Physiotherapy for the Acute Care Management of Traumatic Brain Injury

An Information Package

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June 2005

Funded By The GMCT, Brain Injury Rehabilitation Directorate, NSW Health

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NSW HEALTH Working as a Team

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Acknowledgements:

Physiotherapists from the three adult metropolitan brain injury units for their ongoing feedback and suggestions as this package has developed, particularly Taryn Jones, David Wong, Melissa Stretton, Lyndsay Henry, Joan Leung and Margaret James. Gaurav Tandon from the Brain Injury Directorate of the Greater Metropolitan Clinician Taskforce, NSW Health for his assistance with the layout. Anne Moseley from the School of Physiotherapy, University of Sydney for her editorial comments. Client of the Brain Injury Rehabilitation Programme for his consent to use him as a model for our photographs.

Funding Body details:

GMCT, Brain Injury Rehabilitation Directorate, NSW Health

Graphics and Layout:

Medical Illustration Unit - UNSW Faculty of Medicine & Teaching Hospitals

This package can be downloaded as a pdf version from the Brain Injury Rehabilitation Unit, Liverpool Health Service website: http://www.swahs.nsw.gov.au/biru/

ISBN: 0-9751795-3-5

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Introduction

THE overall incidence of traumatic brain injury in New South Wales, Australia has been estimated at 100:100,000 resident population, with males in the 15 to 24 years age group incidence escalating to 386:100,000 (Tate et al 1998). The most common cause of traumatic brain injury reported in this study was road traffic accidents (40%), with sport and recreation (25%), falls (20%), assaults (8.2%) and other causes (6.1%) following. The severity of the brain injuries reported in this study varied significantly, with 62.2% being mild, 20.3% being moderate, 13.6% being severe, and a 3.9% death rate after admission to hospital.

The Brain Injury Rehabilitation Programme was established in New South Wales, Australia in 1989 (Mid Western Brain Injury Rehabilitation Program 1999) in recognition of the unique requirements of this population in regards to their age, their cognitive and behavioural disturbances and because of their long-term needs. There are currently three adult and two paediatric units based in the Sydney-metropolitan area plus eight regional services.

The physiotherapists at the three Sydney metropolitan rehabilitation units have collaborated to develop this information package. The purpose is to provide information regarding physiotherapy management for people with traumatic brain injury in the acute care setting. It is not intended to be a definitive guide to physiotherapy in traumatic brain injury and does not include advice for acute cardiorespiratory and orthopaedic physiotherapy management. The package has developed out of the commonly asked questions that we receive from other hospitals regarding the physiotherapy management of this population, and from our experience with secondary preventable complications that some patients present to our rehabilitation units with. The package is based on the current practice at the three adult Sydney-metropolitan Brain Injury Rehabilitation Units and on the physiotherapists' experience. A reference list has been included, but is not exhaustive. If you have further questions regarding the information in the package please contact us on the numbers listed below.

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Prevention of Contracture

PREVENTION of contracture is one of the main roles of physiotherapy in the acute care setting for people with traumatic brain injury. Ada and Canning (1990) suggested that if the patient is unable to actively participate in therapy that works the muscle in a lengthened position for a sufficient period of time, then prevention of contracture is best achieved by the application of low load prolonged stretches.

