

Trust Guideline for the Management of: Acute Compartment Syndrome in Adults

A clinical guideline recommended

For use in:	Trauma and Orthopaedic Directorate
By:	All Professionally qualified staff
For:	Adults at risk of Acute Compartment Syndrome
Division responsible for Document:	Division 2 - Surgical
Key words:	Acute Compartment Syndrome (ACS) Continuous Compartment Pressure Monitoring Differential Pressure (ΔP)
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If Yes – does the strategy/policy deviate from the recommendations of NICE? If so, why?	N/A

This guideline has been approved by the Trust's Clinical Guidelines Assessment Panel as an aid to the diagnosis and management of relevant patients and clinical circumstances. Not every patient or situation fits neatly into a standard guideline scenario and the guideline must be interpreted and applied in practice in the light of prevailing clinical circumstances, the diagnostic and treatment options available and the professional judgement, knowledge and expertise of relevant clinicians. It is advised that the rationale for any departure from relevant guidance should be documented in the patient's case notes. The Trust's guidelines are made publicly available as part of the collective endeavour to continuously improve the quality of healthcare through sharing medical experience and knowledge. The Trust accepts no responsibility for any misunderstanding or misapplication of this document.

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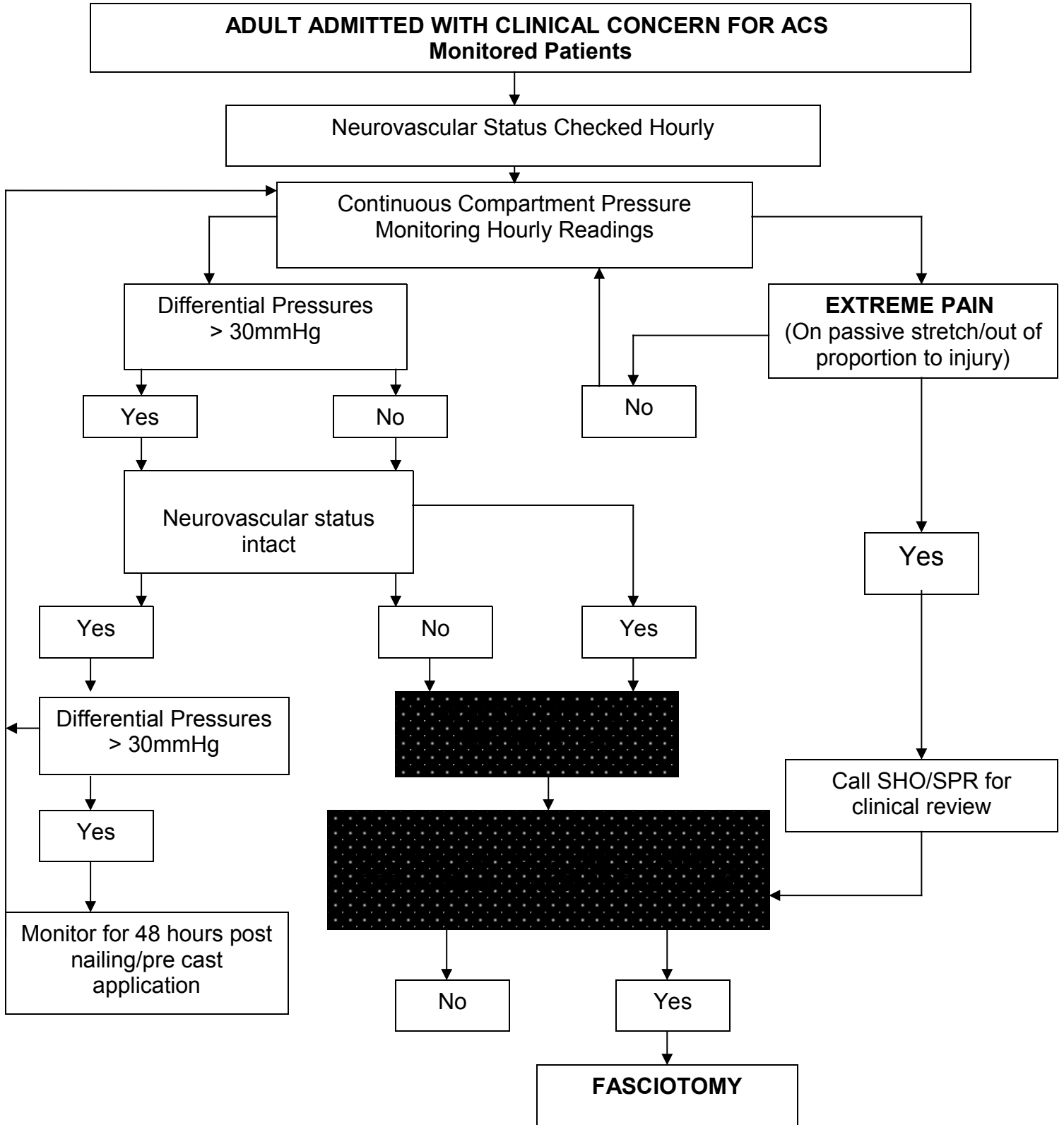
Version Number	Date of Update	Change Description	Author
5	23/04/2021	Removal of requirement for routine invasive compartment pressure monitoring in all tibial fractures and in all post-operative tibial nailing patients. Clarification that ACS is not limited to the lower leg and change of title of the guideline.	Mr A D Patel – revised by Mr B Davis

