



RU-RMT 20 PATHOLOGICAL TREATMENTS • LECTURE 15

Compartment Syndrome

Anatomy, pathophysiology, assessment, contraindications and treatment of acute and chronic exertional compartment syndrome

Based on the Rattray & Ludwig clinical-conditions framework



LECTURE OVERVIEW

Learning Objectives



Describe the compartment

Explain fascial compartments and why they cannot expand under pressure.



Explain the pathophysiology

Trace the ischemia–edema cycle that drives rising intracompartmental pressure.



Distinguish acute vs chronic

Differentiate acute (ACS) from chronic exertional (CECS) compartment syndrome.



Assess and screen

Apply health-history, observation, palpation and ROM findings to recognise red flags.



Apply contraindications

Identify ACS as an absolute contraindication requiring emergency referral.



Plan safe treatment

Outline an appropriate massage and self-care plan for the chronic presentation.



DEFINITION

What Is Compartment Syndrome?

Compartment syndrome occurs when pressure rises within a closed fascial compartment to a level that compromises the circulation and function of the tissues inside it.

The fascia surrounding a muscle group is tough and inelastic. When swelling or bleeding increases the volume inside that fixed space, pressure climbs quickly. Rising pressure first collapses thin-walled veins, then capillaries, and finally arterial inflow — starving the muscle and nerve of oxygen.



A time-critical condition

In the acute form, irreversible muscle and nerve damage can begin within hours. Recognition speed determines outcome.



Most common sites

The leg (especially the anterior compartment) and the forearm are the classic locations, though any compartment can be affected.



The Compartment Concept



Bone & interosseous membrane

Form the rigid inner walls that the compartment is built around.



Fascial sheaths & septa

Tough connective-tissue partitions divide a limb into separate compartments.



Muscles, vessels & nerves

Each compartment houses a functional group plus its supplying artery, vein and nerve.



Key principle: Fascia is strong but minimally compliant. A small rise in volume produces a large, non-linear rise in pressure — the compartment behaves like a sealed, unyielding container.



The Four Compartments of the Leg

1

Anterior

Most commonly affected — dorsiflexors.

Tibialis anterior, EHL, EDL, fibularis tertius. Deep fibular nerve. Anterior tibial artery.

2

Lateral

Evertors of the foot.

Fibularis longus & brevis. Superficial fibular nerve.

3

Superficial posterior

Plantarflexors — the calf.

Gastrocnemius, soleus, plantaris. Sural nerve.

4

Deep posterior

Often hardest to assess clinically.

Tibialis posterior, FDL, FHL, popliteus. Tibial nerve. Posterior tibial artery.



Compartments of the Forearm

The forearm is the second classic site for acute compartment syndrome — often following a supracondylar fracture, crush injury or tight cast.

1

Volar (anterior)

Wrist & finger flexors, pronators. Median & ulnar nerves.

Most affected — site of Volkmann's contracture.

2

Dorsal (posterior)

Wrist & finger extensors. Posterior interosseous nerve.

Less commonly involved.

3

Mobile wad

Brachioradialis, ECRL, ECRB.

Lateral muscle group of the forearm.



The Pressure Cascade

1

Trigger

Trauma, bleeding, swelling or external compression raises the volume inside the compartment.

2

Pressure rises

Inelastic fascia cannot expand, so intracompartmental pressure climbs steeply.

3

Venous collapse

Thin-walled veins are compressed first; venous outflow falls and back-pressure builds.

4

Capillary failure

Capillary perfusion pressure is exceeded; oxygen delivery to tissue stops.