Evidence for Stretching

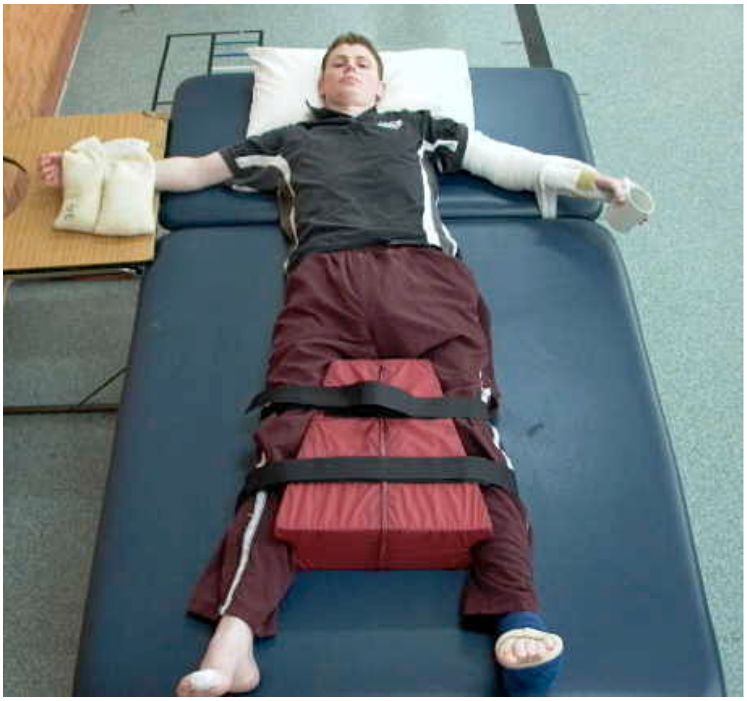
It is currently not possible to determine the minimum time that a muscle needs to be placed on a stretch to prevent contracture developing from clinical trials in humans. Ada et al. (2005) found that 30-minutes of positioning the shoulder in 45° of abduction and maximum external rotation prevented a 17% external rotation contracture in acute stroke patients. Tardieu et al (1988) reported that 6 hours was the minimum time required for the soleus muscle to be stretched to prevent contracture in a small group of children with cerebral palsy. Harvey and Herbert (2002) argue that while there is currently no strong evidence to suggest the timing for stretching to prevent contracture in a spinal cord injured population, that a minimum of 20 minutes, and perhaps as long as 12 hours, a day of stretching should be applied to at risk muscles due to the sound scientific rationale for prolonged stretching. There is evidence from animal studies that short intermittent periods of stretch can prevent muscle shortening (Williams and Goldspink 1984)

Application of stretches

- Place target muscle(s) in a lengthened position and maintain the limb in that position for the necessary time.
- The amount of time necessary for individual stretches can be ascertained by periodically re-measuring joint range of motion to verify whether muscle length is being maintained.
- Often a number of muscles need to be stretched, so a combined position can be used to maximise therapist and patient time. For example, the hip flexors and adductors, knee flexors, shoulder adductors, elbow flexors, forearm pronators, and thumb web space can be stretched at the same time (Photograph 1).
- Resting splints (e.g. ankle backslabs or hand splints) generally need to be applied for at least 6 to 8 hours in a 24-hour period, and can be worn overnight if tolerated.
- Equipment such as splints (Soft-cast™, Soft-foam™, Prelude™ or Thermoplastic™), slings, sandbags, high-density foam and long finger flexor stretching boards can be used to maintain the limb in the stretch position.

Many physiotherapists still use passive ranging to maintain muscle length. There is currently no evidence to support the use of passive ranging exercises, and it is believed that this type of exercise applies a duration of stretch that is insufficient to prevent the development of contracture (Ada and Canning 1990).

If stretching is not maintaining muscle length or if contracture is already present, serial casting may need to be considered.



Photograph 1: Combined stretching position -- positioning to stretch hip, knee and elbow flexors, hip and shoulder adductors, forearm pronators, and thumb web space.

Serial Casting

SERIAL casting is the application of a cast to a limb in order to position the muscle that requires stretching in the lengthened position. Serial casts are usually applied for between 3 and 7 days. They are then removed, range of motion re-measured, and a cast reapplied in the new lengthened position. Casting is usually continued in this manner until the desired range of motion is achieved.

Evidence for Serial Casting

Williams and Goldspink (1978, 1984) found structural changes in animal muscle when they were subjected to imposed maintained length. If they were immobilised in a lengthened position, the muscles did not increase the connective tissue: muscle ratio as they did when immobilised in a shortened position. When muscles were immobilised in the lengthened position sarcomeres were added on. Moseley (1997) found that casting combined with stretching was an effective method of improving ankle plantarflexion contracture in patients with traumatic head injuries. Mortenson and Eng (2003) in a systematic review of the literature on serial casting in the management of joint mobility and hypertonia following brain injury in adults concluded that there was grade B level of evidence to recommend the use of casting to increase or prevent loss of passive range of motion.

Issues to consider before applying a serial cast

• Skin condition needs to be assessed. If there is an area of breakdown or an area that looks like it may breakdown, a member of the nursing staff should be consulted. In some cases, a dressing such as Comfeel™ may be used to protect the area under the cast. It is best to change the cast more frequently if the skin condition is a concern (i.e. 3 to 4 days).

