Case report

A silent compartment syndrome following elective minimally invasive mitral valve repair

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SUMMARY

A 63-year-old male with severe mitral valve regurgitation underwent an elective minimally invasive mitral valve repair. Peripheral cannulation of the right femoral vein and artery was performed with a total cardiopulmonary bypass time of 268 min. There were no intraoperative complications. 12 hours postoperatively the patient reported mild pain in the right lower leg with a subjective decrease in sensation. Compartmental pressures were significantly raised. The patient underwent lower leg fasciotomies, which revealed bulging compartments confirming the diagnosis of an evolving compartment syndrome (CS). This rare case demonstrates the highly variable aetiology, pathophysiology and presenting symptoms of CS. Clinicians in any specialty should consider this diagnosis if there is a possibility of local vascular compromise secondary to an intervention/treatment. This diagnosis is not exclusive to patients with trauma and as such clinicians should have a high index of suspicion for this potentially devastating condition.

BACKGROUND

The classical teaching of pain out of proportion to the injury and pain on passive stretch is synonymous with a suspected diagnosis of compartment syndrome (CS). This typically occurs with high energy trauma. However, CS should form part of the differential diagnosis in cases of possible ischaemic-reperfusion secondary to an intervention without a history of reported trauma. This is an important consideration for all clinicians, to ensure that an accurate diagnosis can be made in cases not typically associated with the development of CS.

CASE PRESENTATION**Patient history**

A 63-year-old man was admitted for an elective minimally invasive mitral valve repair. His symptoms were classed as NYHA III (New York Heart Association Functional Classification). Preoperative transoesophageal echocardiography identified significant mitral regurgitation due to an A2 flail segment of the mitral valve. Pulmonary artery pressures were slightly elevated at 43/15 mm Hg. The only other significant feature was that he had an elevated body mass index (BMI) with a preoperative weight of 102 kg. The preoperative European System for Cardiac Operative Risk Evaluation (EuroScore) which calculates the risk of death after cardiac surgery was 5, indicating a moderate risk of mortality.

Surgical procedure

The procedure was performed under general anaesthetic. Access to the mitral valve was via a minimally invasive right mini-thoracotomy. Cardiopulmonary bypass (CPB) was established via peripheral cannulation of the right femoral artery and vein. The total CPB time was 268 min. As is routine practice for this type of procedure the right leg was not under the influence of intermittent pneumatic compression (IPC ie: Flowtron therapy) nor was distal limb perfusion monitored intraoperatively. No intraoperative complications were encountered.

Postoperative course

In the immediate postoperative phase, the patient remained intubated for approximately 12 hours and followed a normal course of recovery on the cardiac intensive care unit (CICU). Patient-controlled analgesia (PCA) was prescribed for postoperative pain relief. Following extubation, he was confined to bed rest for recovery. The patient reported a mild pain in the right lower leg but no other associated symptoms. No boluses of pain relief were administered at this stage. On the first day, postoperatively, the patient was instructed to begin mobilisation with support from the physiotherapy team. Again, the patient reported a mild pain in the right lower leg with the addition of a decrease in sensation. This was present while standing and at rest. At the time of the initial orthopaedic review, the patient was sat by the bedside, comfortable at rest. Only one bolus of PCA had been administered over the previous 12-hour period. Clinical examination revealed a swollen calf with mild pain on palpation and passive dorsiflexion. Reduced sensation was noted in the saphenous and sural nerve distributions. A measurement of calf diameter was performed to allow comparison on subsequent review. One hour later, the clinical examination revealed no worsening of pain or paraesthesia and no further PCA boluses had been administered. The only clinical change was an increase in the diameter of the lower leg. Peripheral pulses remained palpable, the foot was warm to touch and the distal capillary refill time was similar to the contralateral side. A CT angiogram was performed to rule out the possibility of arterial extravasation and thrombus formation in view of the lack of objective clinical findings and recent operative procedure. Following a negative scan result and a static clinical picture on subsequent review, compartment pressures were measured confirming the diagnosis.

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INVESTIGATIONS

CT angiogram

Background of mild arteromatous disease. Patent arterial supply with normal three vessel run off. No active arterial extravasation. Expanded right soleus muscle. No focal fluid collection seen to rule out deep vein thrombosis (DVT).