This is a Controlled Document

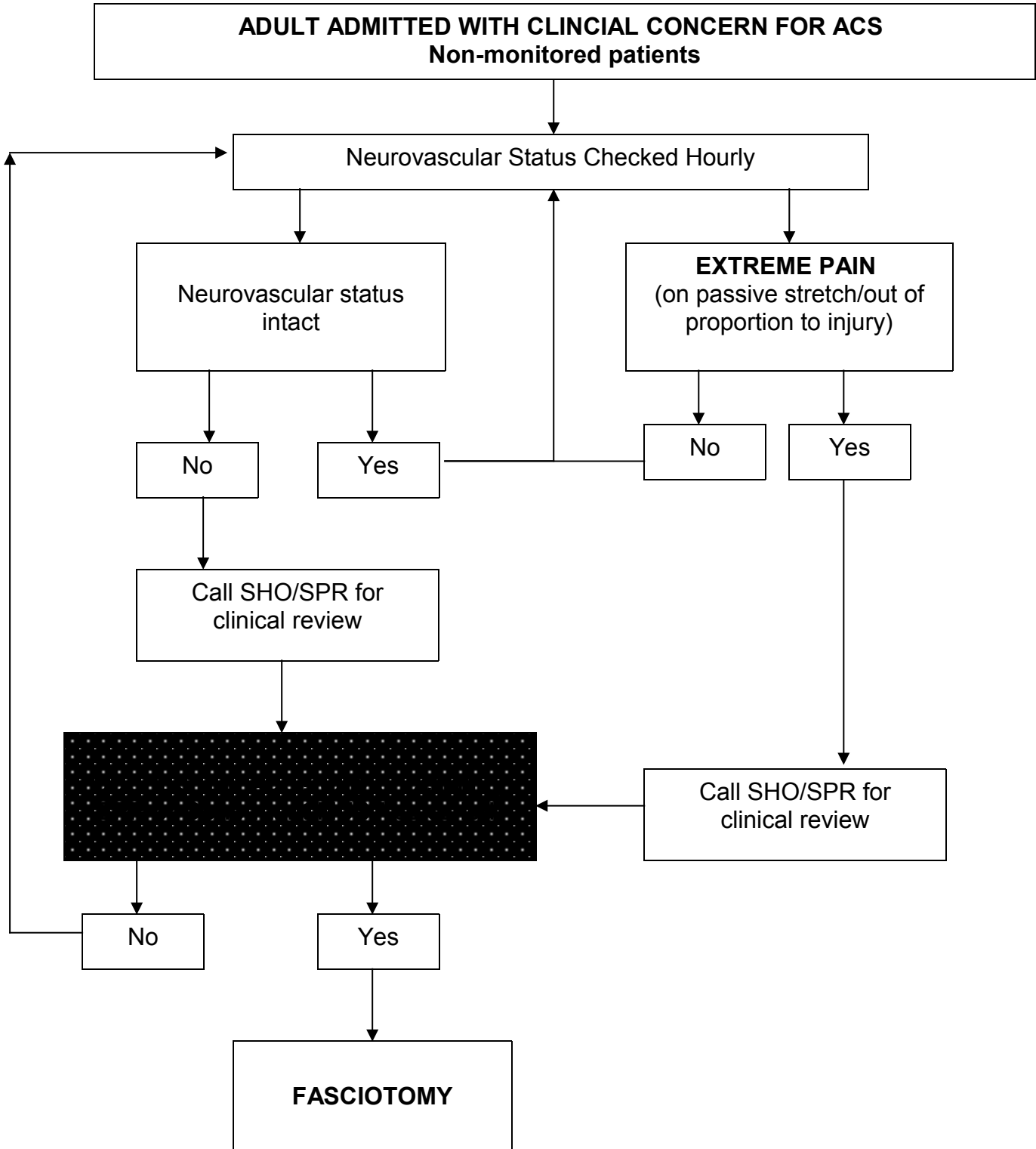
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Quick reference Guideline/s