• Patient behaviour needs to be considered. If there is concern that the person may get agitated with a cast on, you should consult the rest of the team (e.g. treating doctor, nurses) to decide the benefits versus the distress it may cause. If you decide to go ahead, casting in the morning will allow you time to monitor their tolerance throughout the day. Sufficient pain relief medication should also be used for at least the first 24 hours.

Potential side effects or complications

Potential side effects or complications that can be caused by serial casting include:

• pressure areas

• circulation restriction

• nerve compression at superficial points

• increased workload for nursing staff in the short term

• secondary joint stiffness, and

• reduced patient compliance.

Because of these potential complications, regular observations should be conducted. These observations are especially important when the patient is minimally responsive or confused. A monitoring chart should be started by the physiotherapist and given to the nursing staff to complete. The observations should include pulse, circulation, movement, sensation, and warmth, as appropriate. We do hourly observations for the first 4 hours, second hourly observations for the next 8 hours, and then 4 hourly observations for the next 12 hours. After this 24-hour period, the limb is just checked as part of the normal care routine.

Tips for serial casting

1. Use of medications

Muscle relaxants are often used as an adjunct to serial casting to allow the muscle to relax so that it can be positioned in the most lengthened position possible. Commonly used muscle relaxants include Diazepam and Midazolam. A medical officer must prescribe the most appropriate muscle relaxant and appropriate quantity for each individual patient. The muscle relaxant can be administered intramuscularly by a registered nurse or, more effectively, intravenously by a medical officer.

Pain relief may also be given before and after the application of the cast. This may help the person tolerate the stretch and not get too agitated. Commonly used pain relief includes Pethidine and Panadeine Forte.

2. Adequate padding

Pressure areas are probably the biggest concern with serial casting and it is therefore necessary to take great care to minimise the risk of this occurring. Padding should be applied around or over both bony areas and areas of increased pressure. A dense foam (e.g. Polycushion™ or Reston™) is often required in addition to cotton wool padding (e.g. Webril™ or Softban™). Care needs to be taken to ensure that the smallest amount of padding possible is used as excessive padding may lead to movement within the cast, which in turn may lead to pressure areas. The skin should be carefully checked after the removal of each cast and nursing staff should be consulted if excessive redness or a pressure area has developed from the cast, before another cast is applied.

3. Use a combination of synthetic and plaster of paris casting materials

Plaster of paris is more mouldable than synthetic casting materials and therefore it is preferable to use as the bottom layer of a cast to achieve a snug fit that is free from ridges. This leads to a decreased risk of pressure area developing. A layer of synthetic casting material can be used over the plaster of paris to reinforce the cast and to decrease the weight of the cast. The synthetic casting material also dries a lot quicker, and therefore requires less holding time. The use of a final layer of plaster of paris or bandaging over the cast should be considered if there is a risk the patient is going to rub the cast against some bare skin (e.g. if only one leg is cast and they move that leg a lot).

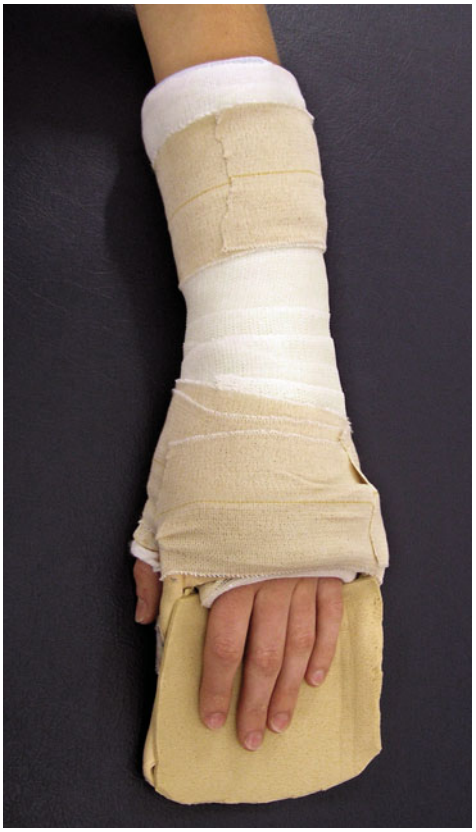
4. Casting with dysautonomic patients

Dysautonomia is a syndrome of episodic abnormalities of autonomic function and increased muscle activity (see following section for more details). Serial casting is often the only method of maintaining muscle length with this group of patients due to the increased tone and the problems of skin breakdown from sweating in thermoplastic materials used in splinting. The use of cotton wool based padding (e.g. Webril™) and plaster of paris on the bottom layer of the cast

