

Injury to the Neck and Information on Headrests

This is the sixth and final article in this series on spinal injury written by Tony, a retired British doctor who has spent much of his free time researching this subject. For the previous articles click here for [No. 1](#), [No. 2](#), [No. 3](#), [No. 4](#) and [No. 5](#)



This last article deals with injuries to the neck - the cervical spine.

Introduction

Of all spinal cord injuries, 60% involve the cervical spine. In recent years the proportion of cervical cord injuries has increased and is now the most common reason for admission to specialised spinal hospital units. A third of patients are transported to hospital without prior immobilisation of the neck. The effect of the initial trauma is irreversible, but the spinal cord is at risk by injudicious early management. Fractures may result from high energy accidents involving vehicles (including gliders), falls or diving.

Care of the Patient

At the site of the accident, an unconscious patient should be assumed to have a cervical injury until an X-ray proves otherwise. The force that rendered the patient unconscious may also have injured the cervical spine. The head and neck should be carefully placed and held in the neutral anatomical position. The head and neck should be stabilised using a rigid collar of a suitable size, sandbags on each side of the neck and forehead tape.

The patient may need to be "log-rolled" by four experienced people into a modified lateral position. The body is 70 to 80 degrees from the prone position, with the head supported by the underlying arm. This enables fluid to drain from the mouth, and avoids rotation of the spine. Witnesses may provide useful information. Wounds may suggest a mechanism of injury - a forehead wound may indicate hyper-extension injury of the neck.

In the **conscious patient**, spinal injury is indicated by pain in the neck or back, loss of sensation in the limbs and weakness or loss of movement in the limbs. Localised trauma to the back may indicate spinal injury.

Plain X-rays will indicate the level and the nature of the bony injury. However, X-rays often appear normal in children and in 15% of adults with spinal injury. Computed tomography will reveal accurate detail of the bony injury. Magnetic resonance imaging will visualise the spinal cord and the spinal ligaments.

(Source of information: "ABC of Spinal Cord Injury", 3rd Edition, D. Grundy, A. Swain.)

Anatomy

(Please see previous articles for an explanation of the technical terms.) There are seven cervical vertebrae, C1 to C7. An interesting point is that there is a round hole (a foramen) for the vertebral artery in each vertebral transverse process.

The first

Survivable Loads On The Pilot

By Tony Segal
Issue 12/2000

Tony started gliding at Lasham, England, in 1956 and has worked as a family doctor for 30 years. On retiring he took a six months' course for the Diploma in Aviation Medicine at the Royal Air Force Institute of Aviation Medicine. He is now carrying out experimental work on pilot safety at the Centre for Human Sciences, DERA, Farnborough, with the help of Les Neil. Tony, who has recently been elected a Fellow of the Royal Aeronautical Society, is dedicated to finding ways pilots can protect themselves from injury by taking simple precautions in the cockpit.



This report discusses the factors involved in causing injury to the pilot in an impact accident.

The direction of the impact can affect the pilot in three directions, as follows:

The axis of the spine, the Z axis.

Fore and aft, across the chest, the X axis.

Sideways, across the shoulders, the Y axis.