5

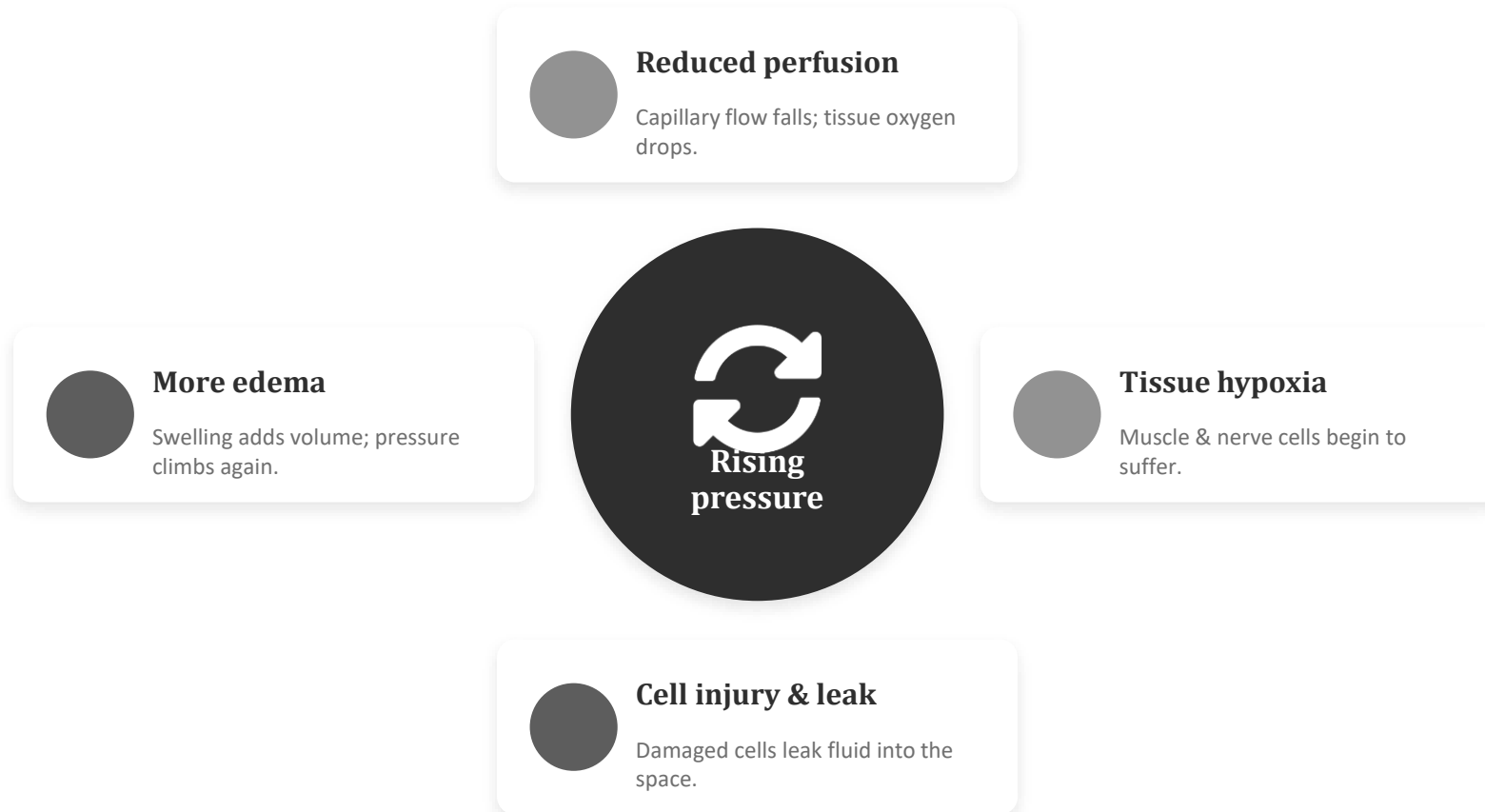
Ischemia

Muscle and nerve become ischemic; further swelling worsens the pressure — a vicious cycle.

Self-perpetuating: ischemia causes more swelling, which raises pressure further — the cycle accelerates until perfusion is restored.



The Ischemia–Edema Vicious Cycle



Why it matters

Each turn of the loop makes the next worse.

Without decompression the cycle does not self-correct.

This is why acute compartment syndrome is a true surgical emergency — only fasciotomy reliably breaks the cycle.