can help absorb the sweat. Various types of absorptive materials (e.g. Biatain™) are available and can be used under the cast directly on the skin in areas more likely to sweat (e.g. the palm of the hand).

5. Casting combined with Botulinum Toxin A

Botulinum Toxin A is thought to be an effective treatment approach for patients with focal spasticity. It works by "… blocking the presynaptic release of acetylcholine into the neuromuscular junction. Clinically, this effect manifests as local muscle paralysis and a reduction of abnormally increased muscle tone …" (Francisco et al. 2002, p.356). Although this pharmacological treatment is mainly used in the rehabilitation setting, it is sometimes used more acutely. Serial casting is often begun approximately one week after the injection if contracture is also present with spasticity, and the usual serial casting procedure is followed (Photograph 2).



Photograph 2: Upper limb serial cast -- plaster of paris was used for the bottom layer and this was reinforced with synthetic casting materials. A thermoplastic hand piece was taped over the cast to hold the fingers in extension. This cast was applied after a Botulinum Toxin A injection.

Dysautonomia

DYSAUTONOMIA (also called autonomic dysfunction syndrome, autonomic or sympathetic storming, hyperpyrexia associated with muscle contraction, hypothalamic-midbrain dysregulation syndrome, acute midbrain syndrome and diencephalic epilepsy) is characterised by "… severe, paroxysmal increases in heart rate, respiratory rate, temperature, and blood pressure, with decerebrate or decorticate posturing, increasing muscle tone, and profuse sweating …" (Baguley et al. 1999, p.39). It affects a small but significant subgroup of survivors of severe traumatic brain injury, but has been poorly reported in the medical literature (Baguley et al. 1999).

In a retrospective study of 70 patients who had sustained a traumatic brain injury (35 with at least five out of the seven dysautonomic features described above for a period of at least 2 weeks, and 35 control matched patients for sex and Glasgow coma scale severity), an association was observed between dysautonomia and younger age at time of injury, the presence of severe diffuse axonal injury and pre-hospital hypoxia (Baguley et al. 1999). Patients in this study with dysautonomia had a poorer functional outcome but showed a similar magnitude of improvement with rehabilitation in terms of Functional Independence Measure (FIM) change scores, suggesting these individuals benefited from intervention.

With this in mind, it is important to consider early intervention to maximise the potential for rehabilitation of patients exhibiting signs of dysautonomia.

Physiotherapy management in dysautonomia

The main aim from the physiotherapist's point of view is to maintain muscle length as far as is possible. Serial casting of the wrist, metacarpophalangeal and interphalangeal joints is often required, along with a program of stretching for the upper limbs and standing on a tilt table. Soft foam splints, bivalved casts or Soft-cast™ removable splints are used to maintain elbow range. Splints may need to be removed during a dysautonomic episode, and reapplied once the episode has passed. Good communication between nursing staff and therapy staff is essential for nursing staff to understand the reasons for persisting with casting and stretching during this time, and assisting with the application and removal of splints.

Priorities in serial casting dysautonomic hands

- Cast with the assistance of an intravenous muscle relaxant (e.g. a titrated dose of Valium).
- Use a cotton wool base padding (e.g. Webril™) and plaster of paris on the bottom layer of the cast to help absorb the sweat.
- Maintain interphalangeal joint extension as a priority over other joints and maintain reasonable length in the long finger flexors. To do this you may have to cast with the wrist in flexion.

Do not cast the elbow at the same time.

• Decide the best way to immobilise the fingers, for example:

- a plaster of paris slab similar in shape to a resting hand splint
- enclosing the hand around a cylindrical object
- separating the fingers as in a ball splint
- casting the finger(s) separately
- hold fingers in position with cast padding and plaster. Put padding between fingers to stop the skin becoming macerated.

