Compartment Syndrome as a Complication of the Lithotomy Position

I Karmaniolou, C Staikou

ABSTRACT

Compartment syndrome is a rare but serious complication of surgical procedures performed in the lithotomy position. Preventive measures include careful placement of the patient's legs and limited elevation. Early diagnosis is based on vigilance and close postoperative follow-up, especially after prolonged surgery. Finally, postoperative analgesia does not delay the diagnosis, if the patient's needs are assessed carefully.

Keywords: Compartment pressure, compartment syndrome, hypoperfusion, lithotomy position

El Síndrome de Compartimiento como Complicación de la Posición de Litotomía

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RESUMEN

El síndrome de compartimiento es una complicación rara pero seria de los procedimientos quirúrgicos realizados en posición de litotomía. Las medidas preventivas incluyen colocación cuidadosa de las piernas de la paciente y elevación limitada. El diagnóstico temprano se basa en la vigilancia y el seguimiento cercano post-operatorio, especialmente luego de una cirugía prolongada. Finalmente, la analgesia post-operatoria no demora el diagnóstico, si las necesidades de la paciente son evaluadas con cuidado.

Palabras claves: Presión de compartimiento, síndrome de compartimiento, hipoperfusión, posición de litotomía

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INTRODUCTION

Compartment syndrome develops when increased pressure within a closed anatomical space compromises the blood circulation and consequently impairs the function of the tissues enclosed (1). Compartment syndrome, as a complication of the lithotomy position, was first recognized in 1979 by Leff and Shapiro in a male patient after urethroplasty lasting 6.5 hours (2). Since then, cases have been described after gynaecological, urological and colorectal surgeries (3−8) but the syndrome was under-reported (7, 9). In long lasting procedures, such as cystectomies, the incidence of compartment syndrome was found to be 1: 500 cases (9). It usually develops within 15 hours, but may occur up to 24 hours postoperatively (8).

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Compartment syndrome due to the lithotomy position

Mechanisms and risk factors

Compartment syndrome during the lithotomy position may develop due to reduction of the perfusion pressure of the compartment, *ie* the difference between the mean blood pressure and compartment pressure (10). Normally, perfusion pressure is above 70−80 mm Hg and compartment pressure is less than 10−12 mm Hg (10). In the lithotomy position, pressure is exerted over the popliteal or femoral vessels, thus obstructing venous return (4, 11−13). Also, direct pressure over the soft tissues of the limb, due to placement, can cause tissue ischaemia or even necrosis (10).

The lithotomy position impairs the perfusion of the lower extremities resulting in decreased oxygen saturation in their muscles (4). Leg elevation above the level of the heart reduces the mean arterial pressure in the toes by 0.8 mmHg/cm (4, 8, 14). However, Horgan *et al* argue that only the combination of lithotomy with Trendelenburg position impairs the blood flow to the limb, while a 45° knee bending lithotomy position does not affect leg perfusion (15). However, other studies have shown that blood flow to the limbs is reduced in the lithotomy position, with a further reduction when combined with the Trendelen-burg position (6, 16, 17). It was also found that after a pro-longed lithotomy position, the compartment pressure can reach up to 70 mmHg and is further increased if Trendelen-burg position is added (11).

The duration of the lithotomy position is of great importance (16). The majority of reports are in operations lasting more than four hours (9, 17, 18). This is consistent with the finding that the compartment pressure reaches a maximum after about five hours (4). The pressure in the anterior compartment of the tibia during the lithotomy position was found to reach 30 mmHg in five hours (12).

Also, the placement of the patient's legs is very important. Excessive passive dorsiflexion at the ankle may increase the pressure in all four compartments of the limb, while the devices used for leg support may exert varying degrees of direct pressure on the muscles (4, 14, 19). Additionally, Pfeffer *et al* indicate that changes in compartment pressure during the lithotomy position depend on the method of leg support (13). It is found that the compartment pressure decreases when the legs are elevated by ankle sling supports, while it increases when calf supports or boot-like devices are used (13, 16).

Devices for deep vein thrombosis (DVT) prophylaxis may also contribute to the development of the compartment syndrome. Elastic stockings may exercise a pressure of 25 mm Hg or greater, although it is not all carried to the muscles (10). It has been found that the continuous external pressure as exerted by elastic stockings increases the compartment pressure (13). On the other hand, pneumatic calf compression devices exert a pressure of 40 mm Hg for 12 seconds each minute and have been implicated in the development of the syndrome (20, 21). Compartment syndrome has also been a direct complication of malfunctioning devices remaining inflated throughout surgery (8). Nevertheless, in healthy volunteers, it has been found that intermittent external pressure reduces the compartment pressure probably by improving venous return (13).

Intra-operative adverse events and patient related factors have also been associated with compartment syndrome during the lithotomy position. Systemic hypoperfusion caused by intra-operative haemorrhage, hypotension or hypothermia favours the neuromuscular damage at lower compartmental pressures (9, 19, 22, 23). Also, in patients with peripheral vascular disease, the already impaired perfusion of their extremities is further affected by leg elevation (9, 14). Other risk factors are male gender (3, 20) because of the increased muscle mass and Body Mass Index (BMI) above 25 kg/m^2 (4, 20).