**Trust Guideline for the Management of:
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Objective

To inform all staff involved in the care of patients at risk of developing Acute Compartment Syndrome (ACS). For all staff to fully understand what ACS is; to recognise early symptoms; to be competent in using the continuous monitoring equipment and to be able to act early to avoid missing ACS.

Rationale

ACS is a complication of trauma with serious sequelae if not diagnosed early. The end result of unchecked ACS includes neurological deficit, muscle necrosis, ischaemic contracture, infection and delayed fracture healing. Irreversible damage can also lead to amputation, renal failure and even loss of life (Appendix 3). It is widely acknowledged that early diagnosis is essential in preventing the complications associated with ACS leading to urgent intervention before irreversible damage occurs.

The diagnosis of ACS in a conscious patient is based on the history, examination and detection of clinical signs and symptoms consistent with ACS. Routine monitoring of the extremities for neurovascular status is current practice within this Trust. In patients considered at high risk of ACS, this should be identified to the nursing staff and hourly monitoring of the patient should take place.

In an unreliable or unconscious patient, neurovascular checks alone may be unreliable and lead to missed ACS. Diagnostic tools have been developed to provide an objective measurement of compartment pressures as an adjunct to signs and symptoms in detecting ACS, one of which is the use of continuous compartment pressure monitoring. Therefore, in a patient that is considered to be at risk of ACS who cannot be reliably monitored clinically, consideration should be given to the use of continuous compartment pressure monitoring.

What is ACS?

“A condition in which the circulation and function of tissues within an enclosed space is compromised by increased pressure within that space” (Matsen, M 1975)

“Occurs when raised pressure within a closed osteofascial compartment compromises the circulation and function of tissues within the compartment” (McQueen, M 1998)

Causes:

Acute traumatic injury

- Commonly associated with fractures but also seen in soft tissue trauma without fracture
- More likely to be present in high energy trauma but can occur with any traumatic injury to a body area with an enclosed fascial compartment

Spontaneous haemorrhage into a compartment

- most likely to be seen in patient's on therapeutic dose anti-coagulants but also occasionally seen in the elderly without anti-coagulation

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Constriction and external compression

- Unconscious patients following anaesthesia or alcohol/substance misuse leading to entrapment of the limb
- Entrapment of the limb under a heavy load
- Prolonged inflation of air splints
- Incorrect application of circumferential casts (POP, Scotchcast™)

Revascularisation

- Postischaemic swelling after circulation restored following vascular reconstruction - particularly if restoration of the circulation is delayed

Surgical procedures with elevation of the lower limbs

- e.g. Lloyd Davies/Lithotomy position for > 4 hours

Thermal Injuries

- Circumferential burns
- Electrical burns (raised interstitial pressure resulting from associated oedema)

Intravenous extravasation

- Occlusion or spasm of a major vessel with an inadequate collateral circulation can also cause swelling of the contents to a muscle group