• Having established a position where the fingers will extend, immobilise the wrist in a short arm plaster.

Positioning

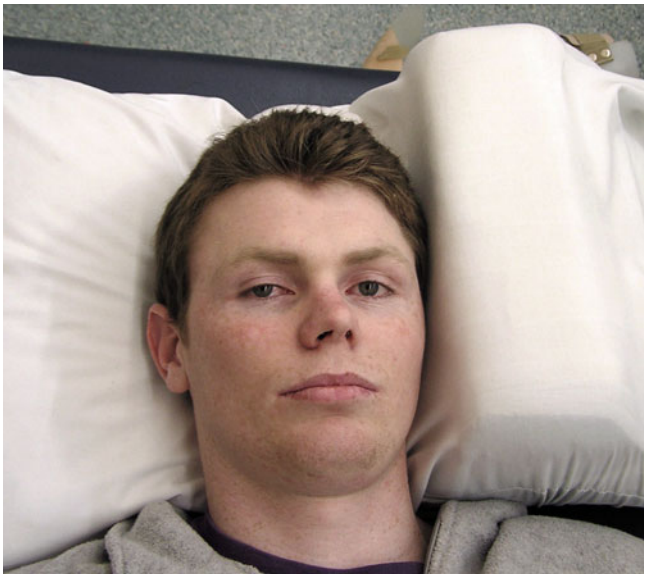
THE risk of pressure areas, contracture, and respiratory complications should be considered when a patient is positioned. To prevent pressure areas developing, the patient's position should be frequently changed. This can be as simple as ensuring the patient is moved from supine to side lying, but should ideally also include the patient sitting out of bed and standing on a tilt table for a period of time.

Issues to consider when positioned in bed

• The patient should be moved between supine and right or left side lying, if possible. The frequency that this occurs is generally a nursing decision.

• Some patients rest their head in rotation and lateral flexion due to increased muscle activity and / or neglect. If this position is maintained a contracture may develop in the patient's neck muscles, which can impede the patient's ability to interact with the whole of their environment when they begin sitting up. The use of sandbags, a rolled up towel or a wedge pillow can be used to maintain the correct head position (Photograph 3).

• Too many pillows in the bed can cause contractures. One pillow under the head is usually sufficient for comfort as too many pillows may lead to contracture of the neck flexors. Pillows placed under the knees can cause contracture of the knee flexors, preventing full extension when standing is begun.



Photograph 3: Head positioning -- a wedge pillow is used to prevent lateral flexion and rotation of the neck in supine.

Issues to consider when sitting out of bed

• Sitting a patient out of bed is usually done by, or in collaboration with, an occupational therapist and should be started as soon as the patient is medically stable as it can be of benefit to their level of arousal and respiratory system.

• Patients may have weak neck extensor muscles or increased neck flexor muscle activity resulting in their head resting in flexion. A headrest with a strap tied over the forehead (a piece of collar and cuff material inside a tubular bandage is a good option for the strap) may help to maintain a neutral position. The patient should be supervised at all times that the strap does not fall down around their neck. Use of a chair that can be tilted is preferable as it will allow the patient to be tilted slightly back so that gravity can assist the head staying in position.

• Adjust footplates or use a pillow or foam block to ensure that the feet are supported with the ankles dorsiflexed (rather than hanging in a plantarflexed position).

Standing on a Tilt Table

THE use of a tilt table in the acute and rehabilitative stage after traumatic brain injury may be beneficial to:

• prevent shortening of ankle plantarflexor, knee flexor, and hip flexor muscles (a wedge placed under the feet can be used to increase the amount of stretch for the plantarflexors)
• prevent loss of bone density in the lower limbs
• increase lung volumes
• increase alertness, and
• address postural hypotension after prolonged bed rest.

The use of a tilt table is indicated for:

• patients who are currently not weight-bearing or mobilising regularly with no orthopaedic restrictions, and
• patients who are mobilising but who have shortened plantarflexor and or knee flexor muscles.

The following precautions and suggestions should be noted:

• Determine appropriate wedge size to place under the feet depending on passive dorsiflexion range of motion.

