

THE HUMAN BRAIN

Cranium or Skull and Brain Stem

The brain weighs around three pounds (1.3kg) and is completely surrounded by a hard, protective, rounded shell of bone, known as the skull or cranium. The important thing to remember about the skull is that despite what you might think the underneath of the skull is not smooth, in fact there are a number of bony ridges, which are quite sharp. Because of this when the brain is shaken around in an accident, these ridges can cause lacerations and damage to the soft tissue of parts of the brain. At the base of the skull is a hole where the lower part of the brain or brain stem is connected to the spinal cord, and from there to the whole of the nervous system and the rest of the body. The brain stem sends and receives messages to and from the brain using nerve fibres. This brain stem area is also known to control such bodily functions as wakefulness, consciousness, tiredness, heartbeat and blood pressure. Damage to this area is thought to cause concussion and loss of consciousness.

Soft Tissue of the Brain and inside the Skull

The texture of the brain is soft and feels a bit like jelly but is held together in the skull by a number of layers of membrane called the dura, pia and arachnoid. Between the pia and arachnoid membranes is the subarachnoid space, in which run the blood vessels supplying and draining the brain. Like any organ, the brain is dependent on blood from the heart, and is crisscrossed by a network of large arteries, which divide into progressively smaller branches. When the brain is shaken about in a head injury, these vessels tear and bleed. As people get older, the blood vessels become more brittle and more likely to tear if shaken around. This bleeding leads to a build-up of blood clots, which pressurizes and damages the delicate tissue of the brain. The brain in its membranous sack sits in cerebrospinal fluid, which fills in all the gaps around the brain and offers some protection and cushioning. Just behind the brain stem sits a curved lump of tissue called the cerebellum. This area regulates all of a person's fine motor co-ordination which is involved in such skills as balancing, moving quickly and gracefully, dancing, threading a needle, climbing a ladder, etc.

Cerebral Cortex

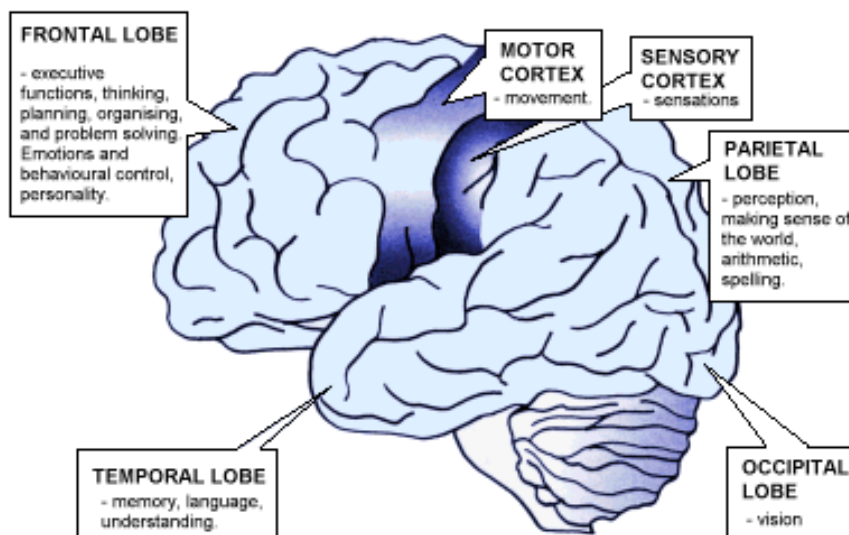
The largest part of the brain is known as the cerebral cortex and is shaped like a large walnut. It is divided into two halves and is joined by a sort of bridge in the middle. The two halves are known as the right and left cerebral hemispheres. The right side controls the left side of our body and the left side controls the right side of our body. So damage which occurs only to the right side may affect movement in the left arm and leg or hearing in the left ear. There is evidence that for most people the left hemisphere contains the language centres involving speech, while the right hemisphere tends to control non-language, spatial skills such as drawing or musical ability. If a person received injuries only to the left side of the brain, by for example having a stroke, it is likely that speech would be affected, as would the ability to move the right side of the body. Strokes tend to affect a specific area, whereas a head injury due to a road traffic or other type of accident usually involves more general and widespread damage.

Nerve Cells

They communicate with each other by passing electrical and chemical impulses between a network of hair like tentacles. Highly complex patterns of communication, or synaptic pathways, build up as the brain develops throughout childhood. The effect of a head injury on this delicate substance is similar to that of vigorously shaking a plate of jelly - it shears and tears, disrupting those pathways of communication.

