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ORIGINAL ARTICLE

Spinal cord injuries among paragliders in Norway

T Rekand[1], EE Schaanning[2], V Varga[1], U Schattel[3] and M Gronning[1]

[1]Department of Neurology, Haukeland University Hospital, Bergen, Norway; [2]Department of Spinal Injury and Multitrauma, Sunnaas Rehabilitation Hospital, Nesodden, Norway and [3]Department of Physical Medicine, St Olav Hospital, Trondheim, Norway

Study design: A national retrospective descriptive study.
Objective: To study the clinical effects of spinal cord injuries (SCIs) caused by paragliding accidents in Norway.
Setting: Spinal cord units at Haukeland University Hospital, Sunnaas Rehabilitation Hospital and St Olav Hospital in Norway.
Methods: We studied the medical files for nine patients with SCI caused by paragliding accidents to evaluate the circumstances of the accidents, and clinical effects of injury. We obtained the data from hospital patient files at all three spinal units in Norway and crosschecked them through the Norwegian Paragliding Association's voluntary registry for injuries.
Results: All patients were hospitalized from 1997 to 2006, eight men and one woman, with mean age 30.7 years. The causes of the accidents were landing problems combined with unexpected wind whirls, technical problems and limited experience with unexpected events. All patients contracted fractures in the thoracolumbal junction of the spine, most commonly at the L1 level. At clinical follow-up, all patients presented clinically incomplete SCI (American Spinal Injury Association impairment scores B–D). Their main health problems differed widely, ranging from urinary and sexual disturbances to neuropathic pain and loss of motor functioning. Only three patients returned to full-time employment after rehabilitation.
Conclusion: Paragliding accidents cause spinal fractures predominantly in the thoracolumbal junction with subsequent SCIs and increased morbidity. All patients experienced permanent health problems that influenced daily activities and required long-time clinical follow-up and medical intervention. Better education in landing techniques and understanding of aerodynamics may reduce the risk of paragliding accidents.
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Introduction

Paragliding was introduced in France in the 1980s[1] and became a popular activity in Norway in the 1990s. Paragliders are developed from parachutes, but a paraglider starts without using aircraft may achieve speed exceeding 100 km h^{-1} and be in the air for a long time. In Norway, the Norwegian Paragliding Association (NPA) has registered and instructed more than 1200 people. Accidents related to paragliding have been voluntarily registered in the NPA registry. Similar registries have been developed in other countries.[1] Paragliding accidents may result in spinal fractures and subsequent spinal cord injuries (SCIs),[1–3] and it has been previously shown that hang-gliding and paragliding are responsible for an increase in sports-related SCIs.[4]

As the sport has become increasingly popular, several paragliders in Norway have experienced accidents with severe outcome. The aim of this descriptive case study was therefore to examine all known paragliding accidents in Norway that have caused SCI: the circumstances of the accidents, the clinical and radiological findings, and the long-term outcome. Persistent nervous system findings at follow-up and disabling changes in daily functioning were of primary interest.

Materials and methods

We identified the participants by reviewing all patient files from January 1990 to December 2006 in all three spinal cord units in Norway (Trondheim, Oslo and Bergen), which are the only institutions providing primary rehabilitation for

Correspondence: Dr T Rekand, Department of Neurology, Haukeland University Hospital, N-5021 Bergen, Norway.
E-mail: tiina.rekand@helse-bergen.no
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patients with SCIs in Norway. We crosschecked the injuries and confirmed via the NPA's registry for injuries. The NPA had registered information about all the cases included.

All patients were hospitalized within a few hours after the accident at the local emergency facility, and the initial clinical and radiological findings were available for all of them. We clinically assessed them retrospectively based on information in the acute patient files using the American Spinal Injury Association (ASIA) classification.[5] The ASIA impairment score is classified as follows:

- A: no sensory or motor function is preserved in the sacral segments S4–S5;
- B: sensory but no motor function is preserved below the neurological level and includes the sacral segments S4–S5;
- C: motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3;
- D: motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more and
- E: sensory and motor functions are normal.