CLASSIFICATION

Two Distinct Presentations



Acute (ACS)

Surgical emergency

- Sudden onset, usually after trauma or fracture
- Severe, escalating pain out of proportion to injury
- Pressure does NOT relieve with rest
- Threatens limb viability within hours
- Absolute contraindication — refer to emergency care



Chronic Exertional (CECS)

Activity-related, reversible

- Gradual onset, brought on by exercise
- Aching, cramping or tightness during activity
- Symptoms RESOLVE with rest within minutes
- Common in runners and endurance athletes
- Massage may help associated tension; refer for diagnosis



PART ONE

A limb-threatening surgical emergency. The clinician's job is rapid recognition and immediate referral — never treatment.



ACUTE • ETIOLOGY

What Causes Acute Compartment Syndrome?



Fractures

The leading cause — especially tibial shaft and forearm fractures, with associated bleeding and swelling.



Crush injuries

Severe soft-tissue trauma causes rapid swelling and muscle bleeding inside the compartment.



Reperfusion swelling

After restored blood flow (e.g. post-embolectomy), tissue swells dramatically.



Tight casts / bandages

External constriction prevents normal expansion and raises compartment pressure.



Burns & bleeding disorders

Circumferential burns and anticoagulated bleeds can both precipitate ACS.



Severe muscle overuse

Rarely, extreme exertion or prolonged limb compression in an unconscious patient.



ACUTE • SIGNS

The Six P's of Acute Compartment Syndrome



Pain

EARLY

Severe, deep, escalating — out of proportion to the injury and worse on passive stretch. The earliest sign.



Paresthesia

EARLY

Pins-and-needles or numbness in the nerve served by the compartment. An early, important sign.



Pressure

EARLY

The compartment feels tense, firm and 'wood-like' on palpation.



Pallor

LATE

Pale, cool skin from compromised circulation. A later sign.



Paralysis

LATE

Weakness then loss of movement as nerve and muscle fail. A late, ominous sign.



Pulselessness

LATE

Absent distal pulse — a very late and unreliable sign; do not wait for it.



ACUTE • SIGNS

Recognising the Picture Early

The hallmark

Pain out of proportion

Pain that is far more severe than the visible injury would explain, that keeps increasing, and that is not controlled by ordinary analgesia.

Pain on passive stretch of the muscles in the compartment is one of the most sensitive early findings.



Tense, firm compartment

Tight and 'wood-like' to palpation; tender over the whole muscle belly.



Worsening despite rest

Unlike most injuries, elevation and rest do not settle the pain.



Neuro changes

Numbness, tingling, then weakness in the distribution of the compartment's nerve.



ACUTE • MANAGEMENT

A Surgical Emergency: Fasciotomy

THE CRITICAL WINDOW

6 hrs

Muscle necrosis can begin within roughly 4–6 hours of sustained pressure. Decompression is time-critical.



Stop and refer immediately

Suspected ACS is a 911 / emergency-department situation. Do not massage, stretch or apply heat.



Do not elevate above heart

Keep the limb at heart level — raising it further reduces arterial inflow and worsens ischemia.



Fasciotomy

The surgeon opens the fascia to release pressure and restore perfusion; wounds are closed later.



ACUTE • CONSEQUENCES

Complications of Untreated ACS



Muscle necrosis

Ischemic muscle dies and is replaced by fibrous scar, causing permanent weakness.



Volkmann's contracture

In the forearm, scarring of dead flexors produces a fixed, claw-like deformity of the hand.



Permanent nerve damage

Prolonged ischemia of the compartment's nerve leaves lasting numbness and weakness.



Rhabdomyolysis

Breakdown products from dying muscle flood the bloodstream and can cause acute kidney failure.



Infection & amputation

Necrotic tissue may become infected; in severe cases the limb cannot be salvaged.



Systemic illness

Severe cases progress to electrolyte disturbance, shock and life-threatening complications.



PART TWO

An activity-induced, reversible rise in compartment pressure — the form a massage therapist is most likely to encounter in practice.



CHRONIC · ETIOLOGY

Causes & Risk Factors of CECS



The mechanism

During exercise, working muscle can swell by up to 20%. In a tight, low-compliance compartment this transient swelling raises pressure enough to reduce blood flow, causing pain. Pressure normalises once activity stops — so symptoms are predictable and reversible.



Repetitive-impact sport

Runners, especially distance and track athletes; also cyclists, skiers and soccer players.



