.

TABLE IV
Major Injury (Non-G.U.)

	Gastro-intestinal tract	Spleen	Liver	Chest	Extrem. or pelvis	Vasc.	Misc.
C				4	1	1	1 (Skull frac.) 1 (Facial inj.) 1 (Laryng. lacer.)
T1-T6	2			17	5	2	1 (Trach. lacer.) 3 (Brach. plex.) 1 (Brain inj.)
T7-T12	3	5	1	18	2	2	3 (Lacer, diaph.) 1 (Facial inj.) 1 (Brain inj.) 1 (Periph. nerve)
L-S	13	1	3	4	7	1	2 (Severe burn) 1 (Periph. nerve) 1 (Facial inj.)

Most of these major injuries were accompanied by minor lacerations and soft tissue shell fragment wounds particularly of the extremities.

The definitive emergency treatment extended to the above injuries is shown in Table V.

TABLE V
Emergency Therapy (Non-G.U.)

Gastro-intestinal tract	Spleen	Chest	Liver	Ext. and/or pelvis
Esophagus Lacer. sut.: 2	Splenectomy: 5	Thoracotomy and/or tube insert.: 39	lacer. sut.: 4	Arm amputation: 1 Debrid. and closure: 3 Fracture aligned: 9
Small bowel Resection: 3 Lacer. repair: 2				
Colon Colostomy: 9 Resection: 4 Lacer. repair: 2				

There were six patients who had laparotomies with completely negative intra-abdominal findings. The resections of colon were formal left or right hemicolectomies with ileo-transverse colostomy performed. There were no injuries of the rectum.

Seventy-seven of the 114 patients (67 per cent.) had major injuries in addition to the spinal cord damage.

The major genito-urinary injuries are presented in Table VI. These are presented separately because of the fact that in following spinal injury patients accurate information regarding the original post-injury state of the urinary tract is so vital.

TABLE VI

Major Injury (G.U.)

	Renal		Blad. rupt.	Uret.	
	Rt.	Lt.		Rt.	Lt.
C	—	—	—	—	—
T1-T6	—	—	—	—	—
T7-T12	1	7	—	—	—
L-S	5	3	1	1	—

As is noted no cervical or high thoracic injury sustained a urinary tract wound. There were in this series no genital wounds of more than minor significance.

The therapy necessary in these injuries is shown in Table VII.

TABLE VII

Emergency Therapy (G.U.)

Renal			Other
Neph.	Part. neph.	Repair and drainage	Uretero-uret. anastom.: 1
8	1	7	Bl. rupture drainage suprapub.: 1

The uretero-ureteral anastomosis failed with extravasation and delayed nephrectomy was necessary.

Table VIII presents data on frequency of laminectomy and correlation of surgical and 'late' clinical findings. Greater than two-cord segments or obvious gross discrepancy are indicated by 'findings do not correlate'. This reiterates World War II experience that laminectomy and clinical findings do not always correlate.

TABLE VIII

Laminectomy

	Done	Not done	Findings correlate	Findings do not correlate
C	14	1	10	3
T1-T6	25	1	14	5
T7-T12	33	2	22	5
L-S	35	2	26	2

In this series 107 patients had a laminectomy with the findings correlating in 72 or 67 per cent. In some cases correlation of clinical and surgical findings was not possible due to failure to open the dura or an inadequate record.

Wound infection in the laminectomy incision occurred in six patients, meningitis was documented in four cases, dural cutaneous fistula developed in two and grand mal seizures occurred in two of the patients with meningitis.

In regard to complications during the follow-up period (2 months to 3 years and 4 months) it can be stated that they were predominantly G.U.; however, decubiti and pain were frequent and troublesome. Table IX presents frequency data on decubiti, pain, and dysreflexia. This last, observed by Head and Riddoch (1917), Guttmann and Whitteridge (1947), and Bors and French (1952) is a well-known syndrome occurring in cervical and high thoracic lesions.

TABLE IX

	Decubiti	Pain		Dysreflexia
		UMN	LMN	
C	8	3	—	4
T1-T6	13	7	—	2
T7-T12	15	8	10	—
L-S	15	1	21	—

The discomfort in the patients with UMN lesions was described usually as burning, crushing, or tingling and in the patients with LMN lesions as shooting or electric; exceptions were noted.

Genito-urinary complications were numerous, the most frequent being infection, calculosis, hydronephrosis, and epididymitis. Data on these, as well as reflux, penoscrotal problems, ureterectasis, and 'pseudopapillomata', are presented in Tables X and XI.