Signs and Symptoms – The 6 ‘P’s

(note: traumatic injury can lead to many of these symptoms and signs in the absence of ACS)

Pain

- Out of proportion to the injury
- Unrelieved by narcotics
- Excessive use of analgesic devices (PCA)
- Increased by movement of the distal digits
- Described as deep or throbbing
- Increases with elevation of the extremity
- May not be present if central/peripheral sensory deficits are present

Paresthesia

- Subtle first symptom
- Best elicited by direct stimulation

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- Patient complains of tingling or burning sensation
- Can lead to hypoesthesia (numbness)

Pressure

- Involved compartment or limb will feel tense and warm on palpation
- Skin will be tight and shiny
- Skin occasionally appears cellulitic

Pallor

- Late sign
- Pale/whitish tone to the skin
- Prolonged capillary refill - > 3 seconds
- Cool feel to skin due to lack of capillary reperfusion

Paralysis

- Late Sign
- May start as weakness in active movement of involved or distal joints
- Leads to inability to move joints or digits actively
- No response to direct neural stimulation due to damage of myoneural junction

Pulselessness

- Late sign
- Very weak or lack of palpable or Doppler audible pulse

ACS - Important Points to Remember

Paresthesia/hyperparesthesia (Sensory changes in the nerve)

- Develop within 30 minutes of the onset of ischemia

Irreversible functional changes

- Start in the muscle after 4 hours

Irreversible nerve damage

- Begins after 12/24 hours of total ischaemia

The lower leg and forearm

- More prone to ACS

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Elevation

- Too high - can contribute to the risk
- Should not be above the level of the heart

Renal Failure

- All patients with ACS are at risk of renal failure
- Monitor renal function and urine output regularly

Invasive continuous monitoring of compartment pressure:

- The diastolic blood pressure and the compartment pressures are recorded **HOURLY** on the compartment pressure monitoring form.
- The compartment pressure is subtracted from the diastolic blood pressure to produce the Differential Pressure (ΔP).
- This should be above 30mmHg to be considered within normal range.
- If the ΔP falls below 30mmHg for two consecutive readings, the SHO/SPR should be informed and a clinical assessment made of the patient. The compartment pressure monitoring equipment should be checked to ensure correct function and placement of the pressure transducer and that the cannula is not obstructed.
- A falling trend of ΔP may signify the onset of ACS and an urgent fasciotomy should be performed if clinical assessment is also consistent with ACS.
- Invasive compartment pressure monitoring should only be performed by a practitioner experienced with the use of the equipment and with the anatomy of the area being monitored. Incorrect cannula placement can lead to erroneous readings, delay in fasciotomy, inappropriate fasciotomy and neuro-vascular injury. In rare cases, infusion of fluid down the cannula while preparing the monitor or with repeat "flushing" can cause compartment syndrome.

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A TREND OF FALLING DIFFERENTIAL PRESSURES (ΔP) INDICATES A RISING COMPARTMENT PRESSURE

Using the Monitor:

- To set Auto BP Recording, press **NIBP** button, the bottom of the screen will display AUTO On/Off press **ON**; the machine will now read every hour after the first reading.
- Press Normal Screen and the STAT B/P button to commence cycle.
- Record the diastolic
- At the same intervals record the mean compartment pressure = '*PRS*' on screen
- Subtract the mean CP from the diastolic NIBP Record the resulting value as 'Differential'

Display Trends

- From 'Normal Screen', press in turn: '*Special Function*'—'*Local Trends/Calcs*'—'*Graphics*' or '*Tabular*'
- Top graph is '*PRS*' (CP) /lower graph is NIBP
- If you get lost or confused, return to '*Previous Screen*' or back to the beginning via '*Normal Screen*'

Tones

To turn off sounds -

- Press '*monitor set up*'- this displays '*tones*' button in bottom left of the screen
- Press '*tones*' button and then '*local alarms*' button – press off to silence the tone
- Repeat the procedure for '*remote alarms*'
- Return to Normal Screen

Monitoring Procedure – Important Points to Remember

- Call theatre orthopaedic ODP's (operating department practitioners) for trouble shooting - they are contactable via the bleep system.
- **The Transducer is not to be purged by recovery/ward staff.** No saline to be used to purge any blockages as this increases the pressure within the compartment.
- Clinical symptoms must be taken into account and the individual assessed accordingly.
- If there are unequivocal positive clinical signs but inconclusive readings, the clinician must make an early decision to perform a fasciotomy.
- Where there are persistently low ΔP readings but the patient has no clinical signs,

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the clinician assessing the patient must make the decision whether to perform a fasciotomy.