Rapid training increases

A sudden jump in volume or intensity, or new hypertrophy, can outpace fascial compliance.



Biomechanics & technique

Forefoot strike, overpronation and certain gait patterns load the anterior compartment.



Younger athletes

Most common in active people under 40; affects both legs in most cases.



CHRONIC · SIGNS

Signs & Symptoms of CECS



Predictable timing

Aching, cramping or tightness that begins after a fairly consistent time or distance into exercise.



Activity-dependent

Builds as activity continues; severe enough to force the athlete to slow down or stop.



Relieved by rest

Settles within minutes of stopping — the defining feature versus the acute form.



Possible neuro symptoms

Numbness, tingling or transient foot-drop may appear at peak exertion, then resolve.



Often bilateral

Frequently affects both legs and the same compartment on each side.



Tightness / fullness

A sense of swelling or muscle hardness in the affected compartment during activity.



Who Tends to Develop CECS?

•
Anterior

compartment

Most commonly involved compartment of the leg in CECS.

•
< 40

years

Typically affects younger, athletically active adults.

•
Both legs

in most cases

CECS is frequently bilateral and symmetrical.

Clinical note: Symptoms often appear once an athlete increases training load. A careful activity history frequently reveals the trigger.



CLASSIFICATION

Acute vs Chronic: Side by Side

Feature	Acute (ACS)	Chronic Exertional (CECS)
Onset	Sudden, post-trauma	Gradual, exercise-induced
Pain & rest	Persists / escalates at rest	Resolves within minutes of rest
Severity	Limb-threatening emergency	Disabling but not dangerous
Typical cause	Fracture, crush, tight cast	Repetitive sport, training spike
Massage role	Absolute contraindication — refer 911	May help; refer for diagnosis first



Differential Diagnosis — Leg Pain

Several conditions mimic exertional leg pain. Distinguishing them guides safe treatment and appropriate referral.

Medial tibial stress syndrome

Diffuse pain along the posteromedial tibial border ('shin splints'); often eases as activity warms up.

Tibial stress fracture

Focal, point tender bony pain that worsens with continued loading; needs imaging.

Popliteal artery entrapment

Vascular claudication-type pain; pulses may change with ankle position — refer.

Deep vein thrombosis

Unilateral calf pain, warmth and swelling at rest — a medical emergency; never massage.

Nerve entrapment / radiculopathy

Pain following a nerve or root distribution, often with back involvement.

Tendinopathy / muscle strain

Localised to a specific tendon or muscle, reproduced by resisted testing.



ASSESSMENT · SUBJECTIVE

Health History

1

When and how did it start?

Sudden onset after trauma points to acute; gradual onset with exercise points to chronic.

2

What brings it on and relieves it?

Pain that escalates and persists vs pain reliably relieved by rest — the key discriminator.

3

Recent injury, surgery or cast?

Fracture, crush, reperfusion or a tight cast raises suspicion for acute compartment syndrome.

4

Activity & training history

New or increased running mileage, intensity or technique change supports CECS.

5

Neuro symptoms?

Numbness, tingling or weakness, and whether they resolve with rest or persist.

6

Red-flag screen

Resting calf pain, swelling, warmth, or escalating pain — screen for DVT and acute CS.



ASSESSMENT · OBJECTIVE

Observation & Inspection



Skin & colour

Note pallor, redness, shininess or bruising over the compartment; compare both limbs.



Swelling & contour

Visible fullness or a tense, bulging muscle belly suggests raised compartment volume.



Posture & gait

Antalgic gait, foot-drop or a guarded limb; observe before and (for CECS) after exertion.



Functional capacity

Whether the client can weight-bear and move the ankle/toes through full range.



Palpation



What you are feeling for

- Compartment tension — firmness or a tense, 'wood-like' quality
- Tenderness over the whole muscle belly, not just one point
- Temperature differences compared with the other limb
- Distal pulses and capillary refill as a circulation check
- Skin texture, swelling and any local warmth



Palpation caution

A tense, exquisitely tender, 'wood-hard' compartment in a client with escalating pain is a red flag for acute compartment syndrome.

