Neurovascular impairment and compartment syndrome

Nurses have a vital role to play in the prompt identification of compartment syndrome in children. Elizabeth Wright reviews the literature for the key assessment criteria nurses should focus on

Abstract

Compartment syndrome is a potential complication of musculoskeletal trauma and surgery. Early identification of compartment syndrome is critical because, if left untreated, it may result in limb loss or death. Nurses routinely perform neurovascular observations as a part of the patient's essential care in hospital. However, there is limited literature on the assessment and early identification of compartment syndrome in children, although most authors agree on assessment criteria such as pain, warmth, colour, movement, sensation and pulses. Improved approaches to assessment and early recognition may be required so that effective action can be taken to reduce the severity of the outcome.

Keywords
Musculoskeletal system and disorders, children: surgery, children: accidents.

NEUROMUSCULAR DEFICIT, vascular impairment and compartment syndrome are well-documented complications of musculoskeletal trauma and surgery. Incidence in children is largely unknown, although a review of the national trauma registry in the United States identified 133 cases of compartment syndrome in which the most common mechanisms for injury were motor vehicle accidents (pedestrian and passenger), falls and sports (Grottkau *et al* 2005).

Early identification of compartment syndrome is critical because, if left untreated, it may result in limb loss or death. Nurses routinely perform neurovascular observations as a part of essential care in hospital.

This article draws on seminal and other recent literature to provide an overview of neurovascular impairment and compartment syndrome, focusing on the nursing role in identification of this complication.

Literature search

A search was undertaken using the CINAHL database (1982 to November 2007). Articles were sought under the broad headings of 'neurovascular assessment', 'limb observation' and 'compartment syndrome'. Using the same broad headings, information was sought from the Medline database (1966 to November 2007).

The two searches identified 2,050 references related to compartment syndrome, 27 on neurovascular assessment and none on limb observation. Relevant references were also hand sought from journals that were not on line, and proceedings of orthopaedic and paediatric nursing conferences attended by the author between 1998 and 2004.

Almost all texts on orthopaedic conditions refer to compartment syndrome as a potential complication of trauma or orthopaedic surgery. Few texts relate solely to paediatrics, so this review also includes literature pertaining to the adult population. Abdominal compartment syndrome is not covered here.

Pathophysiology

Muscles, nerves, blood vessels and bone are surrounded and protected by a tough, inelastic fibrous tissue called fascia. Each group of tissues enveloped by fascia forms a compartment. The fascia are inelastic and therefore do not tolerate any increase in compartment volume or pressure. Compartment syndrome is generally described

as resulting from 'high pressure in the muscle compartment in the closed fascial space' (Maher *et al* 1994) that results in 'cellular anoxia, muscle ischaemia and death' (Olson and Glasgow 2005). It occurs as a result of increased compartmental pressure or decreased compartment size.

An increase in compartmental pressure occurs as a direct result of an insult to the muscle that causes swelling and/or haemorrhage; decreased compartment size is in response to the blood flow to the muscle being interrupted (Ward *et al* 2007). An injury proximal to the muscle compartment may cause blood flow to decrease.

The capillary cell walls collapse as a result of hypoxia, leading to tissue fluid and colloid proteins escaping into the soft tissues. This results in soft tissue (muscle) oedema, which in turn causes increased pressure, obstruction of blood flow and nerve impairment (Maher *et al* 1994).

Muscle oedema can also occur with the inflammatory response caused by direct injury. This increases pressure in the muscle compartment. Eventually the blood vessels collapse, initiating the process described previously and adding to the oedema, resulting in increased venous pressure local to the injury. This causes a progressive elevation in the soft tissue pressure (Melaragno *et al* 1996). Both mechanisms increase compartmental pressure, causing vascular obstruction and nerve impairment.

If left unchecked, muscle necrosis may result, potentially necessitating amputation. If still not treated, renal failure can occur, which may result in death (Love 1998).

Compartment pressure can be raised by either internal (physiological) or external compression (Tumbarello 2000). External compression, or decreased compartmental size, occurs when there is extra fascial haemorrhage or oedema.

Pressure is internalised because the skin is prevented from extending to accommodate the swelling when it is constricted by a plaster cast, tight dressing or due to limb positioning. In both scenarios the pressure is internalised, resulting in compression of the blood vessels and nerves. This compromises their functioning and results in a depreciation of the neurovascular status.

Two types of compartment syndrome are described in the literature – acute and chronic. Acute compartment syndrome can occur up to 54 hours after injury (Simpson and Jupiter 1995), after surgery (Nadeem *et al* 1998) or after systemic illness (Paley *et al* 1996).

Chronic compartment syndrome is described as commonly occurring after exercise, presenting as exertional muscular pain over a long period (Pedowitz and Gershuni 1995).

Acute compartment syndrome may result from plaster casts: the skin is prevented from expanding to accommodate swelling

Causes

Compartment syndrome has been described in association with:

- Fractures and traumatic muscle strain (Stuart and Karaharju 1994).
- Infection (Ramos *et al* 2006).
- Complications of surgery or systemic illness (Paley *et al* 1996).
- Burns, snake bites or crush syndrome (Shirreffs 1990, Carriere and Elmsworth 1998).
- Electrical injuries, immobility or traction and plaster (Mubarak *et al* 2006).