Calculosis. The increased prevalence of renal calculi on the right side has been confirmed (Comarr *et al.*, 1962). There were 11·4 per cent. of our patients who developed renal calculi over the 3 years and 4 months period (Bunts *et al.*, 1967; Bors, 1951). Ureteral calculi were found on the right side in two cases and

TABLE X

Complication (G.U.) Upper Tract

	Calculosis renal		Infection		Reflux		Hydroneph.		Ureterect. alone	
	Rt.	Lt.	Pos.	Neg.	Rt.	Lt.	Rt.	Lt.	Rt.	Lt.
C	5	1	10	4	—	—	—	—	—	—
T1-T6	1	1	21	4	1	1	2	2	—	—
T7-T12	1	1	29	4	2	2	5	3	2	1
L-S	1	2	25	9	—	1	4	4	1	—

TABLE XI

Complications (G.U.) Lower Tract

	Bladder calculi	Abscess	P-S Divert.	Fistula	Epididymitis		'Pseudopap.'	
					Rt.	Lt.	Blad.	Ureth.
C	6	—	—	—	—	—	—	—
T1-T6	13	—	1	2	2	2	2	—
T7-T12	15	1	2	—	2	2	1	3
L-S	22	—	—	4	2	2	—	1

left side in one case. All demanded operative intervention. If these are added to the renal calculi, the occurrence rate rises to 13 per cent. of our patients.

Infection. Cultures were almost all on catheter specimens and rarely mid-streams. The latest culture available was considered. Many patients who were positive by this criterion had previously had negative cultures. The organisms cultured in 'heavy' growth were: Proteus, 67 patients; Pseudomonas, 29 patients; *Aerobacter aerogenes*, 21 patients; *E. coli*, 13 patients; Paracolon, 8 patients; and Klebsiella, 1 patient. In some cases mixed growth occurred.

Reflux. The number of cases of reflux in this group was too small to consider further.

Bladder calculi were all 'infected' stones of the mixed type associated with catheter drainage or a degree of residual urine.

Penoscrotal problems have been eliminated by early intermittent catheterisation (Guttmann *et al.*, 1966). Our patients could not be treated in this way because of combat conditions and 8·8 per cent. developed abscess, diverticulum, or fistula.

Epididymitis. In addition to the figures given in Table XI, two patients developed this complication without the involved side being clearly stated

'*Pseuropapillomata*'. We observed seven patients with excrescences which were diagnosed histologically in five cases as pseudopapillomata and in two cases as squamous carcinoma Grade I and squamous carcinoma Grade II, respectively, of the urethra.

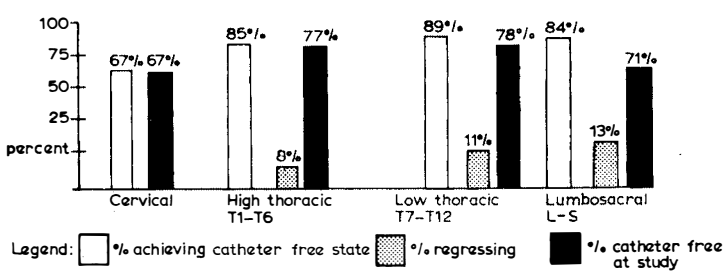
Additional urological complications incurred were: severe 'catheter' urethritis, 2 patients; balanitis (all on condoms), 6 patients; phimosis, 1 patient; venereal warts (proven by biopsy), 1 patient; paraphimosis, 1 patient; severe scrotal dermatitis, 1 patient; ulcers of the glans, 4 patients (on condoms); scrotal abscess, 1 patient. One patient developed an acute renal failure requiring hemodialysis prior to his admission to our facility. One patient had renal papillary necrosis, and one patient developed a right perinephric abscess 21 months post-injury. He had had a partial nephrectomy on the affected side immediately post injury.

The non-urological complications, many of which occurred prior to arrival at the Long Beach VA Hospital, are listed below. There are a reflection of the severity of injury and generally are those to be expected with the surgical treatment of trauma.

G.I. bleeding: 4 patients
Thrombophlebitis: 7 patients
Pulmonary embolus: 2 patients
Deafness: 1 patient
Wound infection: 4 patients
Enterocolitis: 1 patient
Fracture femur: 1 patient
Gram-negative sepsis: 3 patients
Cardiac arrest: 3 patients
Bowel obstruction: 4 patients
Empyema with bronchopleural fistula: 1 patient
Serum hepatitis: 2 patients
Diabetes: 1 patient
Gynecomastia: 2 patients

Urological rehabilitation aimed for renal preservation and bladder balance. Table XII presents data on the percentage of patients achieving a catheter free state.

TABLE XII



The cause of regression, *i.e.* reason to return to indwelling catheter drainage, was evidence of deterioration of the upper tracts or failure to maintain bladder balance. This was discovered on routine IVP re-examination and/or cystogram; or re-examination indicated by clinical symptomatology. The most common reason was a significant degree of ureteral and/or pyelocalyceal dilatation. Catheters replaced for short periods for balanitis, penile lesions, to support ureteral catheters for renacidin therapy were not included.

Table XIII shows the time period necessary for each group to become catheter free. The term catheter free implies a 'balanced' bladder function (Bors, 1948).