• Blood pressure, heart rate and oxygen saturation levels should be monitored when initially using the tilt table. The accepted range of change in these parameters should be discussed with the treating doctor if the patient has abnormal resting parameters. Take baseline measures and then every 5 minutes throughout the initial session. The patient should be tilted to 30 degrees, monitored for 5 minutes, and then tilted to 50 to 60 degrees and monitored. Depending on monitoring, the patient can remain at this level for the first session, or taken to full tilt if the patient is alert and following commands and has not been on bed-rest for a substantial amount of time.

• Initially some patients are only able to tolerate 10 minutes of tilt table standing. Over time this can generally be increased to between 30 and 60 minutes.

• Monitor other signs, including respiratory rate, sweating, colour, facial expression and level of arousal, for an indication of how the patient is coping (particularly for patients who are having dysautonomic episodes). If a patient faints, lower the tilt-table down flat and take blood pressure and pulse rate. Consult a nurse or doctor if you are concerned.

• Pressure areas can occur on the lateral border of the foot if there is excessive plantarflexion

and inversion. The use of sandbags, resting ankle splints or wearing ski boots can be used to prevent the inversion.

• If the patient has poor head control, a strap can be placed across the forehead to prevent the head from dropping forward (a piece of collar and cuff material inside a tubular bandage is a good option for a strap) and don't take the tilt-table all the way up to vertical.

Heterotopic Ossification

"… Heterotopic ossification can be defined as the formation of bone in tissues which normally exhibit no properties of ossification …" (Pape et al. 2004, p.783). It has been reported in people who have sustained a spinal cord injury, a traumatic brain injury, have undergone major joint surgery, and who have sustained burns (Pape et al. 2004). The incidence after traumatic brain injury has been reported to vary between 11% and 22% (Garland 1988; Citta-Pietrolungo et al. 1992). Although there is no clearly defined mechanism for its development, several risk factors have been identified which pre-dispose to its formation after a traumatic brain injury. These risk factors are spasticity of limbs, decerebrate posture, diffuse axonal injury, prolonged immobilisation, and mechanical ventilation (Pape et al. 2004). Heterotopic ossification tends to form near joints, with the most commonly affected sites being the hip, then the shoulder, elbow and, rarely, the knee (Garland et al 1980). The condition usually manifests 4 to 12 weeks after injury and is associated with poor functional outcomes and longer rehabilitation lengths of stay. For this reason, it is important that it is detected as early as possible. Acute care physiotherapists should play a vital role in alerting medical staff when they notice any of the first three of the following signs and symptoms.

Signs and symptoms

- swollen and warm joint
- unusual or sudden loss of range of movement
- severe pain on movement, indicated by grimace, agitation or signs of distress (i.e. increased heart rate and respiratory rate)
- spasticity is nearly always present in the involved limb
- patient may have elevated temperature and malaise
- bone is often palpable in the later stages

Diagnosis

- Biochemical changes

An increase in the serum alkaline phosphatase level reflects osteoblastic activity and an increase has been demonstrated up to 7 weeks before the clinical symptoms of heterotopic ossification become evident (Pape 2004). Note that concomitant fractures or liver disease will also produce a rise in these levels. An increase in the 24-hour urinary excretion of prostaglandin E2 (PGE2) can also be a good indicator in the early diagnosis of heterotopic ossification.

- Radiological changes

X-rays are usually performed first to rule out any undetected fractures. Heterotopic ossification will not appear on x-ray until the bone begins to ossify, which can take up to 6 weeks (Pape 2004). A bone scan is able to detect heterotopic ossification before x-ray. Increasing radio-

nuclide activity indicates growing immature bone whereas decreased uptake suggests slowing down of the disease process.

Treatment

• ***Physiotherapy***

Physiotherapy should include gentle muscle stretching to within the patients' pain tolerance and the encouragement of active assisted movements as much as possible within the pain-free range. Removable splints such as those made from Soft-cast™ may be used for prolonged stretches during the day or night.

• ***Pharmacological agents***

Biphosphonates (e.g. Disodium etidronate [Didronel]) is used extensively clinically to arrest the development of heterotopic ossification, but there is not yet conclusive evidence in the literature of its benefit (Pape 2004). Oral use is recommended for 6 months and the drug can be used prophylactically.