All patients were X-rayed at admission, followed by computed tomography or magnetic resonance imaging. We classified the fractures according to the classification of thoracic and lumbar injuries;[6]

- type A represents vertebral body compression (subtype A1, impaction fractures; A2, split fractures; A3, burst fractures);
- type B represents anterior and posterior element injury with distraction (subtype B1, posterior disruption that is predominantly ligamentous; B2, posterior disruption that is predominantly osseous; B3, anterior disruption through the disk);
- type C represents anterior and posterior element injury with rotation (subtype C1, type A injuries with rotation; C2, type B injuries with rotation; C3, rotational-shear injuries). All the patients were rehospitalized for rehabilitation and clinical follow-up at least once (1–2 years) after the acute injury, and recent clinical data (past 2 years) were available in all cases.

We contacted all patients during their hospitalization and gave them oral and written information about the study. They gave written consent to participate in the study and for the use of the patient files. The local ethics committee in Bergen approved the study. Complete data were available in all cases, and we extracted the final relevant information in Bergen.

Results

The first patient was hospitalized in 1997 and the last one in 2006. We identified 10 patients and excluded one. He suffered from multiple traumas but had no clinical signs of SCI. We included eight men and one woman in the study. Their ages at the time of the accident were 22–59 years (Table 1). All were amateurs except one pilot. All patients were licensed on level three or higher and were certified for independent paragliding without a trainer or supervisor. One was performing a very first independent flight when the accident happened. Two were beginners with less than 10 independent flights and seven experienced, with substantial experience in independent flights. All accidents were due to landing problems, such as changes in wind conditions in five cases and unexpected technical problems in two cases. One patient performed paragliding in tandem as an instructor and one patient (no. 9) had an uncontrolled landing and a fall 200–300 m in a mountainous area. In addition to SCI, she suffered multiple fractures in the spine, face, pelvis and extremities and concussion of the brain. The patients' professions included electrical engineer, computer programmer, part-time paramedic and farmer, student, nurse, sailor, joiner and bank executive.

All patients had type A fractures (complete burst fractures in eight cases and a split fracture in one case) as demonstrated by radiological examinations (Table 1). They were initially treated with intravenous methylprednisolone, followed by operative laminectomy shortly after admission. The fracture occurred most commonly at the L1 level (Table 1). No injuries at the cervical levels were observed. At acute admission to the hospital, one patient had a clinically complete SCI (ASIA score A) and the others incomplete SCIs. At follow-up, all patients had clinical signs of incomplete SCI (ASIA scores B–D).

At the most recent follow-up, seven patients had urological dysfunction; five needed intermittent bladder catheterization

Table 1 Description of clinical findings 24 h after injury

Case no.	*Sex, age (years)*	*Spinal fractures*	*Other injuries*	*ASIA score at primary hospitalization*
1	Male (28)	Th12, L1	Pneumothorax	A
2	Male (28)	L1		C
3	Male (32)	L1		C
4	Male (23)	L1	Fracture in the calf Concussion of the brain	D
5	Male (50)	Th12		C
6	Male (29)	L2	Fracture in the calf	
7	Male (26)	Th12, L1		C
8	Male (59)	Th12, L1, L2	Fracture in the foot	C
9	Female (22)	Th9, Th10, L4, L5	Multiple fractures in the face, pelvis and both lower extremities Concussion of the brain	D

Abbreviation: ASIA, American Spinal Injury Association.

(Table 2). Four men needed treatment because of sexual dysfunction. Three patients reported chronic neuropathic pain and two others chronic nociceptive pain. Two patients had severe paraparesis and used a wheelchair. However, only one reported muscular weakness as a main problem, and the other one reported neuropathic pain as a most disabling problem.

Three patients had returned to full-time employment, three patients had part-time employment and three were receiving disability pension at the recent follow-up.

Case 1

A 28-year-old previously healthy farmer performed his very first independent flight in 2003. During the flight, the wind conditions changed and he lost control over his paraglide and landed promptly on the buttocks.