TABLE XIII

Time to become Catheter Free

	3 months	3-6 months	6-9 months	9-12 months	1 year	Nil	Regression
C	3	4	2	1		5	
T1-T6	1	9	7	2	3	4	2
T7-T12	4	14	9	4	2	4	4
L-S	5	8	8	8	2	4	5
Total	13	35	26	15	7	17	11

11·5 per cent. of our patients became catheter-free within 3 months of injury; 30·9 per cent. between 3 and 6 months; 23·0 per cent. between 6 and 9 months; 13·2 per cent. between 9 and 12 months; and 6·1 per cent. over 1 year. This yields a total of 84·7 per cent., achieving a balanced state with 9·7 per cent. regressing. At time of study 75·0 per cent. were catheter-free.

The procedures used to facilitate bladder balance in those that did not recover function spontaneously are outlined in Table XIV.

TABLE XIV

	Blocks	TUR	Sphincterotomy
C	2	0	—
T1-T6	1	2	—
T7-T12	2	4	—
L-S	4	3	1

The blocks used were: (*a*) mucosal anaesthesia using a surface application of pontocaine $\frac{1}{4}$ per cent. in the bladder, xylocaine in the urethra, and nupercaine in the rectum (Bors, 1964); (*b*) pudendal blocks using $\frac{1}{4}$ per cent. xylocaine to block gamma fibres progressing as necessary to a 1 per cent. solution. The TUR was done as recommended by Comarr (1959).

Delayed intermittent catheterisation is currently being practised in this Centre. This may be an additional factor in hastening bladder recovery. In 28 patients of this study this was utilised. Table XV presents data pertinent to the delayed intermittent catheterisation programme. It should be noted that catheterisation began every 4 hours, progressing to every 8 hours, every 12 hours, to a Q24-hour schedule. This, in fact, gave an accurate check regarding residual urine.

In the cervical complete group one patient was not successfully voiding by 90 days on the programme and was considered an 'unsuccessful' result. The 90-day figure was arbitrarily chosen. In the T1-T6 incomplete and L-S complete groups one patient is still on the programme and so not fully evaluated. Twenty-three developed balanced bladders, three of whom regressed. One patient required a TUR; two patients, pudendal blocks and three patients, mucosal anaesthesia.

TABLE XV

Delayed Intermittent Catheterisation

	Length cath. was in place (days)	Time of inter. cath. (days)				Succ.	Unsucc.	Regression	Urine C. & S. prior		Urine C. & S. after	
		0-15	15-30	30-60	60-90				pos.	neg.	pos.	neg.
C com.	101, 123, 122 68, 87	1	—	—	2	3	2	—	5	—	4	1
C incom.	—	—	—	—	—	—	—	—	—	—	—	—
T1-T6 com.	104, 202, 146 135, 151, 98 185, 293, 102	2	2	3	1	8	1	1	9	—	8	1
T1-T6 incom.	99, 360	1	—	—	—	1	—	—	2	—	1	—
T7-T12 com.	94, 112, 114 98, 118, 148 141, 71	3	2	1	1	7	1	2	6	2	5	3
T7-T12 incom.	—	—	—	—	—	—	—	—	—	—	—	—
*L-S com.	170, 200, 120	—	1	1	1	3	—	—	3	—	2	—
L-S incom.	77	—	—	1	—	1	—	—	1	—	—	1

All of these patients were relatively young men. Some of their greatest problems were created by psychosexual conflicts. Table XVI presents sexual data.

TABLE XVI

Sexual Data

	Erection		Nil	Relat.	Ejac.
	Psychic	Reflex			
C com.	—	8	1	2	—
C incom.	3	3	—	2	—
T1-T6 com.	—	12	3	4	—
T1-T6 incom.	3	3	—	3	—
T7-T12 com.	2	11	11	7	—
T7-T12 incom.	4	5	—	1	—
L-S com.	14	5	5	5	3
L-S incom.	8	2	3	4	1

There were 76 patients or 66·6 per cent. who had erections of some kind. Of the remaining 38, 16 did not provide the appropriate information so that only 19·2 per cent. can assuredly be said to be impotent. Twenty-eight patients (24·5 per cent.) were able to have relations. It is to be noted that many of our patients were interviewed when still hospitalised and in a debilitated condition so the percentage able to achieved relations may be higher.

Data regarding vocational rehabilitation are presented in Table XVII.

TABLE XVII

Vocational Rehabilitation

	School	Work	Nil	Still hospitalised	Unknown
C	2	2	4	7	—
T1-T6	10	2	4	7	3
T7-T12	8	2	10	10	6
L-S	9	3	9	11	5
Total	29	9	27	35	14

Many patients developed a vocational plan while in the hospital which frequently changed on release. For this reason the patient was placed in the unknown group unless it was specifically known at the time of the study with what the patient was vocationally involved. Twenty-nine patients (25·4 per cent.) were enrolled at college and nine (7·8 per cent.) were gainfully employed. Thirty-five (30·7 per