Non-steroidal anti-inflammatory drugs (e.g. Indomethacin) inhibit prostaglandin E2 thus preventing osteoid formation. It also suppresses inflammation, mesenchymal cell proliferation and woven bone formation.

Surgery is indicated when the heterotopic ossification interferes with self-care, mobility and rehabilitation, or if nerves are entrapped. Surgery should occur only after the bone has matured to reduce the likelihood of recurrence, and this is not recommended until 18 months after a traumatic head injury (Garland 1991).

Shoulder Care

FOLLOWING a traumatic brain injury, there are some complications that may occur in the upper limb. It is particularly important to take care of the shoulder joint to prevent the development of subluxation, stiffness and pain. A recent study, conducted in the three adult Sydney metropolitan Brain Injury Rehabilitation Units, reports that the prevalence of shoulder pain on admission to the rehabilitation unit is 56% for people with traumatic brain injury (Leung and Moseley 2005). Good shoulder management on the acute ward by nursing and therapy staff is essential. It is important that all staff that work with these patients are trained in the management of the paralysed and/or painful shoulder. Physiotherapists should take on this role as educators to other staff.

The National Neurology Group (New South Wales Chapter) of the Australian Physiotherapy Association has developed an information and resource package for "optimising upper limb function following stroke" (Hall 2001). The information provided in that package may also apply for clients who have suffered from traumatic brain injuries. Following are some important points in the upper limb package.

For patients with a paralysed arm (e.g. score less than 4 for item 6: Upper Arm Function on the Motor Assessment Scale):

- arm supported on lap tray in sitting
- button on arm "MIND MY ARM" to remind carers not to pull on paralysed arm
- triangular sling applied temporarily when standing and/or walking
- electrical stimulation of the posterior deltoid and supraspinatus muscles every day with sessions progressively increased from 1.5 to 6 hours
- positioning program with shoulder in external rotation, forward flexion and abduction, and forearm and wrist in supination and extension for 30 minutes per day to prevent development of contracture
- when lifting patients, use hoists and transfer belts to avoid pulling on the affected arm, and
- avoid lying on the affected shoulder, so sleep either in a supine position or side lying with affected arm upper most and supported on a pillow.

Management of the Confused/ Agitated Patient

AFTER a traumatic brain injury and emergence from coma, clients go through a stage of recovery that may include confusion, disorientation and sometimes agitation. This is called post-traumatic amnesia. Common behaviours seen during this stage include:

- confusion as to who they are and where they are
- reduced ability to take on new information
- short attention span
- distractibility
- fatigue easily
- easily overstimulated
- irritability and aggression, and
- perseveration on topic or task

Physiotherapy during this time of confusion is still possible if the patient is not physically aggressive. Patients are still able to learn simple motor tasks through procedural learning. It is important, however, to keep the following points in mind when structuring and carrying out a physiotherapy session with a patient in post-traumatic amnesia.

- Keep instructions simple, short and to the point. Patients may take your words very literally, so consider how you say your instructions.
- Avoid overstimulation: reduce stimulation and distractions by turning off the television or radio when you are speaking to the client, keep loud noise to a minimum and if possible work in a quiet environment without other clients around.
- Keeping physiotherapy functional and relevant to the client may improve their attention span and reduce agitation. It may help to concentrate on whole practice rather than part practice where possible.
- If the client's attention span is short, be prepared to vary your treatment and give the client a concrete start and finish point in the session (e.g. "we will do this 10 times and then you can lie down and rest").
- Give the client time to process the information or instructions you are giving them and allow them time to carry these out.
- Mental and physical fatigue can be an issue during physiotherapy. It may be more effective to carry out two or three short sessions rather than one long session.
- Pain may be an issue, especially if the client has orthopaedic injuries. If this is the case ensure sufficient analgesia is available, if necessary with a PRN dose before physiotherapy sessions.

• Remember to give positive feedback when appropriate behaviour is shown and when goals (or part of them) are reached.

Agitation or aggression in physiotherapy sessions

Do

- avoid conflict
- reduce stimulation and noise
- adopt a calm manner
- reassure them
- be detached if a behaviour is inappropriate
- allow time out if required
- use an additional staff member to increase safety if you are at all concerned

Don't

- take abuse personally
- panic or overreact
- argue the point or force compliance
- ignore or dismiss concerns

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