He complained of pain in the entire vertebral area and had no sensation or movement in his legs. He was treated with intravenous methylprednisolone prior to the hospitalization. The X-ray examination showed pneumothorax, and instable fractures in Th12 and L1 level. On admission, the clinical examination revealed complete motor and sensory loss from L1 and no sphincter control. He was operated with laminectomy at level Th12 and L1 and fixation between Th9 and L2.

He was admitted to the Spinal Cord Unit for rehabilitation 2 weeks after the injury. Clinically, his motility (grade 4 for flexion, adduction and abduction in both hips, paralysis in the ankles and toes) and sensation had improved. Further examinations revealed urological as well as sexual dysfunction. The urological problem was treated with intermittent catheterization, and the sexual with sildenafil.

Two months after the acute injury, he developed daily irradiating icing pain in thighs and legs, corresponding to grade 4–9 in a visual analog scale (VAS). In addition, he complained of spinal pain in the operation area, with VAS score of 4–7. Medication with pregabalin, gabapentin, diclofenac, paracetamol, carbamazepine, oxcarbazepine, lamotrigine, topiramate, klonidine, opiods including oxycodone, fentanyl or tramadol, and transcutaneous electrical nerve stimulation during the following 2 years were without any effect on his pain and/or with unacceptable side effects. In 2005, the fixation material was surgically removed. After surgery, the pain in the spinal area diminished to VAS score 1–2. However, the neuropathic pain in his lower limbs is still present (VAS up to 9) and has remained his main health problem. He uses currently a combination of amitriptyline

Table 2 Long-term outcome after paragliding accidents

Case no.	*Observation time (year)*	*Main health problem reported by the patients at follow-up*	*Neurological findings at follow-up*	*Assistive devices*	*Medication at follow-up*
1	4	Pain	Pareses from hips with paralysis in the ankles Sensory loss from L2 Urinary and sexual dysfunction[a] Chronic neuropathic pain, VAS 7–9	Wheelchair Intermittent bladder catheterization	Amitriptyline Opioids Sildenafil
2	4	Gait disturbance	Spasticity in the leg and ankle No other findings	No	Botulinum toxin
3	1	Gait disturbance	Pareses in ankles Sensory loss from S1 Urinary and sexual dysfunction[a]	No	No
4	2	Sexual dysfunction	No pareses or sensory loss Bowel and sexual dysfunction[a]	No	Sildenafil
5	9	Loss of gait function	Pareses from hips with paralysis in the ankles, spasticity Sensory loss from L2 Urinary dysfunction[a] Intermittent nociceptive pain, VAS 4–5	Wheelchair Intermittent bladder catheterization	Nonsteroidal anti-inflammatory drugs
6	10	Pain	Pareses from knees Sensory loss from L2 Urinary and bowel dysfunction[a] Chronic neuropathic pain, VAS 5–7	Orthopedic shoes	Gabapentin, nonsteroidal anti-inflammatory drugs
7	1	Sexual and urinary dysfunction	Normal motor function Analgesia from S2 Urinary dysfunction[a]	Intermittent bladder catheterization	Sildenafil
8	6	Pain	Paresis from hips with distal progression Sensory loss from L2 Urinary and sexual dysfunction[a] Chronic neuropathic pain, VAS 7–8	Orthosis for knee Intermittent bladder catheterization	Gabapentin Opioids Sildenafil
9	4	Pain	Thoracolumbal scoliosis after multiple fractures No pareses Sensory loss L5 and S1 Urinary dysfunction[a] Chronic nociceptive pain, VAS 2–3	Intermittent bladder catheterization	No

Abbreviation: VAS, visual analog scale.
[a]Findings are based on clinical examination.

and buprenorphine patches (opioid) for pain treatment. Since 2003 he has been hospitalized 12 times and regularly followed up at the outpatient clinic with adjustment of medication, psychological counseling and physiotherapy.

