An Alternative Solution for Diagnosing and Monitoring Acute Compartment Syndrome

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Introduction

There are approximately 850,000 admissions to UK hospitals per year relating to broken legs (Mills & Simpson 2013). Broken legs can be treated in a variety of different ways depending of the nature and severity of the fracture, which often ultimately leads to a full recovery with proper treatment. However, every broken leg fracture comes with risk of complications following treatment; the most common being acute Compartment Syndrome.

Acute compartment syndrome is when internal bleeding occurs in one of the muscle compartments, which leads to a build in intracompartment pressure as the surrounding fascia is non-yielding. The build up in pressure eventually restricts blood supply to the muscle tissue, causing ischaemia and loss in nerve function (Auerbach 2012). Irreversible damage can occur after 6 hours of treatment. This is why early diagnosis of this condition is so important, as earlier treatment gives the patient a better chance of restoring normal lower leg function. If left untreated then permanent damage can occur which can lead to leg amputation and even death in extreme cases. The aim of this project was to explore different avenues when it comes to diagnosing and monitoring acute compartment syndrome in the lower leg.

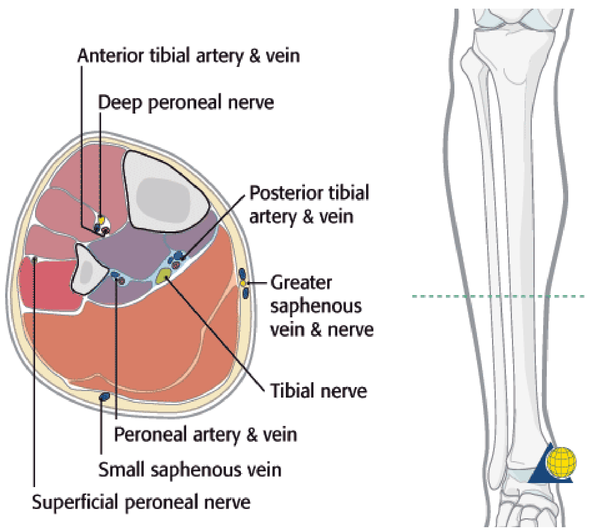

Figure 1 – Anatomical Schematic showing how the calf is separated into four main muscle compartments
source: www.aofoundation.org

Research – Current Methods

Current diagnostics include a clinical overview, which consists of a clinician assessing the patient's symptoms – the most obvious being severe pain that is out of proportion to their recent treatment. However this method is considered too subjective and can easily lead to a misdiagnosis which can lead to unnecessary emergency fasciotomies which is ≈ £4000 a procedure or irreversible muscle damage as ACS wasn't diagnosed early enough.

Diagnosis is also confirmed via inserting an intracompartment pressure needle into the compartment reading into the compartment with a reading above 30mmHg indicating compartment syndrome (Von Keudell et al. 2015). However there are too many factors that can compromise these readings such as incorrect placement of the needle. There were also reports of malfunctions regarding invasive methods on the FDA MAUDE complaints database. Therefore there is a clear need for an alternative solution that explores non-invasive methods.

PDS – Some Sample Requirements
Can detect acute compartment syndrome
Early Diagnosis
Hand-held and portable
Must be Compatible for Intramedullary Nail (most commonly linked with ACS)
Should consider use for other fixation methods
Can't provide subjective data
Non-invasive
Re-usable up to at least 25 uses
Storage temp between 10 and 40 C
Operating temp between 10 and 40 C
Less than 250g
Alert user at low battery and 0 battery
RRP of less than £4000 pu

Concept Selection Process

A scoring based system identified two front runners:

- A device that implements Near Infrared Spectroscopy (NIRS) to measure oxygen saturation levels in muscle tissue. As ischaemia leads to a reduction in oxygenated haemoglobin ACS can be detected early. NIRS has already been used in other clinical settings such as muscle activity monitoring in athletes.
- A device that measures the relative hardness of each muscle compartment with a particular hardness threshold indicating ACS.

The NIRS based concept was identified as the best solution as muscle hardness may only be detected following irreversible muscle damage. The final concept would consist of four non invasive probes that link to a main device body – alerting clinicians once oxygen saturation levels go below a critical level.

Conclusions and Recommendations

Use of NIRS to diagnose and monitor ACS has the potential to eradicate the use of invasive and subjective methods to diagnose compartment syndrome at an early stage of development with less risk of misdiagnosis – making it more fit for purpose and cost efficient due to less surgical and litigation costs.

However clinical studies are required to verify its feasibility for this use. These include:
- Testing required to determine the StO2 levels that are determined "normal" and "dangerous" – is there a significant difference?
- Investment required to get better understanding on variables that effect results – subcutaneous fat & skin pigments

References
Mills LA, Simpson AHRW. The relative incidence of fracture non-union in the Scottish population (5.17 million): a 5-year epidemiological study. 2013, BMJ Open
Auerbach, P.S., 2012. *Wilderness medicine*, Elsevier/Mosby.
Von Keudell, A.G. et al., 2015. *Emergency surgery 3 Diagnosis and treatment of acute extremity compartment syndrome*