Case report

A severe complication following intraosseous infusion used during resuscitation of a child

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A R T I C L E   I N F O
Article history:
Accepted 12 May 2011

1. Case report

An eleven year old boy who had previously been fit and well collapsed in a public place. Bystanders trained in basic life support started resuscitation and the patient was transported to a paediatric Accident and Emergency department by ambulance.

On arrival in the resuscitation room the patient was noted to be in ventricular fibrillation with no palpable peripheral pulses. A defibrillator delivered one shock, which resulted in sinus rhythm being restored. The patient was noted to have poor peripheral perfusion with cool peripheries and attempts at obtaining vascular access were at first unsuccessful. An intraosseous needle (15 G EZ-IO) was then inserted through the superficial border of the right tibia using the power driver technique, it was noted that insertion was routine with no complications and fluid flowed easily with no resistance. The intraosseous needle was used to infuse an immediate bolus of 500 ml of normal saline followed by adrenaline at a rate of 1 mcg/kg/min. At this stage both central and peripheral vascular access were successfully obtained.

The patient was then transferred to the Paediatric Intensive Care Unit (PICU) for ongoing care. During the next 24 h the intraosseous needle was used to infuse adrenaline, calcium and potassium.

On the day after admission it was noted by the nursing staff that the there was swelling and echymosis around the intraosseous needle insertion site. The infusions were immediately stopped and an orthopaedic opinion was requested by the PICU staff.

The orthopaedic surgeon who reviewed the patient noted that the right lower leg was swollen on inspection, firm to palpation and that the peripheral pulses were weak although the capillary refill was less than 2 s. There was also restricted dorsiflexion of the ankle joint. A provisional diagnosis of compartment syndrome was made and immediate compartment pressure monitoring1 was undertaken. The initial compartment pressure recording was 55 mmHg and the patients diastolic blood pressure was 50 mmHg giving a difference in pressure (ΔP) of −5 mmHg supporting a diagnosis of compartment syndrome.

Four compartment fasciotomies were then undertaken through a routine two incision technique. As the patient's cardiovascular status was too unstable for transfer to an operating theatre this procedure was carried out in the paediatric intensive care unit. The findings of the procedure were: globally tight muscles, the muscles in the anterior compartment appeared dark with little bleeding and diminished contractility. The muscles in the other three compartments appeared tight but otherwise unremarkable. It was noted that after fasciotomies dorsiflexion of the ankle improved. The fasciotomies were left open and the leg was dressed and the patient continued to be supported in the PICU.

Seventy-two hours after admission and when cardiac status allowed, the patient underwent a formal second look and debridement under joint care of the orthopaedic and plastic surgical teams. It was evident that there was full thickness skin loss, subcutaneous tissue loss and bone necrosis of the proximal tibia, surrounding an area corresponding to the entry point of the cannula. The soft tissue injury was in keeping with a chemical injury with evidence of an extravasation injury, spreading from the insertion point of the cannula in the proximal tibia radially and in an outward direction from deep to superficial. Examination of the anterior compartment revealed that 80% of the proximal tibialis anterior muscle was necrotic with only the distal 20% of the muscle remaining viable. 100% of the extensor digitorum muscle was necrotic. The anterior tibial neurovascular bundle was intact. In the deep posterior compartment the proximal muscle bellies of tibialis posterior and flexor digitorum longus were necrotic. In the superficial posterior compartment the soleus muscle was necrotic in its proximal section (corresponding to the area of tibia affected). The heads of gastrocnemius were viable but there was evidence of chemical injury on the deep surface of this muscle, again corresponding to the area where extravasation would have occurred. The posterior tibial artery and vein were pulsatile. The contents of lateral compartments appeared normal. All necrotic muscle and skin were excised. Thorough washout was undertaken and the wounds were re-dressed and the patient was returned to the PICU.

Day six post-injury, the patient was returned to theatre for a third look, at this procedure further necrosis of the proximal skin...
was noted and further debridement was undertaken of the skin, along with the remaining 20% of tibialis anterior in the anterior compartment. A vacuum assisted closure (VAC) dressing was also applied at the end of this procedure.

A fourth review was undertaken 48 h later. The osteonecrosis of the proximal tibia was clearly demarked with no further progression (Fig. 1). In the anterior compartment only the distal tendon of tibialis anterior remained along with the anterior tibial neurovascular bundle. The lateral compartment was still intact. The remaining contents of the deep posterior compartment were as described before and viable. In the superficial posterior compartment the gastrocnemius muscle was viable, with no progression of injury, as was the distal half of the soleus muscle. The progression of tissue loss and injury therefore seemed to have halted.