Apart from dividing into a left and right hemisphere, the cerebral cortex (the walnut area of the brain) can be further divided into a number of areas known as lobes. The frontal lobe is the area behind the forehead and deals with intellectual activities such as planning and organizing, as well as dealing with personality and the control of emotions and behaviour. Just behind and below the frontal lobes are the temporal lobes, which are situated behind the ears. This area holds the bulk of memories, and the ability to understand things and speak. At the back of the brain above the ears sit the parietal lobes, which deal with our ability to understand spatial relationships and to read and write. Between the frontal and parietal lobes are areas that control movement and sensation. At the very back of the head are the occipital lobes, which are responsible for sight. Injury to this area can cause complete or partial blindness or at the very least a worsening of our ability to see to some extent.

Hidden in the middle of this walnut-like cerebral cortex are a number of small white nerve centres, collectively known as the diencephalon. In this area lies the small pea-sized hypothalamus, which controls appetite regulation, sexual arousal, thirst and temperature control, and some aspects of memory. Close to this area is another important set of nuclei, referred to as the limbic system. Damage to this area can play havoc with emotions, leaving the individual with dramatic and sudden mood swings.



WHAT HAPPENS IN A TRAUMATIC BRAIN INJURY?

An outside force being applied to the head causes a brain injury, at least initially. This can be anything from a severe blow to the head to a simple whiplash type of force and includes the complications which can follow, such as damage caused by lack of oxygen, and rising pressure and swelling in the brain or just the lacerations which are described above. A traumatic brain injury can be seen as a chain of events beginning with the initial injury which occurs immediately after the accident, and being made worse by a further injury which can happen in the minutes and hours after this, depending on when skilled medical intervention occurs.

The Initial Injury

There are three sorts of initial injury - Closed, Open and Crush.

Closed Head Injuries

Closed head injuries are the most common type, and are so called because no break of the skin or open wound is visible. These often happen as a result of rapid acceleration or deceleration, for example when a car hits a brick wall, or a car is hit from behind at traffic lights i.e. a whiplash injury. The head is rocked backwards and forwards or is rotated, and the brain has to follow the movement of the skull. It can twist, and the billions of nerve fibres, which make up the brain, can be twisted, stretched and even torn in the process. Even mild injuries of this sort can produce damage, which is quite widespread throughout the brain. This is defined as diffuse brain injury. The front of the skull has sharp bony ridges with which the brain can also collide, causing more damage. Arteries and veins running through the brain can also be damaged, allowing blood to leak into the surrounding area.

Open or Penetrating Wounds

These are not so common. In this type of injury the skull is opened and the brain exposed and damaged. This could be due to a bullet wound, or collision with a sharp object such as a road sign or part of a car or bike, or being hit by an axe. If the damage is limited to one specific area, outcomes can be quite good, even though the accident may have seemed horrific. In many cases, however, this type of injury may be combined with a whiplash type injury as well.

Crush Injuries

In this type of injury, the head might be caught between two hard objects, such as part of a car and the road. This is the least common type of injury, and often damages the base of the skull and nerves of the brain stem rather than the brain itself.

Further Injury depending on medical intervention

This can happen when the brain is starved of oxygen, which makes damage from the initial injury worse. It can happen for several reasons. Examples are choking on vomit after an

which could be causing an obstruction to their airway. If other injuries are present, as they often are, serious blood loss can affect blood flow to the brain. As it is blood that takes oxygen to the brain the oxygen getting to the brain can be reduced. Many hospitals now have a better understanding of the relationship between the initial injury and the effects of lack of oxygen and this has led to improvements in roadside care provided by paramedics. They will make sure breathing is maintained and blood pressure is brought back to normal levels so far as they can by emergency transfusions.

Further injury can take place in the days and sometimes weeks which follow, and could be as a result of bleeding, bruising or swelling in the brain or because blood clots have developed. Blood leaking from torn blood vessels and other body fluids leaking into the area cause the brain to swell. This is a very serious problem because the skull is a fixed space, and there is no room for expansion. It causes complications in two ways. Firstly, the walls of the skull are hard and don't move, and damages the soft brain tissue when it is squeezed against it. Secondly, when the brain swells it can squeeze the blood vessels, limiting the brain's blood circulation. This can be fatal, so intra cranial pressure is monitored very carefully once the patient gets to hospital. Measures to reduce the risk of raised pressure include putting the patient on a ventilator to ensure a good supply of oxygen, and controlling the amount of water and salts in the body to cut down on the flow of fluid into the brain.