- When spurious readings occur (i.e. possible monitoring fault/misplaced cannula) where there is a persistently low ΔP , but neurovascular status is intact, clinical symptoms are negligible, and the consultant has decided there is no ACS - then he may decide to discontinue monitoring. However, neurovascular observations should be continued.
- **The person ultimately responsible for this decision is the patient's Consultant Orthopaedic Surgeon and if the clinician has any doubts regarding this decision, then they should refer to the consultant.**

Distribution list / dissemination method

To be distributed to all those involved in continuous compartment pressure monitoring –

Denton Ward	EAUS	
Earsham Ward	Theatre Recovery	Buxton ward for reference only –
Gateley Ward	Orthopaedic Theatres	not to be used in Paediatrics

The guidelines will be distributed in hard copy form to each of the above departments and will also be accessible via the Intranet.

Original neurovascular observation chart created by Helen Fordham in consultation with staff on EAUS. The original version was then updated by Steve Hume and Karl Rich to version 2. All were on EAUS at the time.

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Further information and references can be obtained from

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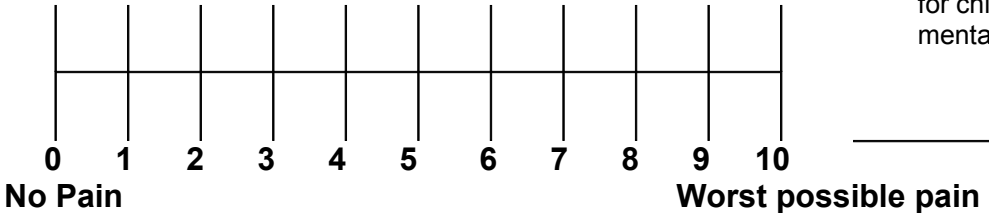
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Date <small>(dd/mm/yyyy)</small>	Time <small>(24hr clock)</small>	Colour * <small>i.e. Pink Blue Dusky White</small>	Warmth <small>Hot Cold Clammy</small>	Skin Condition <small>Normal Altered (e.g. Blisters)</small>	Pulse <small>Present Strong Weak Absent</small>	Pain <small>State Site (See VAS) **</small>	Sensation <small>Normal Altered Pins & Needles (State Side)</small>	Movement of Digits <small>Normal Reduced (specify) NB. Passive Extension</small>	Signature

* N/A in non-white skin – check nail bed for alteration in colour

** Alternative scale may be appropriate for children / patients with reduced mental capacity e.g. Faces Scale

NUMERICAL RATING SCALE



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Compartment Pressure Monitoring

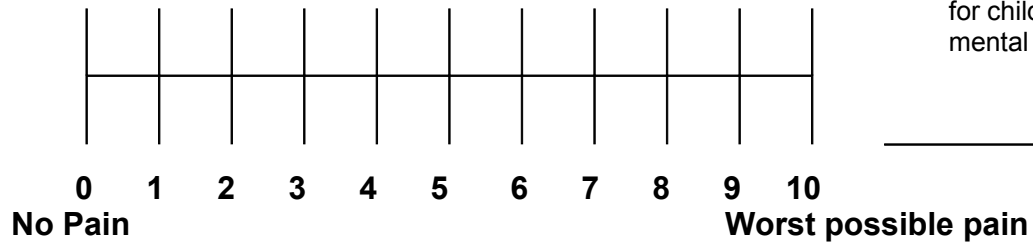
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Date	Time	Colour *		Warmth		Skin Condition		Pulse		Pain		Sensation		Movement of Digits		Signature	
		e. Pink	Blue	Hot	Cold	Normal	Altered (e.g. Blisters)	Present	Strong	State	Site (See VAS) **	Normal	Altered	Passive	Extension		
		Dusky		Clammy				Weak				Pins & Needles					
		White						Absent				(State Side)					