Further investigation was undertaken to allow operative planning with respect to either reconstruction or amputation of the limb. The patient then underwent an MRI scan which confirmed osteonecrosis of the proximal tibia and a CT arteriogram demonstrated intact popliteal, peroneal, anterior tibial and posterior tibial arteries. Reconstruction with a latissimus dorsi free flap was planned with boney debridement as necessary. Unfortunately, the patient had a further cardiac episode at anaesthetic induction. The decision was made to do the shortest most appropriate procedure. The options were either above knee amputation or boney debridement/acute bone shortening and a medial gastrocnemius flap. The second option was chosen. A medial gastrocnemius flap was then used to cover the soft tissue defect over part of the anterior aspect of the proximal tibia leaving a 2 cm strip of exposed bone and periosteum (Figs. 2 and 3). Split skin grafts were used to cover the gastrocnemius flap and lateral fasciotomy wounds. At further inspection, to aid soft tissue coverage, two centimetres of proximal tibia were excised in the region of the osteonecrotic area using a transverse shortening osteotomy and this was held with an Hoffman external fixator (Stryker Ltd, Leeds, UK) (Figs. 4–6). The patient was fitted with an implanted cardiac defibrillator and after a period of in-patient rehabilitation was able to be discharged home. Unfortunately the osteotomy was complicated by an infected non-union (Figs. 7 and 8) and 11 months after the initial presentation the patient had to undergo debridement and application of a circular lizarov frame. Eighteen months after the initial presentation there are now signs...
of some bone bridging across the osteotomy site (Figs. 9 and 10). The infection appears to have resolved with treatment but bony healing is, however, far from complete and union may not be achieved. Further surgery with bone grafting and synthetic osteogenic products is being considered. The option of through-knee amputation to provide optimal functional outcome is being
discussed as foot and ankle function is poor and distal sensation patchy.

2. Discussion

The use of intraosseous needles and infusion is valuable in resuscitation of both paediatric and adult patients where there is difficulty in obtaining vascular access and immediate infusions of drugs and or fluids is required. Although potentially life saving, this technique is not without complications. At present there is no clear consensus from the literature regarding: the length of time an intraosseous needle should remain in place, the maximum rate or volume that should be infused through this route and what drugs should be avoided or be used in altered concentrations through this route.1–5 Musculoskeletal complications as a result of intraosseous infusions are rare and occur in less than one percent of patients.6 Reported complications include: compartment syndrome and resultant amputation,7–11 osteomyelitis12 and myonecrosis.13

We report a patient who had a severe complication as a result of intraosseous infusion, the cause of the complications is unclear and may be attributed to a combination of factors. One explanation is a direct pressure effect from extravasation of fluid into the soft tissues either from incorrect placement or from dislodgement of the catheter, however, the insertion of the needle was reported as being routine and there was no difficulty reported in infusing fluid through the needle.

Another explanation is that due to pressure from a high rate of infusion or as a consequence of a large total volume infused there could be secondary extravasation from the intraosseous canal into the soft tissues. An experimental study in dogs by Gunal et al.4 showed that even when the intraosseous needles were cemented in place correctly there was evidence of extravasation of fluid into the soft tissues which was shown fluoroscopically using radio-opaque dye. Infusion of greater than 350 ml led to an increase in measured compartment pressure which was proportional to the amount of fluid infused. In the case we describe, the intraosseous infusion was over a period of 24 h and included a 500 ml bolus of fluid and then on-going infusions. This may have contributed to the development of compartment syndrome.

Chemical toxicity to bone and or soft tissues is another possible explanation for the complications observed. The intraosseous catheter was used to infuse adrenaline, calcium, potassium and possible other drugs. Intraosseous adrenaline has previously been implicated in causing skin necrosis and osteomyelitis leading to bony destruction.7 It is possible that the skin necrosis and osteonecrosis seen in this case was a result of local toxicity from adrenaline and or one of the other drugs infused.

Intraosseous needle placement for infusion is a potentially lifesaving aid during resuscitation and current guidelines13 state that it is a suitable method for administration of all drugs used during resuscitation where there is a delay in establishing intravenous access. This case report serves to highlight some potential complications associated with these methods and reminds readers that careful observation of the limb is required during prolonged intraosseous infusion so that potential compli-
cations are avoided. Further work is needed to develop recommendations for maximum duration, dose, volume and rates for intraosseous infusion.

References