Blood clots occur when blood has leaked from damaged veins and arteries and then pools into a clot. They can press on the surrounding brain tissue, which can damage it, and they also raise pressure in the brain. Blood clots, also called haematomas, can occur after quite minor injuries, and this is why patients are often kept under observation in hospital until the risk is passed.

The Effects of Traumatic Brain Injury on Brain Function

Damage to the nerve fibres deep in the central part of the brain, which normally keeps a person awake and alert, results in the most obvious of symptoms - coma. This link between damage to particular parts of the brain and a corresponding lack of brain function means, for example, that damage to the side of the head (parietal lobes) results in weakness in the limbs on the opposite side of the body. Injury to the left side of the brain or the brain stem itself tends to cause speech and language impairment. Coma, loss of power in the arms and legs, and speech impairment are the most visible signs of brain injury. However, traumatic brain injury causes numerous 'hidden disabilities' in that it results in changes to personality, thinking and memory. For example, damage to the brain behind the forehead (frontal lobes) results in behavioral problems, such as loss of insight and self-restraint.

Coma

Unconsciousness follows traumatic brain injury, whether for a few seconds or for a few weeks, and is the most typical symptom of a head injury. There are different levels of coma, and the Glasgow Coma Scale is used to rate the unconscious patient's ability to open his eyes, move and speak. A patient is assigned a number in each of three categories, namely eye opening, motor response and verbal response. The minimum number is 3 and the maximum possible number is 15. The more severe the injury, the lower the performance, and the lower

the number. Waking from a coma is gradual, starting with eyes opening, then responses to pain, and then responding to speech. The longer a person stays in coma, the more likely it is that the long term effects will be severe.

Severity of the Injury

After a traumatic brain injury, whether or not the person was actually unconscious, a state occurs where the person seems to be aware of things around them but is confused and disorientated. They are not able to remember everyday things or conversations, and often do or say bizarre things. This is called Post-Traumatic Amnesia (PTA), and is a stage through which the person will pass. The length of PTA is important as it gives an indication of the severity of the injury. Used in combination with length of time in coma, these two give the best measure of eventual outcome.

Minor Head Injury

A brief period of unconsciousness, or just feeling sick and dizzy, may result from a person banging their head getting into the car, walking into the top of a low door way, or slipping over in the street. It is estimated that 75% of all head injuries fall into this category. The effects of a minor head injury can be anything but minor to the person concerned. They can include nausea, headaches, dizziness, impaired concentration, memory problems, extreme tiredness, intolerance to light and noise, and can lead to anxiety and depression and subsequently a lack of patience which, combined, can put a great strain on family life and relationships/friendships. When problems like this persist, and once diagnosed are often called post-concussion syndrome. A common problem is that either no scans were done at the time of the accident, or subsequent scans show no damage. This frequently gives rise to the impression that there is nothing medically wrong. The persistent problems can frequently be misunderstood by GP's (and sometimes even by hospitals), sometimes being considered as almost hypochondria on the part of the patient. Although it is true that in some cases where the symptoms persist for months a psychological element such as depression can come into play. Whilst this may make existing conditions even more difficult to live with, it is not on the whole true or helpful to say that 'it is all in the mind'. A second opinion should be sought from a neurologist or neuro-psychologist.

It is important that relatives, friends and employers are warned about the possible effects of a minor head injury, and for plans to be made accordingly. These might include not rushing to return to work, keeping stress to a minimum in the short term, and abstaining from alcohol. Family in particular have to be very patient and bear in mind that the demeanor One study showed that almost one third of people with a minor head injury were not working full-time three months after receiving the injury, although other studies have been much more optimistic. Difficulties are certainly made much worse if the person has a mentally demanding job where there is a low margin for error. The general conclusion seems to be that the vast majority of people who experience a minor head injury make a full recovery, usually after 3-4 months. However there is a very small sub-group whose recovery is not so good.