TABLE XVIII

Hospitalisation Time

	Injury to VAHLB adm.				VAHLB stay					Total hospital stay						Still Hosp.
	< 1 mo.	1-3	3-6	> 6	< 3 mos.	3-6	6-9	9-12	> 1 yr.	3-6 mos.	6-9	9-12	12-15	15-18	18-21	
C	—	8	5	1	1	4	2	1	—	—	3	4	1	1	—	4
T1-T6	—	9	11	5	4	10	2	3	1	—	6	5	5	1	2	6
T7-T12	—	8	20	8	6	9	11	3	—	—	10	17	1	1	1	6
L-S	—	4	16	16	8	10	4	5	1	—	4	11	6	5	1	10
Totals	—	29	52	30	19	33	19	12	2	—	23	37	13	8	4	26*

* The difference between the figures in the text of 35 patients 'Still hospitalised' against 26 patients 'Still hospitalised' shown in Table XVIII is caused by readmission of nine patients for checkup examination.

cent.) were as yet hospitalised. Some patients required one year or more before they made definite vocational plans.

To complete our observations Table XVIII presents data regarding length of hospital stay.

Eighty-five patients only are included in 'VAHLB' and 'Total Hospital Stay' of Table XVIII. Twenty-six patients still hospitalised at the time of study are not included. Three patients were treated primarily at other spinal cord injury centres and were transferred to VAHLB. These are not included.

Mortality. There were two deaths, one 4 months post-injury of meningitis and pneumonia and the other 1 year and 7 months post injury of pneumonia. Both patients had cervical cord lesions.

DISCUSSION

Age of Patients. In combat paraplegics the age at injury is younger than in other groups be they military or civilian. All of our patients were under 40 years and 70 per cent. (80 patients) were under 24 years. In cases of non-combat or civilian injuries the age among a sample of 153 patients was found to be considerably older. One hundred and twenty-one patients (79 per cent.) were under 40 years of age and 37 (24·1 per cent.) under 24 years of age at time of injury. It has been shown that the younger the patient at injury the better the prognosis for survival and rehabilitation (Nyquist and Bors, 1967).

Level and extent of lesion: In our series 13·1 per cent. were cervical injuries; 22·8 per cent., T1-T6; 31·5 per cent., T7-T12; and 32·3 per cent., L-S injuries. In a series of 1884 patients reported by Nyquist and Bors (1967) 29·8 per cent. were cervical; 16·6 per cent., T1-T6; 35·2 per cent., T7-T12; and L-S, 7·4 per cent. This included both combat and non-combat injuries. The L-S group shows great variance which can be explained by the difference in the mechanism of injury. The combat injuries are largely the result of bullet wounds the rifleman aiming for the largest area or shell fragments with the fragment displaced upward from ground level. In non-combatants the lower parts of the spine are rarely exposed to direct impact of a force except in falls from great heights or direct hits by a falling object.

In another series of 233 patients reported by Bors (1956) cervical cord lesions were caused by gunshot in 8·6 per cent. and by other violent trauma (excluding auto accidents, diving, and falls) in 9·4 per cent. The total 18 per cent. compares with the 13·1 per cent. of Table II. In contrast is the 29·8 per cent. cervical injuries noted above. This variation is due to the fact that they are largely automobile and diving accidents.

In this combat series 79 (69 per cent.) had complete and 35 (31 per cent.) incomplete lesions. In the large series of Nyquist and Bors (1967) 1135 (65 per cent.) had complete and 716 (35 per cent.) had incomplete lesions. These percentages are similar.

Mechanism of Injury. Fifty-seven (50 per cent.) of our patients were injured by a bullet wound. This was usually by sniper fire or ambush. This would attest to a degree of success of this means of attack. Claymore mines caused injury by direct shell fragment or by blast effect and were the next most common mode of injury. Friendly fire accounted for three bullet injuries.

The mechanisms of injury in combat are haphazard, not following any pattern as compared with civilian injuries. In this latter the cervical lesions are caused by

automobile or diving mishaps, *i.e.* cervical flexion or hyperextension. Direct trauma, *i.e.* thrown from vehicle, fall from a height, 'jackknifing' in mine or under a car, or direct blow, account for lesions at other levels.

Additional Injury, non-G. U. The fact that 67 per cent. of patients had major injury in addition to the spinal injury and survived eventually to reach a spinal injury centre attests to the quality of emergency care. The time period from injury to evacuation to a field hospital or hospital ship is said to average one hour; from field hospital to evacuation hospital averages one day; from evacuation hospital to active therapy in the U.S. or Japan only three days (Busch *et al.*, 1967). Evacuation during World War II was much less rapid. The extensive use of helicopter rescue services and air evacuation have been responsible for this change.

Chest injuries (all resulting in hemopneumothorax) occurred in 43 patients; 35 of these had T1-T12 injuries as is expected. Of 18 gastro-intestinal tract wounds 13 were in patients with lumbosacral lesions.

Additional Injuries, G. U. There were 16 kidney injuries severe enough to demand exploration. In five additional patients haematuria occurred but the exact source could not be defined. The incidence of renal injury is 12·2 per cent. (14 patients). To contrast, Busch's series of 370 patients had 2·7 per cent. (10 of 370) renal injuries (Busch *et al.*, 1967), and in 1096 patients reported by Oschener *et al.* (1969) 2·4 per cent. (27 of 1096) had renal injuries. Both of the above series contained patients without spinal cord involvement. This would indicate a greater severity of injury in our patients.