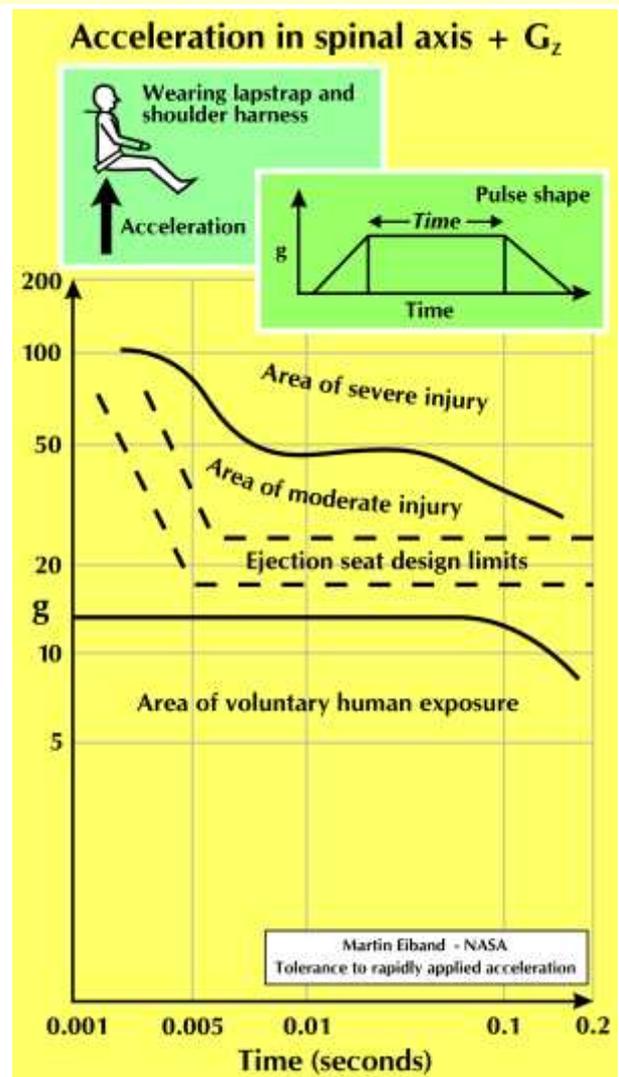
The axis of the spine is the most significant. First, for causing compression injury to the vertebral bones of the spine, with possible subsequent injury to the spinal cord and paralysis. Next, the internal organs of the thorax and abdomen can move up and down in the body cavity, rather like a piston in a cylinder, and thus can be exposed to damage.

Impact across the chest is not so serious, the internal organs being to some extent held in place between the front of the chest wall and the back.

Impact in the direction across the shoulders may cause injury to the neck.

The site of application of the impact affects the outcome. Impact on the back or on the buttocks will cause least effect.

The value of the deceleration caused by the impact affects the pilot in three ways. The peak value of g (the unit used to measure acceleration and deceleration), the rate of rise of g (the "jolt") and the duration of g all make the effect of the impact worse when their values are increased. This is shown in the Eiband diagram (alongside).



Close coupling of the pilot to his seat is important. The pilot should maintain close contact with the seat and not bounce about.

Lastly, the age of the pilot matters. The bones of the spinal column get weaker with age, as shown by the following table.

Breaking load in compression of the lumbar (lower spine) vertebrae, from work carried out by Yamada follows:-

20 - 39 years - 1750lbs.f.

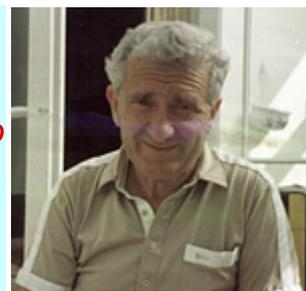
40 - 59 years - 1144lbs.f.

60 - 79 years - 737lbs.f.

Spinal Injury In Gliding Accidents

By Tony Segal
Issue 4/2001

This is the second of a six part series of articles by Tony Segal, a British doctor, who has devoted much of his retirement researching into pilot safety in the cockpit. See also his article, [Survivable Loads On The Pilot](#), which was posted in December.



This article will show that four out of five injuries incurred in gliding accidents involve spinal injury. I find this particularly upsetting because not only is there the risk of fracture of the spinal vertebrae, but there is the more serious possibility of injury to the spinal cord with resulting permanent paralysis.

The German Aviation Department of the Transport Ministry (BMV) was concerned by the number of fatal and serious injury accidents where the glider was often not itself seriously damaged. A research project to increase the passive safety of gliders was initiated by the Federal Aviation Agency (LBA). This research was carried out by Dipl.Ing Martin Sperber at TuV Rheinland, Cologne. Martin has been most helpful in sending me his research papers and in answering my queries on the telephone.

My wife, Liz, kindly translated the relevant pages in Martin's report from the German into English. The report was dated January 1991 and Liz translated the title as "Complete Support System for Gliders".

The accidents investigated occurred in Germany, or abroad if a German pilot was involved. The period covered was from the January 1, 1987 to December 31, 1989. One slightly confusing point in analysing the figures was that as some of the gliders were two-seaters, the number of pilots involved was more than the number of gliders and accidents.

The total number of pilots involved was 558. The severity of injury to these pilots is given below:

Uninjured	Fatal	Severe Injury	Slight Injury	Total
404 (72.4%)	28 (5.0%)	90 (16.1%)	36 (6.5%)	558 (100%)

It follows that 154 pilots (27.6%) were injured or died in the accidents.