Do not apply pressure, deep work, friction or stretch to a suspected acute compartment. Stop the assessment and refer for emergency evaluation.



ASSESSMENT • OBJECTIVE

Range of Motion Testing

AF

Active free

Client moves the joint alone. Pain, limited range or weakness may appear, especially after exertion in CECS.

PR

Passive relaxed

Therapist moves the joint. Pain on passive STRETCH of the compartment's muscles is a classic acute warning sign.

AR

Active resisted

Tests muscle strength. Weakness can reflect ischemic or nerve involvement within the compartment.

Watch for: pain on passive stretch combined with escalating rest pain — together these strongly suggest acute compartment syndrome.



ASSESSMENT • MEDICAL

Medical Diagnostics



Intracompartmental pressure

A needle manometer measures pressure directly. Sustained elevation, or a small gap between compartment and diastolic pressure, confirms the diagnosis.



Exercise provocation testing

For CECS, pressure is measured before and after the provoking exercise to capture the transient rise.



Imaging & vascular studies

MRI, ultrasound or vascular tests help exclude stress fracture, DVT and arterial entrapment.



Clinical diagnosis

Acute CS is diagnosed clinically and treated urgently — investigations must not delay surgery.



STOP & REFER IMMEDIATELY



Pain out of proportion that keeps escalating and is not relieved by rest



A tense, firm, 'wood-hard' compartment that is exquisitely tender



Pain dramatically increased by passive stretch of the muscles



Progressive numbness, tingling or weakness in the limb



Recent fracture, crush injury, surgery or a tight cast



Pale, cool, or pulseless limb (late signs — do not wait for these)



CONTRAINDICATIONS

Acute CS — Absolute Contraindication



Never treat

Suspected acute compartment syndrome is an absolute contraindication to massage therapy. There is no scenario in which hands-on treatment is appropriate.



Pressure & heat worsen it

Compression, deep work and heat all increase compartment volume or pressure.



Delay costs the limb

Any time spent on massage delays the surgery the limb actually needs.



Your role is referral

Recognise, reassure, and direct the client to emergency care without delay.



CONTRAINDICATIONS

Chronic CS — Cautions & Local Limits

CECS is not an emergency, but treatment is supportive and proceeds only after medical diagnosis. Observe these cautions:



Refer for diagnosis first

Confirm CECS (and exclude DVT, stress fracture, vascular causes) before any vigorous work.



Avoid deep work during a flare

Do not perform deep or sustained pressure on an acutely symptomatic, tense compartment.



Cautious heat

Avoid aggressive heat over a symptomatic compartment; it can increase local swelling.



Monitor neuro symptoms

If numbness, weakness or escalating pain appear, stop and re-screen for the acute form.



Respect post-exertion timing

The compartment is most reactive right after exercise — adjust intensity accordingly.



Stay within tolerance

Work to comfortable tolerance; treatment supports, but cannot resolve, the structural issue.



PART THREE

Massage cannot reverse the structural compliance problem — but it can ease associated muscle tension, support recovery, and improve the client's comfort and function.



Treatment Goals & Set-Up



Treatment goals

- Reduce tension in the affected and surrounding muscles
- Address compensating muscles and altered gait patterns
- Improve tissue mobility and general circulation
- Support recovery between training sessions
- Educate on load management and self-care



Positioning & timing

- Comfortable prone or supine with the leg supported
- Avoid sustained compression of a symptomatic compartment
- Treat outside of acute post-exertion flare where possible
- Keep the limb at a neutral, well-supported position
- Re-screen circulation and neuro status before deep work



TREATMENT • TECHNIQUES

Massage Techniques



Warming & effleurage

Begin superficially to warm tissue, assess tone and improve circulation before deeper work.



Petrissage & kneading

Address general tension in the calf and surrounding muscles within comfortable tolerance.



Trigger-point release

Treat trigger points in the affected and compensating muscles to reduce referred pain.



Myofascial techniques

Gentle fascial work to improve tissue glide and mobility around the compartment.



Treat the kinetic chain

Include hip, thigh, foot and opposite limb to address gait-related overload.



Gentle, graded depth

Progress depth gradually; never force through guarding or provoke neuro symptoms.