* N/A in non-white skin – check nail bed for alteration in colour

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NUMERICAL RATING SCALE



Compartment Pressure Monitoring

Date:

Time															
Systolic															
Diastolic															
Mean Compartment Pressure															
Differential															
Initials															

Compartment Pressure Monitoring

Date: (dd/mm/yyyy)

Time															
Systolic															
Diastolic															
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Date:

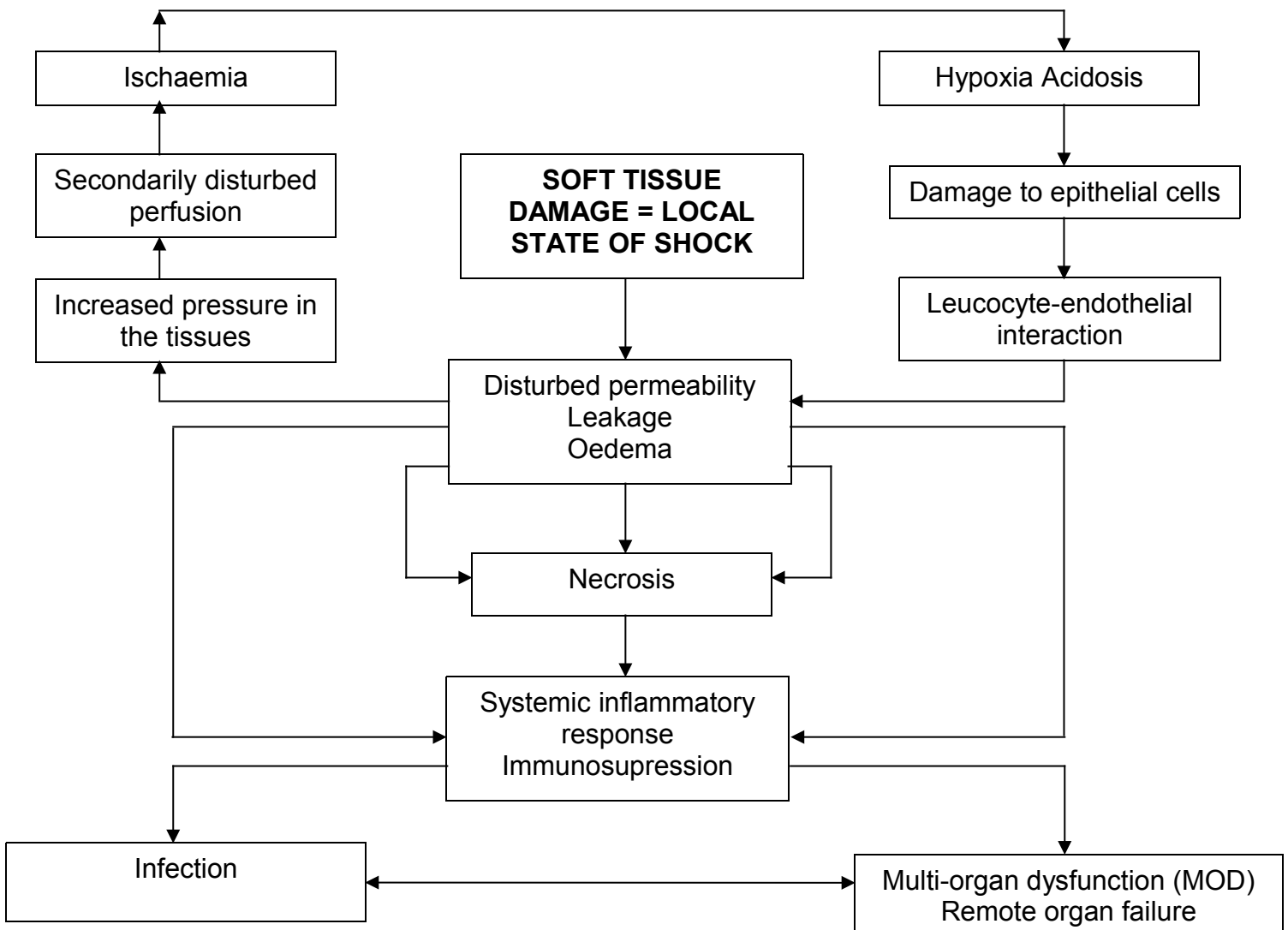
Time															
Systolic															
Diastolic															
Mean Compartment Pressure															
Differential															
Initials															