Moderate Head Injury

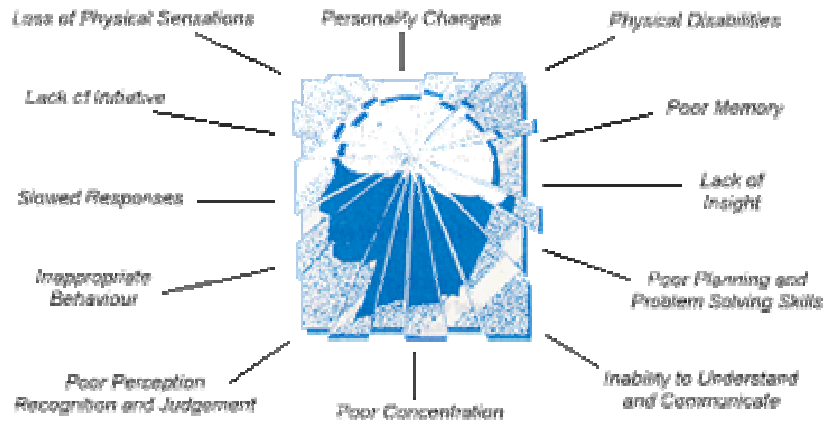
A moderate head injury is defined as loss of consciousness for between 15 minutes and 6 hours, and a period of post-traumatic amnesia of up to 24 hours. The patient can be kept in hospital overnight for observation, and then discharged if there are no further obvious medical injuries. Like those with a minor head injury, patients with moderate head injury are likely to suffer from a number of residual symptoms. The most commonly reported symptoms include tiredness, headaches and dizziness (physical effects), difficulties with thinking, attention, memory, planning, organizing, concentration and word-finding problems (cognitive effects) and irritability (an emotional and behavioral problem). Understandable worry and anxiety accompany these symptoms. This can be particularly pronounced if the patient has not been warned that these problems are likely to arise. If the patient expects to be perfectly well within a few days and symptoms are still prominent after a few weeks, they may worry or feel guilty. This has the effect of creating a vicious circle leading to more symptoms and so on. A large proportion of people find that when they return to work they have difficulties and feel that they are not functioning at their highest level. For the majority of people these residual symptoms gradually improve, although this can sometimes take 6 to 9 months.

Severe Head Injury

A severe head injury is usually defined as being a condition where the patient has been in a coma for 6 hours or more, or a post-traumatic amnesia of 24 hours or more. These patients are likely to be hospitalized and receive rehabilitation once the acute phase has passed. Depending on the length of time in coma, these patients tend to have more serious physical deficits. A period of unconsciousness of 48 hours or more, or a period of PTA of 7 days or more defines a further category of very severe injury. The longer the length of coma and PTA, the poorer will be the outcome. However, there are exceptions to this rule and, just as there is a small group of people who have a mild head injury who make a poor recovery, so there is a small group of individuals who have a severe or very severe injury who do exceptionally well.

Persistent Vegetative State

A small number of people sustain a head injury so severe that they remain in a state of coma for months and years without recovering sufficient consciousness to make any form of communication, but can breathe without mechanical assistance. They may have sleeping and waking cycles allowing them to be fed, but they do not speak, follow commands or have any understanding of what has been said. The Glasgow Coma Scale score for such people is usually below 9. When this is the case, despite all reasonable application of rehabilitation measures for at least 3 years, a person may be described as being in a Persistent Vegetative State or PVS. There are normally just less than 100 people in the UK in PVS at any one time.



REHABILITATION

Rehabilitation is a process of change through which a brain injured person goes, to try to regain former skills and to compensate for skills lost. Its aim is always to achieve the optimum levels of physical, cognitive and social competence followed by integration into the most suitable environment.

Rehabilitation is not achieved by doing something to somebody. It involves a process of change in which the person concerned participates.

The greatest visible progress occurs in the first 6 months, after which improvement is often more subtle and less obvious. But it is important to bear in mind that progress does not stop after 2 years, as has been suggested in the past. Rather people continue to improve even 5, 10 or more years after a head injury. Rehabilitation has two stages, the first being the formal intervention to improve the individual, and the second stage is when the family and carers work to maintain that improvement. Research suggests that patients who make the best recovery are those whose family is actively involved, and can maintain this informal rehabilitation at home.

The Rehabilitation team

Nurses

Nurses are trained in all aspects of general health care and will help with dressing, washing, feeding and toileting. A sister or charge nurse, accompanied by a staff nurse and nursing assistants will run a ward.

Doctors

A consultant will co-ordinate the day-to-day medical care, carrying out examinations and prescribing medication while the patient is in hospital. The consultant is head of a medical team and will be assisted by junior medical staff such as registrars and house officers, who will spend more time on the ward than the consultant.