Discussion

Our study confirms that paragliders are at risk for fractures in thoracolumbar region of the spine with subsequent SCI, as previous studies have indicated.[1,3,7] Landing at high speed on straight feet or crashing on the buttocks puts the thoracolumbal junction of the spine at risk for fractures caused by high energy. Similar injuries have been reported among skydivers and among snowboarders[8,9] indicating that this type of extreme sport increases the risk of spine injuries. Among skydivers and snowboarders, approximately one-third of the SCIs occur in the cervical or upper thoracic level.[8,9] In contrast to these and to epidemiological data on SCI in Norway, paragliding injuries are more homogeneous, as serious neck and head trauma is rare, indicating that the spinal cord and spine are at high risk due to vertical high-energy force evoked toward the spine due to the paraglider's fixed body position.[1,3,10,11] Demographically, the paragliders with SCIs were similar to those in the general population of Norway, with clear male predominance.[10,11]

Interestingly, most of the paragliders in our study were experienced, and the causes of accidents were unexpected circumstances and misjudgments in the landing process. Our findings are in accordance with the results of previous studies,[1,12,13] suggesting that continuous education in aerodynamics and training is crucial for reducing the risk of paragliding accidents. Another study found that inexperienced beginners are the most accident-prone group,[14] and use of the safer glider in the beginner category and padded back protection has therefore been proposed. In Norway, back protection was introduced as compulsory equipment from 2003. The number of traumas did however not decrease. Pilots' personality may also influence their perceptions. A previous study has demonstrated that paragliders have a more sensation-seeking personality than people in the general population.[15] Sensation-seekers usually underestimate or accept risks to enjoy some types of sensations and experiences. This kind of personality has a high risk of accidents. However, these personality traits were not examined in our study, but according to the NPA statistics, taking unnecessary risks causes many accidents.[16]

Functional recovery occurred in all our cases, including the patient who initially was classified as ASIA A. A study from Switzerland[3] stated that vertebral body compression type fractures (type A) result in better nervous system outcome than rotation type (type C) injuries. In our study, only type A fractures occurred, which may explain why all the patients experienced considerable nervous system recovery. Disabling loss of motility was found only in a few cases, as demonstrated also in other studies.[1,3] This may be explained by anatomical reasons, as spinal motoric areas and pathways are located farther from the influence of the spinal fracture.

All our patients reported disabling health problems at follow-up, and no one experienced complete functional recovery without any health problems. The individual persistent complaints varied from urinary and sexual disturbances to neuropathic pain and loss of gait function similar to the results from other studies.[3,17] The most common health problem was urological dysfunction, and five patients needed intermittent bladder catheterization. Intermittent catheterization influences social functioning and may contribute to physical disability.[18] In five cases disturbed sexual functioning was reported. Previous studies have indicated that a high proportion of patients with traumatic SCI experience both sexual and bladder disturbances as the main health problems requiring continuous medical follow-up.[19,20] Chronic pain was reported as a major health problem by five patients. Chronic pain influences the quality of life, and is reported as the main disabling problem among a high proportion of patients with SCI also from the other causes.[21,22] The pain may prevent community reintegration and return to the daily activities the patients enjoyed before the injury.[23] Urological and sexual dysfunction and chronic pain are not visually obvious to the families, friends and employers, but may nevertheless be the most disabling symptoms to the patients. As shown in our study, the health problems affected also professional life and ability to earn their own income. Six patients were awarded disability pension and were unable to return to full-time employment.

This study is based on hospital data and includes nine cases. We expected to identify relatively few cases because the population of paragliders is limited in Norway. However, many acute clinical findings in this study are in accordance with previously published information.[1–3] Our results focus on the long-term outcome and reveal the need for regular rehabilitation and clinical follow-up.

Conclusions

Paragliding landing accidents imply a high risk of fractures in the thoracolumbal junction with subsequent SCI because of high-energy force impacting the spine in the accident. Although all patients gained function during the primary rehabilitation, they all experienced persisting disabling symptoms. Urinary and sexual disturbances, chronic pain and loss of gait function were the most prevalent health problems.

Education and training of paragliders on managing various aerodynamic conditions and safe landing at high speed are crucial to reducing the risk of accidents.

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