The 16 renal injuries were treated by nephrectomy in 8 instances; partial nephrectomy in 1; and in 7, debridement and drainage. In Oschener's series of 27 there were 8 nephrectomies; 1 partial nephrectomy; 4 suture repair; and 14 debridement and drainage. In Salvatierra's series of 79 renal injuries (1969) 10 were managed by bed rest; 28 by debridement and drainage; 6 by partial nephrectomy; and 35 nephrectomies were done. The management of renal injury does not vary due to the spinal cord involvement.

Ureteral Injury. The well-known fact that trauma *per se* rarely causes ureteral injury is again shown in that only one patient suffered a ureteral wound.

Bladder Injury. The one bladder injury was treated in the conventional way by insertion of suprapubic tube, repair and perivesical drainage.

Laminectomy. There is general agreement regarding the necessity of laminectomy in compound injury. 94·7 per cent. of our patients underwent laminectomy. Ninety or 78·9 per cent. of patients sustained compound injuries. Conversely there is great controversy in regard to the indications for laminectomy in closed spinal cord trauma. Six closed injuries (5·3 per cent.) did not have laminectomy. This leaves a group of 17 patients where laminectomy for closed injury was performed. Bony deformity, manometric block, failure to recover function were the indications. The results regarding degree of recovery in this group cannot be analysed due to lack of precise neurological data.

Complications, non-G. U. Well-known phantom sensations were extremely common but were not studied in each patient. Dissociation was observed to last for six or more months following incomplete cervical cord lesions with additional brachial plexus lesions and lacked correction by visual control, so that reduplication of one upper extremity was experienced.

Pain was reported in 19 patients with upper motor neuron lesions and 31 with lower motor neuron lesions. It often abated with time and with progression of

rehabilitation. Acute complications (G.U. usually) often caused an exacerbation to the discomfort which abated with successful therapy. Hypnosis was useful in selected patients. In the entire series no cordotomy or rhizotomy has been performed (Porter *et al.*, 1966).

Autonomic dysreflexia of varying severity can be provoked by an appropriate stimulus in all lesions above the splanchnic outflow (Guttmann and Whitteridge, 1947; Bors and French, 1952). Of 15 patients with cervical lesions (10 complete, 5 incomplete) this was a problem in 4 patients. In 26 patients with T1-T6 levels (19 complete, 7 incomplete) this was a problem in 2 cases. The acute episode was managed by elevation of the head of the bed and bladder drainage. If a distended rectum was the inciting cause, this was emptied. If these were not successful, mucosal anaesthesia (as described previously) was utilised. Etamon (tetraethyl ammonium chloride), a ganglionic blocking agent, was used. Patients in whom this was a frequent problem were placed on Ansolysen (pentolinium tartrate). In no patient was it necessary to consider spinal block either as a temporary or more permanent (alcohol) measure.

Complications related to General Surgical Trauma. The gastro-intestinal haemorrhages that occurred (four patients) were all serious and believed related to stress ulcers.

Gram-negative sepsis was documented by blood cultures in three patients. All occurred prior to admission to the Long Beach VA Hospital.

Cardiac arrest (three patients) occurred during anaesthetic induction for further surgery in the early post-injury period. One patient arrested on two occasions under these circumstances and showed signs of transient cerebral damage with recovery.

Bowel obstruction was due to volvulus (small bowel) in one patient and adhesions in three patients. All had undergone laparotomies immediately post-injury.

Deafness occurred in a patient being treated for a urinary tract infection with Kanamycin.

Diabetes was found six months post-injury in a patient of Hawaiian ancestry with no family history.

Gynaecomastia occurred in two patients (1·7 per cent.) which contrasts with 10·2 per cent. reported by Bors (1948) in World War II patients. Klatskin, Salter and Humm (quoted by Bors, 1948) did not find an abnormality of estrogen or other steroid production but suspected a temporarily deficient inactivation of estrogen in the liver.

Thrombophlebitis involving the lower limbs was recorded in seven patients; five of these had upper motor neuron lesions (T6, T7, T9, T10, L1), and two had lower motor neuron lesions (T6, L3). The number is small but does not agree as regards frequency in lower motor neuron lesions as opposed to upper motor neuron lesions when examined with phlebography (Bors *et al.*, 1954). All occurred in the early post-injury period. All of the above were diagnosed clinically and not by phlebograms. One patient developed a pulmonary embolus in whom no clinical thrombophlebitis could be demonstrated.