Case Managers

A person experienced in managing the care of people with Head Injuries will often be appointed to co-ordinate all the various carers, anger management specialists, consultants appointments, occupational therapists, nurses etc once a patient is released home by the hospital. This is especially so where there is a legal case involved as it is important for all aspect to be carefully co-ordinated to ensure everything that can be done is being done and is being done as efficiently as possible (within the patients capabilities).

Physiotherapists

The physiotherapist aims to help patients recover the ability to use their muscles and joints so they can sit or stand without losing balance, co-ordinate movements, walk and use fine hand movements. The physiotherapist will set exercises and activities for improving physical ability, and help with learning techniques for lifting and transferring from a wheelchair.

Occupational Therapists

The occupational therapist (OT) is concerned with helping to develop independence in carrying out everyday tasks such as dressing, cooking, and housework. They will also help the individual develop skills, which underlie these activities such as budgeting, planning, improving thinking and finding ways around problems. They may also provide special equipment and adaptations around the home.

Clinical Psychologist

The clinical psychologist will help in assessing the patient's mental skills and weaknesses, such as memory and concentration (a cognitive problem), using specially designed tests. They may also advise on management and rehabilitation and cognitive retraining programmes, both in hospital and in the community. They may also provide counselling and advice on dealing with the emotional problems involved in adjustment and coping.

Social Worker

Social workers are skilled in helping families receive the practical help that is needed. They can provide information about benefits, accommodation and transport. The social worker is also an experienced counsellor, and is there to talk to about emotions and feelings. If there has been no contact with a social worker in hospital, ask for an appointment to see one.

Speech and Language Therapist

Speech and language therapists aim to help patients communicate more effectively using both the spoken and written word. They may provide structured exercises and activities aimed at improving speech and language skills, or may work with other staff and relatives to improve all-round communication. The speech therapist will also have experience of communication aids.

There are many other therapists and carers who may be involved in the care and rehabilitation of a patient too numerous to mention eg anger management and physical therapists (rather than physiotherapists).

Driving after suffering a head injury

Many people who have had a head injury are naturally very keen to return to driving again. However, if you have had an injury which could affect your ability to drive, and if the effects of the injury are expected to last for 3 months or more, you **MUST** inform the Medical Advisory Branch of the DVLA at Swansea.

In practice, any head injury, which has involved a stay in hospital of more than a day or two may impair the ability to drive and the DVLA and insurance companies should be informed.

Remember it is illegal to drive without a valid licence and it is an offence not to inform the DVLA of any injury, which could affect driving. Failure to do invalidates the driving licence, the driver risks prosecution and the vehicle is uninsured in the case of an accident.

Returning to work after a head injury

Returning to work after a head injury is a very important goal for most people. However, especially after a serious head injury, the long-term prospects can be disappointing, with only approximately 15% of people with severe brain injuries returning to work within 5 years.

Experts suggest that people who have had a period of post-traumatic amnesia (PTA) of between 1 and 14 days might be able to return to the same job, but be less capable. A period of PTA of between 2 to 4 weeks means that there will be definite difficulties, which will make it unlikely that the person will be able to perform the same job. A PTA of between 4 to 12 weeks suggests that the person will be lucky to get part-time employment, while a PTA of over 12 weeks suggest that the person is likely to be unemployed, work in a sheltered environment, or do voluntary work.

The most important message for the patient and the family and friends or work colleagues is to **THINK POSITIVELY AND REALISTICALLY!** This means that you must consider the problems, which will have to be faced, and pitch ambitions and expectations accordingly.

Education and retraining after a head injury

Education is an essential part of rehabilitation, but this aspect is often delayed or neglected. Educational input will vary not only according to how severe the injury is, but also according to the age of the person and the time since injury. Although it is easier for children to gain access to education than adults, it is important for people of all ages to be given the opportunity to regain and develop former skills.

Useful Web Sites

Headway – www.headway.org.uk

Brain Injury Resource Centre - www.headinjury.com

Anatomy of a Head Injury - www.ahs.uwaterloo.ca/~cahr/headfall.html

Medline Plus – head injuries - www.nlm.nih.gov/medlineplus/ency/article/000028.htm

Neurosurgery - head injuries www.neurosurgery.org/health/patient/detail.asp?DisorderID=33

Brain Injury Association of America - www.biausa.org/Pages/home.html

Closed Head Injuries in Children (USA site) - www.aap.org/policy/ac9858.html