For the purposes of his study, Martin selected 84 accidents where the main primary impact was with the ground. However, this number had to be reduced by 24, leaving only 60 accidents that were suitable to be followed up. The reason for rejecting these 24 accidents was as follows:

Eight cases - "fatal injury", where no further details were given of the injuries.

Twelve cases - no information was available; the papers were marked "These papers are confidential".

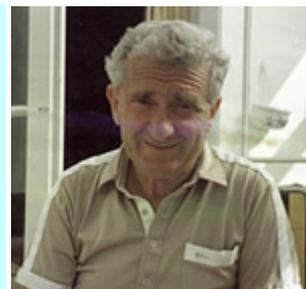
Two cases - "severe injury" was recorded, but no further details were given.

Two cases - these were

Spinal Injury In Gliding Accidents

By Tony Segal
Issue 6/2001

Tony, a UK general practitioner who has spent much of his retirement on experimental work on pilot safety at the Centre for Human Sciences, DERA, Farnborough, with the help of Les Neil, devotes the third of his six articles to explain the anatomy of the spine and the effect of injury. He apologises if readers find it rather technical, but it is a vital part of this series. Click on [No. 1](#) and [No.2](#) for the previous articles.



The previous article in this series, April 2001, showed that four out of five serious gliding injuries involved spinal injury. To understand the mechanism of injury, it is necessary to have knowledge of the anatomy of the spine and the classification of the types of spinal injury.

The clear diagram of the spine, Fig 1, is taken from Grant "Grant's Atlas of Anatomy" and, like all the drawings used in this article, has been enhanced by Steve Longland. The change of curvature between the thoracic spine and the lumbar spine is well shown. At the junction there is a stress concentration which results in the majority of fractures occurring at this level.

This is illustrated in Fig 2, taken from Ernsting (*et al*) "Aviation Medicine". It shows the distribution of spinal fractures in a group of Royal Air Force (UK) pilots who sustained spinal fracture on emergency ejection from their aircraft. The loads on the spine are the same, but in the opposite sense, from those imposed by a heavy landing.

The function of the spine is to support and to allow movement of the trunk. The spine also protects the nerve elements of the spinal cord and the corda equina.

The lower end of the spinal cord terminates in a number of nerve fibres that resemble a horse's tail, hence the name corda equina. The spine has to withstand the following forces - axial compressive forces, axial tension forces, rotation forces and shear forces.

A spine "motion segment" consists of two adjacent vertebrae articulating anteriorly (in the front) through an intervertebral disc, and posteriorly (in the back) through the facet joints. This is shown in Fig 3, from Gertzbein, "Fractures of the Thoracic and Lumbar Spine". The structure consists of the bony components, the intervertebral disc, and the ligaments.

The bony structures are shown in Fig 4, from Gertzbein "Fractures of the Thoracic and Lumbar Spine". The vertebral body, anteriorly (in front), is a cylinder of bone. Posteriorly (in the back) are the following bony structures:

The neural arch, protecting the spinal cord, is formed by two laminae (leaves). The laminae are joined to the vertebral body by the stout pedicles. Arising from the neural arch are the facet joints, the spinous processes, and the transverse processes.

An intervertebral disc is situated between each pair of vertebrae. It has been described as "like a jelly-filled doughnut". The disc consists of three parts - the central nucleus pulposus,<

Spinal Injury In Gliding Accidents

By Tony Segal
Issue 7/2001

Types Of Stable And Unstable Spinal Fractures

This is the fourth of a series of six articles on Spinal Injuries by Tony, a retired doctor, but this time it has to be more technical to cover the subject thoroughly. The next article will discuss how to prevent (or reduce the risks) of spinal injury. Click on here for [No. 1](#), [No.2](#) and [No.3](#) for the previous articles.



The previous article in this series discussed the anatomy of the spine. This information is now used to describe the various types of spinal fracture, and their significance for prognosis and treatment.

The pilot of a Royal Air Force [UK] aircraft exposed to ejection forces, or to a high level of vertical acceleration in an impact accident, will undergo the following investigations. This is even with no, or minimal, symptoms of spinal injury. This has been taken from Ernsting et al "Aviation Medicine".