Complications G. U.: Calculosis. Munro (1948) in a report of 101 World War II soldiers found in 14·0 per cent. incidence of renal calculi. Bunts (1967) in his World War II group reported 13 per cent. at one year decreasing to 8 per cent. at four years; however, in his Korean war group the incidence was 5 per cent. during the first four years of follow-up. Bors (1951) in a series of 354 World War II

wartime injuries reported an incidence of 15·5 per cent. Our finding of 13 per cent. correlates with all except for the Korean group of Bunts (1967). All calculi were treated by means or renacidin infusions by ureteral catheters with the exception of three that dropped into the ureter. Data on this method of therapy are being evaluated. All of these calculi occurred within two years of injury. All but two patients had accompanying injuries of variable magnitude, which may be important.

Infection. There was no attempt to define the incidence of upper urinary tract infection in our patients. Lower urinary tract infection was more clearly documented with 21 patients (19·8 per cent.) achieving a sterile urine at time of discharge or on latest culture. Eighty-five patients (80·2 per cent.) were infected by the same criteria. Three of the 21 had been managed by intermittent catheterisation and the remainder were catheter free. Many of these patients had incomplete lesions. Proteus (rettgeri, vulgaris, mirabilis, morgagni) was present in 75·2 per cent. of the infected urines. There was no attempt to sterilise the urine when a patient was on catheter drainage by means of antibiotics. Our patients were maintained on high doses of vitamin C and Mandelamine (methenamine mandelate) in association with a high fluid intake. Antibiotics were relegated for treatment of special cases of acute clinical infection and accompanied by high-volume intravenous fluids.

Hydronephrosis. Twenty kidneys (11 right and 9 left) developed varying degrees of hydronephrosis on IVP. Most cases were accompanied by ureterectasis. Fourteen were in patients with lower motor neuron lesions and six were in patients with upper motor neuron lesions. All occurred in patients who were catheter free; two (left side) were associated with renal calculosis. In 63 patients with upper motor neuron lesions (126 kidneys) six kidneys developed hydronephrosis (4·7 per cent.), while in contrast in 51 patients with lower motor neuron lesions (94 kidneys) 14 kidneys became hydronephrotic (14·8 per cent.). Two kidneys (one left, one right) have returned to a normal IVP configuration on catheter drainage. One kidney remains unchanged, and in 10 it is too early to evaluate. In no instance could anatomic obstruction be demonstrated (*i.e.* ureteral catheters passed readily). The exact mechanism is unknown but further evaluation by cine studies is planned. It is of special interest that 14/20 (70 per cent.) occurred in balanced lower motor neuron bladders many of which showed severe changes on cystoscopy.

Pathological changes at the penoscrotal (PS) junction: In our patients 8·8 per cent. developed pathological changes at the P-S junction with six (5·2 per cent. progressing to fistual formation. In a World War II series of 354 patients Bors (1951) reported 3·1 per cent. incidence of fistula formation. A peacetime group of 269 patients at the same time had developed fistula in 11·9 per cent. The wartime groups' low figure can be attributed to the fact that suprapubic cystostomy was almost routinely performed in paraplegics during World War II. Diverticula were found in 48·4 per cent. of Bors' series (1951) while only three patients (2·1 per cent.) of our series showed this. Urethrograms were done only for specific indications in our present series; thus our percentage may be higher than 2·1 per cent. In the above quoted patients with an incidence of 48·4 per cent. routine urethrograms were done and the follow-up period was longer. None of our patients treated with intermittent catheterisation has developed penoscrotal pathology, which again reiterates Guttmann's (1966) experience.

'*Pseudopapillomata*'. Papillary excresences were found in the bladder in three

instances (2·6 per cent.) and urethra in four instances (3·5 per cent.). In the latter group two lesions were reported as squamous carcinoma. Therapy consisted of excisional biopsy (where possible) and fulguration. The catheter (present in all patients) was changed to a smaller size or to a plastic catheter. Silver nitrate (1:10,000 to 1:1000) irrigations were done. The two patients reported as having squamous carcinoma of the urethra are both doing well under close scrutiny. In a review of 2046 patients Shey and Bors (1966) found the incidence of vesical papillomata to be 7·9 per cent. and urethral 1·6 per cent. They noted infection and the presence of a catheter to be the probable inciting causes both of which were present in our cases.

Suprapubic Cystostomy. A suprapubic tube was present on admission to the Long Beach VA Hospital in five patients. In two instances cystostomy was emergent in treating a ruptured bladder; in one instance it was iatrogenic. One patient had a tube placed for urethritis; one for spasms and one for a P-S fistula. In treating urethritis we recommend the use of a smaller or of a plastic catheter. Spasms in our experience are not an indication for suprapubic cystostomy which may often aggravate them. In the past it has been rarely necessary to use a suprapubic diversion to achieve a closure of a P-S fistula. In patients with lower motor neuron lesions it is contra-indicated as urine will continue to leak via the bladder outlet. Our suggested indications for suprapubic cystostomy are: (*a*) ruptured bladder, (*b*) severe impassable urethral stricture, and (*c*) subtrigonal diverticulum making catheter insertion very difficult. The last condition can be occasionally treated by a transurethral deroofing procedure.