Compartment pressure monitoring

Anterior compartment 40 mm Hg, lateral compartment 48 mm Hg, superficial posterior compartment 41 mm Hg, deep posterior compartment 81 mm Hg.

Note: A normal compartment pressure is between 0 and 8 mm Hg. A CS is indicated when intra-compartmental pressures are greater than 30 mm Hg or within 10–30 mm Hg of a patient's diastolic blood pressure.

DIFFERENTIAL DIAGNOSIS

- ▶ DVT post-prolonged period of immobility during surgery.
- ▶ Arterial thrombus post-restoration of circulation.
- ▶ Crush injury secondary to prolonged immobility during surgery and lack of IPC.
- ▶ CS secondary to reperfusion injury.
- ▶ Ruptured bakers cyst.

TREATMENT

Following the elevated compartment pressures, a working diagnosis of CS was made. The patient was taken to theatre as a Category 1 (Immediate) National Confidential Enquiry into Patient Outcome and Death (NCEPOD) case. Full-length lower leg fasciotomies were performed via two incisions. All four compartments were decompressed. There was bulging of the muscle in all four compartments confirming the diagnosis. No ischaemic or necrotic muscle was found. Following extensive irrigation, the wounds were left open, covered with saline soaked gauze and bandaged. The patient returned to CICU for close observational monitoring. Following extubation and review of the patient's symptoms, the pain had almost completely resolved and full sensation was restored to the leg within an hour of the procedure being performed. The patient underwent a second look of the lower leg 48 hours later. The muscles in all four compartments appeared healthy and contractile. The wounds were primarily closed. Despite the complication of a lower limb CS requiring emergency fasciotomy, the patient was discharged within 6 days of admission. The authors of this article believe that despite the additional surgical interventions required, the patient's hospital stay was not significantly prolonged.

OUTCOME AND FOLLOW-UP

The patient was discharged from CICU 3 days later. No further complications from the surgery or the lower leg fasciotomies were noted.

DISCUSSION

The reported case was made challenging by the vague presentation of symptoms on a background of minimally invasive cardiac surgery for which lower limb CS is an extremely rare complication. Under normal circumstances, the examination findings of disproportionate pain and pain on passive stretch would be strongly suggestive of a diagnosis of CS negating the need for any further investigation. However, due to the absence of significant positive findings, alternative diagnoses were considered. A CT scan was performed to rule out the complication of arterial extravasation (secondary to femoral artery cannulation) which

Box 1 Signs and symptoms of compartment syndrome

- ▶ Pain (spontaneous and/or disproportionate to the injury)
- ▶ Pain on passive stretch
- ▶ Swollen/tense compartment ('woody-like' feel)
- ▶ Rapid progression of symptoms over a short period of time
- ▶ Paraesthesia (late sign)
- ▶ Loss of palpable pulses (late sign)
- ▶ Paralysis (late sign)

may have required a return to theatre for vascular repair as well as the possibility of a DVT which may have accounted for the swelling and pain in the lower limb. While compartmental pressures are not required in a suspected diagnosis of CS they were only measured in this case, due to a lack of progressing symptoms and negative imaging.

CS is a clinical diagnosis and its signs and symptoms are well documented (box 1). Particularly in cardiothoracic cases involving vascular intervention, clinicians should maintain a high index of suspicion in patients who have had an interrupted arterial supply lasting more than 4–6 hours.¹ It should be noted that certain signs are a late finding and if present may be an indication that irreparable damage may have already occurred.

Due to the rapid progression of symptoms that can arise over a period of hours the need for serial clinical review is essential. When the diagnosis is unclear or when dealing with an intubated/unconscious patient, compartment pressure monitoring can be considered. A delta-P value (diastolic pressure minus the intra-compartmental pressure) less than or equal to 30 mm Hg or an absolute intra-compartmental pressure of 30 mm Hg or more indicates the presence of a CS. However as discussed earlier, CS is a clinical diagnosis and if suspected, further investigations including blood tests and compartment pressure monitoring should not delay the need for urgent fasciotomy. Blood tests may show a significantly elevated creatine phosphokinase secondary to severe muscle damage and ischaemia. However, this is unlikely to be present in the early stages of CS and if present may identify the presence of a delayed or missed CS.