A civilian Accident and Emergency Hospital Department is unlikely to be aware of the forces involved in an aircraft accident, so this level of study is unlikely. With a stable compression fracture, if there is no neurological deficit and there has been no surgical stabilisation operation carried out, the pilot will be able to return to full Service Flying Category (including flying fast jets) after four months. The list of investigations is as follows:

History and examination.

Assessment by a consultant neurologist or neurosurgeon.

X-ray of the cervical spine.

MRI scan of the entire spine.

Two weeks after the accident, there is a whole-body isotope scan to detect healing fractures not recognised on the initial X-ray.

Other X-rays and MRI scans may be carried out if indicated.

An MRI scan of the brain is only carried out if there is a suggestion of brain injury.

Stability is an important concept in spinal injury. In early acute instability the neural elements are at risk. In late instability there is the risk of the following problems developing - kyphosis (forward bending of the spine), especially in the elderly with coexistent osteoporosis - chronic pain - and neurological deficit. Stability is well discussed in a book edited by Ross "Key Topics in Orthopaedic Trauma Surgery". Stability is defined as the ability of the spine under normal physiological loads to maintain a normal relation between vertebrae such that neurological structures are not injured, and deformity and pain does not develop.

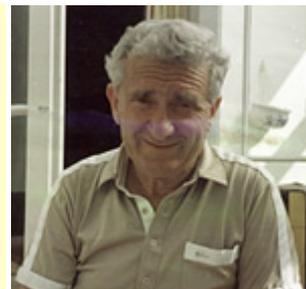
Acute stability is defined by the query "If the patient is mobilised immediately will one vertebra move with respect to its neighbour putting the spinal cord or nerve roots at risk?".

Chronic stability is defined by the query "Will physiological loads, eg walking, lead in time to progressive unacceptable deformity and pain?". If the answer to these queries is "Yes" then the spine is unsta

Spinal Injury In Gliding Accidents

By Tony Segal
Issue 9/2001

In his fifth of a series of six articles Tony discusses the methods of avoiding, or reducing the severity, of spinal injury. For the previous articles click on here for [No. 1](#), [No.2](#), [No.3](#) and [No. 4](#).



The back of the pilot should be fully supported by the seat back and by the parachute pack. If necessary, any gaps between the seat back and the parachute pack should be filled with a firm, non-compressible material. The parachute pack should be thin, flexible, and have a soft lower border. If the parachute pack has a hard lower border and ends part of the way up the spine, a stress concentration will be present at this level, and a spinal fracture may occur on accident impact.

A suitable lumbar back pad will increase the strength of the spine against longitudinal compression loading, and increases pilot comfort during a long flight. Maintaining the normal lumbar spinal curvature results in the adjacent faces of the intervertebral bodies meeting squarely and so spreading an impact load. The facet joints will also engage with each other, so providing a second load pathway.

I recommend a lumbar pad made of a firm material such as Sunmate (Dynafoam) foam. My pad measures 10 1/2 inches x 4 inches x 1 inches, with the long edges next to the pilot chamfered off. However, it can be shaped to suit the individual pilot by using an electric carving knife. It can be covered with denim or thin canvas, and held in place around the waist by a thin webbing belt with the ends fastened by Velcro. This pad is, of course, worn **under** the parachute.

I do not recommend air filled bladders, although they are very convenient. They will cause a rebound movement under accident loading. Incidentally, they will become harder at altitude.

The Royal Air Force (UK) provide pilots who suffer from backache with an individually moulded GRP back support. However, in the case of glider pilots, I consider the hard upper and lower edges of the support could injure the pilot in an accident. Paragliding pilots have found that composite back supports covering the whole length of the spine increase the risk of spinal injury by interfering with the parachute landing roll.

Six point harness is ideal once technical problems are solved

The seat harness design should prevent the pilot "submarining" down and under the lapstrap. The spine will flex forward as the shoulder harness becomes slack. The rear of the intervertebral spaces will open up, so increasing the risk of an anterior wedge fracture occurring. The present design of a four point harness with a steep rake to the front portion of the seatpan is not entirely satisfactory. The widely used five point harness is excellent in preventing submarining, but the fifth strap could cause injury in the case of a semi-reclining seating position. It will also cause problems for male pilots attempting to pass urine during flight. A six point harness is ideal, but some technical problems have to be sorted out before it can be put into use.

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