Urological Rehabilitation. Reference to Table XII will show that the percentage of catheter free patients at the time of this study was within a 11 per cent. range for all lesion levels (67 per cent. for cervical to 78 per cent. for low thoracic lesions). The level of the lesion does not seem to affect the chance of achieving a catheter-free state. The chance of reaching this goal was enhanced by incompleteness of the lesion (Comarr, 1959).

Reference to Table XIII will show that the largest number of our patients developed a 'balanced' bladder between 3 and 6 months post-injury (35) and 6 and 9 months (26). This correlated with previous experience at this centre. It is of interest that with the use of early intermittent catheterisation Hardy (1966) found 13 of 17 patients to develop balanced bladder function within 3 months after injury. This experience was similar to that reported by Guttmann (1966) in a larger group. Our patients did not have the advantage of early intermittent catheterisation, but it is our impression that even in individuals with delayed intermittent catheterisation balanced bladder function is facilitated. In contradistinction to Guttmann's (1966) series only 4 of 28 patients developed sterile urine on intermittent catheterisation; however, these series are not strictly comparable as our patients arrive with well-established lower urinary tract infections as this procedure cannot be used in the field and the Foley catheter is used rather than the Gibbon.

Sexual Data. There was some difficulty accurately interpreting patients' statements in regard to psychic and reflex erections. The presence of pseudo-spontaneous erections, reflex in nature, were occasionally interpreted by the patient as psychic.

At all levels patients with incomplete lesions reported psychic erections.

Two patients with flaccid paralysis and dermatome levels below T11 and T12, respectively, had psychogenic erections. It is possible that cholinergic impulses are

conveyed by the hypogastric nerves to explain the psychic erections. In the low thoracic (T7-T12) group, 11 patients reported no erections. Most of these had lower motor neuron lesions. In the L-S complete group, five patients noted reflex erections; three had epiconal lesions, the other two had lower motor neuron lesions. Marburg and Ranzi (quoted by Jelliffe and White *Text of Neurology*) claim that reflex erections are possible under these circumstances based upon an alleged peripheral reflex mechanism. One patient with a complete L3 epiconal lesion noted both psychic and reflex erections. Although this is exceptional it has been noted (Bors and Comarr, 1960).

Sixteen of 38 patients with clinically complete lower motor neuron lesions 'claimed' psychic erections (42·1 per cent.). This is higher than the 27 per cent. reported by Bors and Comarr (1960). In this group ejaculation occurred in four instances (10·5 per cent.). In all instances it was the typical dribbling emission. This compares with 19 per cent. in a similar group in the above quoted series.

Vocational Rehabilitation. Reference to Table XVII shows that of a total of 114 patients 35 are yet hospitalised and in 14 the activity status is not accurately known. This leaves 38 patients actively engaged at school or work while 27 patients are inactive. It furthermore illustrated that in this group of young people the preference of school over work is better than 3:1. Further analysis of the table shows that at all lesion levels the distribution between active and inactive patients is about the same. Motivation for schooling is markedly enhanced by government support extended to these patients.

Hospitalisation Time. Reference to Table XVIII shows that no patient was admitted to our facility within one month of injury; 26·1 per cent. from 1 to 3 months; 46·8 per cent. from 3 to 6 months; and 27·1 per cent. over 6 months. Many of this last group were over one year post-injury. There is an obvious hold up at armed forces hospitals which in many cases seemed undesirable. The speed of delivery of patients to the Spinal Cord Injury Centre is in sharp contrast to the speed of emergency care and evacuation previously alluded to. We are aware that combat injuries cannot be transferred in the early post-injury period in the same way as civilian injuries as reported by Cheshire (1967), where 70 per cent. were received within 48 hours.

In regard to length of stay at our facility, 22·3 per cent. were discharged within three months; 61·1 per cent. within six months. Only 2·3 per cent. were hospitalised over one year. This is in sharp contrast with our past experience with World War II and the Korean conflict when hospitalisation at this centre averaged 18 months for paraplegics and 24 months for quadriplegics. This would suggest that the experience gained over 20 years has contributed to more security and less self-consciousness of the patient, both of which may have been the cause of delayed discharge in World War II patients. Society has learned to accept these patients and the patients have met the challenge of competition with non-paraplegics.

Eighty-five patients have completed their primary hospitalisation. In regard to total length of hospitalisation (date of injury to discharge from spinal cord injury centre), 23 patients (27 per cent.) required 6 to 9 months; 37 (43·5 per cent.) required 9 to 12 months; 25 (29·5 per cent.) required over one year of hospital care. This again reflects a shorter hospital stay than was our experience with World War II or Korean patients.

Mortality. The mortality over the short follow-up period was 1·7 per cent. It must be stressed that mortality figures for a chronic disorder, such as spinal cord

injury, are meaningless unless a long period of follow-up is utilised (Nyquist and Bors, 1967). It is not surprising that renal pathology was not the cause of death as it is recognised that renal deterioration of lethal degree rarely occurs in paraplegics under five years.