Negative fasciotomies carry the risk of infection and a potential need for subsequent skin grafting.² Clinical evidence of a developing CS must therefore be present to minimise unnecessary patient morbidity. This is particularly true in the postoperative phase when alternative diagnoses are possible. Similarly, fasciotomies performed in physiologically stable patients, with a missed or significantly delayed diagnosis of CS are also controversial. The concern is the potential for widespread systemic effects due to the reperfusion of prolonged ischaemic tissue which may be necrotic and infected. This can result in the development of a systemic inflammatory response and acute respiratory distress syndrome, metabolic acidosis and renal failure.³ Therefore, prior to performing fasciotomies in these cases, the benefit of salvaging remaining muscle that is threatened but viable, must be balanced against the risk of a widespread systemic insult and possible death.⁴

Ischaemic reperfusion (IR) injury occurs secondary to acute inflammation. This is in response to tissues being re-perfused following a prolonged period of ischaemia. Reactive oxygen species are thought to be the main pathophysiological factor responsible for IR-related skeletal damage resulting in lipid peroxidation and neutrophil activation.⁵ Lipid peroxidation causes cell membrane damage and is the mechanism responsible for uncontrolled membrane permeability. Activated neutrophils

release intracellular granules resulting in further lipid peroxidation, neutrophil adherence and leakage as well as endothelial dysfunction.⁶ As a result of these mechanisms, the ensuing oedema causes an increase in swelling and pain as the pressure within the closed osseofascial compartments rise. Progressive compression of the capillaries occurs resulting in ischaemia and irreversible necrosis of the muscle and nerves.

CS of the lower leg is a rare complication of minimally invasive cardiac surgery. Lamelas *et al* conducted a single-centre retrospective study involving 2645 patients in whom minimally invasive valve surgery was performed. Of the 2400 patients who underwent femoral artery cannulation only two cases developed a lower leg CS. Both required fasciotomies.⁷

Tarui *et al* identified different risk factors in the prediction of patients with leg ischaemia undergoing minimally invasive cardiac surgery with single femoral artery cannulation. The authors conducted a retrospective study involving 162 patients and determined that BMI, cannula size and operation time were significant risk factors for the development of leg ischaemia.⁸

Orrapin *et al* conducted a prospective study involving 22 patients presenting with non-traumatic acute limb ischaemia of

the lower leg to identify predictive factors for the development of post-ischaemic CS. Of the five patients who developed a CS, predictive factors included inadequate backflow (poor collateral circulation to distal arteries), a high serum creatine kinase (marker of tissue damage), a positive fluid balance (inducing extravasation of intracellular and intravascular fluid into the extracellular space) and an advanced stage acute limb ischaemia (advanced peripheral artery disease).⁹

Contributors CG: clinician directly involved in review of the patient and workup to surgery. Responsible for decision to proceed to case report, write-up and structure of the article, data acquisition and final proofing. JP: consultant directly involved in the case from presentation to surgery. Assisted in article structure and write up. Critically appraised the article and provided feedback on how to restructure when required. IA: consultant who performed the initial elective procedure. Involved in supplying information relevant to the procedure as well as critical appraisal of the Cardiothoracic aspects of the case. Involved in critical appraisal and final proofing. All authors were actively involved in drafting and critical appraisal of the final article.

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Learning points

- The classical signs of pain out of proportion to the injury and pain on passive stretch may not be present in a developing compartment syndrome (CS). Equally, the syndrome can occur without a history of high energy trauma.
- CS should be considered in cases with an interrupted arterial supply lasting more than 4–6 hours.
- Risk factors for leg ischaemia in minimally invasive cardiac surgery include high body mass index, large cannula size for femoral artery cannulation and a prolonged operative time.
- Risk factors for the development of CS in non-traumatic limb ischaemia include inadequate backflow, high serum creatine kinase, positive fluid balance and an advanced stage acute limb ischaemia.
- If clinicians are suspicious of a diagnosis of CS, the relevant teams should be notified immediately for assessment of the need for urgent fasciotomy.

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