When the compartment pressure increases, the local blood flow is obstructed resulting in hypoxia and eventually cell death and loss of function of the enclosed nerves and muscles (4, 23). Initially, venous return is prevented, but consequently arterial blood flow is also compromised (3, 8). Ischaemia and tissue hypoxia lead to anaerobic metabolism with lactic acid production and depletion of cellular ATP (4). The function of ATP-dependent K^+/Na^+ pump in the cell membrane is impaired and the integrity of the endothelium is disrupted resulting in interstitial oedema, which further increases the intra-compartment pressure (4, 19, 20, 24). Oxygen free radicals cause more damage to the endothelium and thus more oedema (4, 11) while the intrinsic coagulation cascade, neutrophils and complement, are activated (4). Muscle cell destruction leads to myoglobinaemia and myoglobinuria with subsequent metabolic acidosis, hyperkalaemia and renal failure (3−5). Lungs may also be affected due to white blood cell activation, thus aggravating hypoxia (4). Finally, local inflammation becomes systemic and ultimately sepsis and progressive multiorgan failure may lead to death up to 15% of patients (25).

Clinical manifestations of the syndrome are pain in the affected extremity, oedema, high sensitivity to external pressure (10) and intolerance to passive movements (4, 21, 22). Late signs include absence of distal pulses, paraesthesia and paresis (11). Symptoms and signs are generally not reliable for the diagnosis, which is even more difficult in the anaesthetised patient (24). Postoperatively, difficulties with pain control might be the only sign (24). Differential diagnosis includes DVT, arterial injury and peripheral nerve damage (19).

Laboratory findings indicative of severe muscle damage, such as increased values of creatinine phosphokinase and myoglobin can help to confirm the diagnosis, but are not useful for early diagnosis (10). Continuous measurement of intra-compartment pressure (catheter-transducer system) provides a reliable monitoring (10). Technical difficulties include the precision in transducer placement and catheter obstruction by clots or tissue (10, 24). It has been suggested that MRI can contribute to diagnosis (26). However, Kostler *et al* argue that MRI does not show tissue changes early before neurological damage (10). Near-Infrared Spectroscopy (NIRS) is a promising, non-invasive diagnostic method which provides direct and continuous measurement of tissue hypoxia, using a principle similar to that of the pulse oximeter (24, 27).

The role of postoperative analgesia in diagnosis

Postoperative analgesia could potentially obscure the diagnosis of compartment syndrome. Mar *et al* reported that in three paediatric patients, epidurally administered local anaesthetic, producing sensory and motor block, delayed the diagnosis of compartment syndrome (24). On the contrary, Montgomery *et al* reported that in two urological patients with compartment syndrome, postoperative epidural analgesia based on opioids did not delay the diagnosis, since the leg pain was not relieved but became progressively worse (19). The drug and dosage used for epidural analgesia is mandatory. Epidurally administered opioids and low concentration local anaesthetics, such as ropivacaine 0.2%, are suitable for postoperative analgesia as they produce adequate analgesia without impairment of mobility or masking of compartment syndrome symptoms (24).

Regarding femoral nerve block, there are no studies relating it with a delay in compartment syndrome diagnosis in patients with femoral bone fracture (28). However, delayed diagnosis has been reported in a patient with a ‘‘3 in 1’’ block (femoral, obdurator and lateral femoral cutaneous nerve) for postoperative analgesia by the use of 0.5% bupivacaine (29).

Finally, Patient Controlled Analgesia (PCA) with morphine has delayed the diagnosis of postoperative compartment syndrome in six orthopaedic patients (24). It has been suggested that regular administration of bolus morphine instead of PCA ensure close and repetitive assessment of patients, so it is less likely that the symptoms of compartment syndrome will be left unnoticed (30, 31).

The key point of postoperative compartment syndrome is the failure of usual analgesic techniques to relieve the leg pain. After a surgery performed in the lithotomy position and adequate doses of analgesics, patient's complains for severe and persistent leg pain should always be carefully evaluated.

Prophylactic measures

It has been suggested that during the lithotomy position, the legs should be positioned slightly below the level of the left atrium (32), or that they should be lowered every two hours (22), or that the lithotomy position should not be maintained throughout surgery, in order to reduce the period of limb hypoperfusion (17). Patient's legs should be placed carefully in order to avoid direct pressure on the muscles. Also, sling support at the ankle is considered safer than other methods used for leg support (13, 16).

The suggestions about the use of devices for DVT prophylaxis are contradictory. Lachmann *et al* suggest that elastic stockings should not be used in patients placed in the lithotomy position (33), while Wilkinson *et al* suggest that calf compression devices should be kept in the lithotomy position, especially in oncological surgery which is associated with a high risk of DVT and pulmonary embolism (34). We consider that each patient's risk factors should be assessed carefully and if devices for DVT prophylaxis are used, they should be used cautiously.

Treatment

The treatment of choice is fasciotomy, which reduces intra-compartment pressure and restores blood flow. It should be performed urgently at perfusion pressure ≤ 30 mmHg (10). Additional measures include placement of the affected limb at the level of the heart and intravenous administration of fluids and mannitol for blood flow improvement and renal failure prophylaxis (4, 10, 25). Also, Vitamin C has been studied in animal models with encouraging results (35).

CONCLUSIONS

Compartment syndrome is a rare, but serious complication of the lithotomy position. Preventive measures include careful placement and limited elevation or periodical lowering of the patients' legs. Postoperative vigilance and careful assessment of patient's pain and analgesic needs are mandatory for early diagnosis of the syndrome, especially after prolonged surgery and in high risk patients.

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