Paletta and Dehghan (1994) reported that of the 20 patients in their study, 75 per cent had a related trauma, but only 15 per cent had a fracture. The main causes were snake and insect bites and crush injuries. In addition to the above causes, acute compartment

Table 1 Signs, symptoms and observations (Wright 2007a)

Signs and symptoms	Nursing observations
Increasing pain, out of proportion to the injury or surgical intervention. The first most reliable sign (Wright and Bogoch 1992).	Regular pain assessments using an age appropriate pain tool. Give all prescribed analgesia.
Pallor	Observe perfusion of digits on the affected limb. Assess to see if capillary refill time is less than one second.
Paraesthesia	Ask if the child can feel 'pins and needles' in the digits. Lightly touch all digits, asking the child to confirm that they can feel the touch and that the feeling is normal or the same as the non-affected hand.
Paralysis	Ask the child to move the affected digits. The child may be reluctant to move the digits because of pain, but should be able to do so.
Pulselessness The last sign. If pulselessness occurs then the compartment syndrome is well established and amputation is likely.	Record the pulse distal to the site of injury. It may be necessary to make a hole in the plaster to access the pulse.
Coldness	Feel the digits for warmth and compare with the other limb.

syndrome may result from:

- Vascular injuries.
- Complications of intravenous and intraosseous infusions.
- Resuscitation.
- Automated blood pressure monitoring.
- Incorrect positioning during surgery.
- Plaster casts.
- Bandages.
- Traction (Mars and Hadley 1998).

Diagnosis

Recommended diagnostic methods require significant resources and highly trained personnel. Procedures are mostly invasive, causing discomfort to the patient or at least requiring the patient to undergo a radiological investigation. There is some discussion in the literature about diagnostic criteria, but there is agreement that once compartment syndrome has been diagnosed, surgical intervention in the form of a fasciotomy is needed (Olson and Glasgow 2005, Friedrich and Shin 2007, Gourgiotis *et al* 2007).

Compartmental pressure monitoring is an invasive technique performed under local anaesthetic by medical personnel. It involves inserting a needle or catheter into the compartment and attaching to a battery-powered pressure transducer or manometer apparatus. The normal compartment pressure is 0-8 mmHg. Compartment syndrome is said to be present when the compartment pressure is elevated above this.

In the literature, compartment pressures are discussed either as absolute values or as a differential pressure that is calculated as the diastolic blood pressure minus the absolute compartment pressure. Opinions vary about when surgical treatment (fasciotomy) should be performed. Using absolute pressures, Hargens *et al* (1989), among others, recommended 30mmHg; other investigators suggested 40mmHg (for example, Schwartz *et al* 1989) or 45mmHg (Matsen *et al* 1980). Using differential pressures, McQueen and Court-Brown (1996) advised surgical decompression between 10-30mmHg.

A recent review by Wall *et al* (2007) identified variance in the type of compartment pressure measured and the level at which surgical intervention is instigated.

Perron (2001) argues that variance is due to pressure assessment techniques. Recent papers describe new non-invasive techniques for the diagnosis of compartment syndrome (Wiemann *et al* 2006, Joseph *et al* 2006).

The nursing role

Because nurses spend a long time in contact with patients on the ward, they are in a unique position to monitor their condition and neurovascular status (Love 1998).

The literature acknowledges the vital role of nurses in identifying the early signs of compartment syndrome or neurovascular impairment (for example, Judge 2007, Miller and Askew 2007). Among others, Altizer (2002) and Wright (2007a) describe neurovascular assessment and the clinical signs and symptoms of compartment syndrome. Wright (2007b) provides a validated assessment tool and highlights the importance of accurate documentation and effective communication of clinical concerns to the healthcare team.

Observations of the patient include assessment of pain, warmth, sensation and movement of a limb that has recently experienced trauma or surgery (Altizer 2002, Wright 2007a, Dykes 1993) succinctly lists these as the 5Ps – pain, pulses, pallor, paraesthesia and paralysis.

Wright and Bogoch (1992) include a further P – palpation of the limb. If the muscle compartment

within the limb feels tense and bulging, it can be assumed there is high pressure within the muscle compartment. It should be noted that the initial indicators of neurovascular impairment can be very subtle (Choi *et al* 2007). Pain that is out of proportion to the injury is the most reliable indicator of neurovascular impairment. If the distal pulse is no longer palpable, the likelihood of limb amputation is high.

There are some variations in the literature related to assessment. Both Tucker (1998) and Proehl (1988) report recording the actual compartment pressure. The tool described by Wright (2007b) has four assessment categories – vascular, movement, sensation and pain – each with detailed assessment criteria. Observations for neurovascular impairment should be carried out hourly in children at risk, or more frequently if there is clinical concern (see Table 1).

This tool does not allow the presence of a plaster to be recorded and there was some discussion about its ease of use with young children and those with limited communication skills (Wright 2007b). Paletta and Dengham (1994) and Elliot and Johnstone (2003) also recognised the specific difficulties of conducting neurovascular assessment with young children.

Conclusion

Most of the literature discusses compartment syndrome as a complication of trauma and other conditions, and describes the different approaches to medical diagnosis and management. Numerous articles and texts identify compartment syndrome as a serious complication. However, there is limited literature on the subject of neurovascular assessment to identify compartment syndrome in children. If diagnosis is delayed the child may require limb amputation. Improved approaches to assessment and early recognition may be required so that effective action can be taken to reduce the severity of the outcome.

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