Fascial & Mobility Work

Why fascia?

Because the fascial sheath is the unyielding wall of the compartment, improving the glide and pliability of surrounding fascia and managing tissue tension is a logical focus for supportive care.

Important: manual work does not surgically release the fascia — set realistic expectations with the client.



Slow fascial spreading

Gentle, sustained techniques to encourage tissue glide around the compartment.



Cross-fibre & skin rolling

Mobilise superficial fascia and reduce adherence in surrounding tissue.



Joint & muscle mobility

Restore ankle, foot and knee mobility to reduce mechanical overload.



TREATMENT • ADJUNCTS

Hydrotherapy Applications



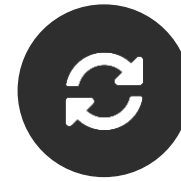
Cool after exertion

Cool applications after the provoking activity may help limit post-exercise swelling and discomfort.



Gentle warmth between flares

Mild heat away from a symptomatic flare can relax surrounding muscle and aid general circulation.



Contrast (with caution)

Alternating temperatures can stimulate local circulation — use conservatively and monitor response.

Never apply heat to a suspected acute compartment or an acutely swollen, tense compartment — heat increases volume and pressure.



TREATMENT · SELF-CARE

Remedial Exercise & Stretching



Gentle stretching

Stretch the affected and antagonist muscle groups within comfort to maintain mobility.



Mobility & ROM

Ankle and foot mobility work to support normal mechanics and tissue glide.



Graded loading

Reintroduce activity progressively, respecting symptom thresholds and recovery time.



Gait & technique

Address running form, footwear and surface in collaboration with the client's coach or therapist.



Strength balance

Balance strength around the ankle and lower leg to distribute load more evenly.



Rest & recovery

Plan adequate recovery between sessions; encourage early reporting of warning symptoms.



Client Self-Care & Home Advice



Encourage the client to:

- Modify training load and progress gradually
- Warm up, cool down and stretch consistently
- Apply cool after provoking exercise as advised
- Review footwear, surfaces and running technique
- Report any change in pain or new numbness early



Teach the warning signs

Make sure the client knows that pain which does not ease with rest, keeps worsening, or comes with spreading numbness is NOT normal and needs urgent medical assessment.

Empowering self-monitoring is itself a safety intervention — it helps the client catch a transition to the acute form early.



OUTCOMES

Prognosis & Expected Outcomes



Acute (ACS)

- Excellent if decompressed early enough
- Delayed treatment risks permanent deficit
- Outcome depends almost entirely on speed
- Possible contracture, weakness or nerve loss if late



Chronic (CECS)

- Generally good; not limb-threatening
- Many improve with activity modification
- Massage supports comfort and recovery
- Refractory cases may need surgical fasciotomy



Clinical Scenario



The presentation

A 26-year-old runner reports aching tightness in the front of both shins that begins about 15 minutes into every run, becomes severe enough to force a walk, and disappears within 10 minutes of stopping. No trauma. Symptoms began after doubling weekly mileage.



Most likely

Anterior CECS — predictable, exertional, bilateral, relieved by rest, with a recent training spike.



Action

Refer for medical diagnosis to confirm and to exclude stress fracture and vascular causes.



Massage plan

Supportive work on the anterior/lateral leg and kinetic chain; education on graded loading.



Safety check

If pain ever fails to settle with rest or numbness escalates — re-screen for the acute form.



SUMMARY

Key Takeaways



Fixed container, rising pressure

Compartment syndrome is increased pressure in a non-expandable fascial space that chokes off perfusion.



Acute is an emergency

Sudden, escalating, rest-resistant pain after trauma — an absolute contraindication; refer to 911.



Chronic is exertional & reversible

Predictable activity-related pain that resolves with rest — manageable, but diagnose first.



Assessment screens for red flags

History and exam separate the dangerous acute form from the supportable chronic one.



Massage supports, not cures CECS

Ease associated tension, treat the kinetic chain, and educate on load and warning signs.



When in doubt, refer

Missing acute compartment syndrome can cost a limb — err firmly on the side of caution.



Thank you — let's discuss any cases or questions.

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