SUMMARY

Observations on 114 Vietnamese combat injuries with spinal cord involvement treated from December 1965 to April 1969 are presented. Eighty (70 per cent.) of patients were under 24 years of age and 11 (9·6 per cent.) over 30 years; there were 79 (68 per cent.) clinically complete and 35 (31 per cent.) incomplete lesions; 61 patients had UMN lesions and 53 patients had LMN lesions. Fifty-seven patients received their injury by bullet wounds, the remainder largely by shell fragment, blast, or vehicle crash. Sixty-seven per cent. of patients had multiple injuries with 43 chest injuries and 18 patients sustained gastro-intestinal tract wounds. There were 16 renal injuries, one ureteral laceration and one ruptured bladder. Emergency therapy was rapidly performed in well-equipped hospitals. Evacuation was markedly enhanced by helicopter service. The renal injuries resulted in eight nephrectomies, one partial nephrectomy, and seven repairs with drainage. One hundred and seven patients underwent laminectomy, 90 for compound injuries.

During the follow-up period G.U. complications found were: renal calculosis in 14 patients (13 per cent.); hydronephrosis in 20 patients (11·4 per cent. of kidneys in patients with LMN lesions, 4·7 per cent. of kidneys in patients with UMN lesions); lower urinary tract infection in 85 patients (80·2 per cent.); epididymitis in 14 patients (12·8 per cent.); PS pathology in 10 patients (8·8 per cent.); 'pseudo-papillomata' in 7 patients (3 bladder, 4 urethra); bladder calculi in 56 patients (49·1 per cent.). Decubiti and pain were frequent problems. Pain was treated by non-operative means.

In regard to urological rehabilitation 67 to 78 per cent. (varying with lesion level) were catheter-free at the time of study with 53·5 per cent. of patients achieving this by 9 months post-injury. The procedures necessary to achieve this, including delayed intermittent catheterisation, are presented.

Seventy-six patients (66·6 per cent.) had erections and 28 (24·5 per cent.) have been able to have relations. 42·1 per cent. of patients with clinically complete lower motor neuron lesions claimed psychic erections.

At the time of the study 29 patients have returned to school and 9 to gainful employment; 35 patients are still hospitalised and 27 are vocationally inactive. This did not vary with the lesion level.

The length of hospitalisation is presented and contrasted with that of World War II and Korean paraplegics. 61·1 per cent. of patients required under six months of care at a spinal cord injury centre and only 29·4 per cent. (25 patients) required over one year of total hospitalisation.

REFERENCES

BORS, E. (1948). *Veterans Administration Technical Bulletin*, TB 10-503.
BORS, E. (1951). *Journal of the American Medical Association*, **146**, 225.
BORS, E. (1956). *Bulletin of the Los Angeles Neurological Society*, **21**, 105.
BORS, E. (1964). *Journal of the International College of Surgeons*, **42**, 22.
BORS, E. & COMARR, A. E. (1960). *Urological Survey*, **10**, 191.

BORS, E., CONRAD, C. A. & MASSELL, T. B. (1954). *Surgery Gynecology and Obstetrics*, **99**, 451.
BORS, E. & FRENCH, J. D. (1952). *Archives of Surgery*, **64**, 803.
BUSCH, F. M., CHENAULT, O. W., ZINNER, N. R. & CLARKE, B. G. (1967). *Journal of Urology*, **97**, 763.
CHESHIRE, D. J. E. (1967). *Clinical Spinal Cord Injury Conference Proceedings*, p. 39.
COMARR, A. E. (1959*a*). *British Journal of Urology*, **31**, 1.
COMARR, A. E. (1959*b*). *Journal of Urology*, **81**, 537.
COMARR, A. E., KAWAICHI, G. & BORS, E. (1962). *Journal of Urology*, **85**, 647.
GUTTMANN, L. & FRANKEL, H. (1966). *Paraplegia*, **4**, 63.
GUTTMANN, L. & WHITTERIDGE, D. (1947). *Brain*, **70**, 361.
HARDY, A. G. (1966). *Medical Services Journal, Canada*, **22**, 538.
HEAD, H. & RIDDOCH, J. (1917). *Brain*, **40**, 188.
MICHAELIS, L. S. (1968). *Paraplegia*, **6**, 46.
MUNRO, D. (1948). *American Journal of Surgery*, **75**, 3.
NYQUIST, R. H. & BORS, E. (1967). *Paraplegia*, **5**, 22.
OCHSNER, T. G., BUSCH, F. M. & CLARKE, B. G. (1969). *Journal of Urology*, **101**, 224.
PORTER, R. W., HOHMANN, G. W., BORS, E. & FRENCH, J. D. (1966). *Archives of Surgery*, **92**, 765.
SALVATIERRA, O. J., RIGDON, W. O., NORRIS, D. M. & BRADY, T. W. (1969). *Journal of Urology*, **101**, 615.
SHEY, H. H. & BORS, E. (1966). *Urologia internationalis*, **21**, 253.
WADEWITZ, P., LANGOIS, P. J. & BUNTS, R. C. (1967). *Journal of Urology*, **98**, 706.