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Appendix 3 Systemic Response to Soft-tissue Injury

Severe damage can also lead to a marked inflammatory response (MOD, multi organ dysfunction syndrome) with the release of proinflammatory cytokines (TNF α , IL-1, IL-6, IL-10) and damage to central organs away from the injury site (remote organ injury). Pathophysiological changes in damaged tissue after soft tissue trauma – a vicious circle, comprising:

1. Impairment of microvasculature with hypoxia
2. Acidosis
3. Permeability damage
4. Oedema
5. Increase in interstitial pressure due to oedema in the presence of constriction of the swelling tissue by fasciae or skin with secondary disturbance to perfusion
6. Metabolic dysfunction of the tissue and necrosis
7. Greater vulnerability to infection of the damaged tissue. Acidosis of the poly-traumatised patient
8. Protraction of all mechanisms in the presence of generalised hypoxia and acidosis of the poly-traumatised



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Acute Compartment Syndrome: What is it and how do I recognise the symptoms?

What is it?

Thick layers of tissue called fascia separate groups of muscles in the leg from each other. Inside each layer of fascia is a confined space called a compartment that includes the muscles, nerves, and blood vessels (they are surrounded by the fascia much like wires surrounded by insulation). Significant swelling can follow trauma, such as a broken bone (fracture), and pressure can sometimes build up in the compartment. This may lead to a condition called 'Acute Compartment Syndrome'.

Unlike a balloon fascia does not expand so any swelling in a compartment will lead to increasing pressure in that compartment, which will compress the muscles, blood vessels, and nerves. If the pressure lasts long enough, there can be permanent damage to these structures. In the worst case scenario, Acute Compartment Syndrome may even lead to the loss of a limb (amputation).

How do I recognise the symptoms?

The most important symptom of Acute Compartment Syndrome is severe pain. Typically, this pain will occur when a muscle running through a compartment is passively moved. For example, when a doctor moves the toes up and down a patient with compartment syndrome in the foot or leg will experience severe pain. In more advanced cases there may be decreased sensation, weakness, and paleness of the skin.

How is Acute Compartment Syndrome diagnosed?

ACS is a clinical diagnosis based on history and examination. In situations where this may be unreliable, a test that assists the doctors in diagnosing this condition involves measuring the pressure in the compartments by inserting a needle attached to a pressure meter into one of the compartments of your body (continuous compartment pressure monitoring). The pressures within the compartment are measured and your blood pressure is taken every hour. The differences between your blood pressure and your compartment pressures are then compared to give a differential pressure. This should usually be more than 30. If your readings drop below this a doctor will be asked to come and review your condition and ask you about any symptoms you have been experiencing.

Treatment

The treatment for Acute Compartment Syndrome is to relieve the pressure. This may be as simple as releasing a tight dressing or plaster but often will require surgery (fasciotomy). Incisions are made in the skin of the body to release the compartments and thus the pressure building inside. The wounds are generally left open (covered with a sterile dressing) and closed during a second surgical procedure 48-72 hours later. Sometimes skin grafts may be required to close the wounds.

Prevention

While there is probably no way to prevent Acute Compartment Syndrome you being very aware of this condition and receiving early diagnosis and treatment will help to prevent many of the complications. A nurse will observe the swelling in your limb, the colour and condition of the skin and will check the blood and nerve supply. You will be asked about any pain you may have and about the sensation in your limb. Please tell the nurse if you experience any of the following:

- Extreme pain that is not helped by the pain relieving medications you are taking.

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- Tingling sensation in the limb.
- Loss of sensation (numbness) in the limb.