Iatrogenic Lower Limb Ischemia in Children with Congenital Cardiac Disease

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Abstract

Aim: To report our experience of the management of peripheral artery cannulation-induced limb ischemia in neonates, infants, and children (<5 years). Materials and Methods: Children <5 years old with peripheral ischemia who had undergone cardiac surgery or intervention who were referred to the vascular surgery service from March 2013 to June 2014 were included prospectively. All patients were assessed at referral and during follow-up clinically and with arterial duplex imaging. Follow-up included clinical review and arterial duplex at 1 week and clinical follow-up thereafter. Results: Twenty-six children (14 males, 12 females) with a median age of 21 months were assessed. This included three neonates with a median age of 10 days (range 3–26) and 12 infants with a median age of 5.5 months (range 3–11 months). Referral to the vascular service was initiated on the basis of a combination of absent pulses (46.2%), pregangrenous changes (34.6%), and cold limbs (19.2%). Thirteen (50%) patients had limb ischemia postarterial line insertion, while all other patients presented with limb ischemia postarterial sheath insertion. Median duration for limb ischemia postarterial line was 6 days while it was 3 h for sheath. All patients were treated with intravenous heparin infusion, antiplatelet, and supportive care. No patient required any surgical intervention. On mean follow-up of 11 months, no patient had any complication or limb loss or any further progression of pregangrene. Out of 26, five patients (19.2%) died, four due to underlying cardiac disease, and one due to septicemia, which were not directly related to limb ischemia. Conclusion: In our experience, anticoagulation, antiplatelets, and supportive care are very effective in the management of iatrogenic femoral artery-associated ischemia in young children, infants, and neonates.

Keywords: Congenital cardiac disease, iatrogenic, limb ischemia, pediatric

Introduction

Limb ischemia among children is a challenging problem for most vascular surgeons. The most common cause of limb ischemia among young children is iatrogenic. This is most often secondary to the use of indwelling arterial catheters (IACs) that are widely used for hemodynamic monitoring and blood sampling purposes in neonatal and pediatric intensive care units. It may also be a consequence of the use of larger sheaths for diagnostic or therapeutic endovascular interventions. Our center, Narayana Hrudayalaya Hospital, Bangalore, is a high volume pediatric cardiac center. Annually, approximately 2000 pediatric cardiac surgeries and more than 1200 therapeutic and diagnostic endovascular procedures are being performed in pediatric age group.

We report our experience with a series of neonates, infants, and children (<5 years) with acute arterial occlusion after arterial line or sheath insertion with a view to highlighting the range of problems encountered, management strategies, and outcomes.

Materials and Methods

All children with suspected limb ischemia referred to the vascular surgical service from March 2013 to June 2014 are included in this series. All data have been collected prospectively. The Institutional Review Board approved the protocol, and informed consent was obtained for all patients. All children were assessed clinically for signs of ischemia, pregangrenous changes (skin discoloration, blisters, or very prolonged capillary return), motor or sensory impairment (where possible), compartment syndrome,

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and tissue loss. This was in addition to an assessment of comorbid conditions, preceding interventions, and the general physiologic state of the child. All children underwent Duplex assessment of the arterial tree of the affected limb; an experienced radiologist carried this out. Initial management comprised of removal of arterial line or sheath immediately on the affected limb with a protocol of intravenous unfractionated heparin through peripheral line with an initial bolus dose of 80 units/kg followed by continuous infusion of 18 units/kg/h. The dose was titrated to achieve a target activated partial thromboplastin time of 2–2.5 times normal. All children were also commenced on antiplatelet therapy (aspirin in a dose of 3–5 mg/kg/day up to maximum dose of 100 mg) with supportive care, i.e., hydration, skin care, and warming.

All children were managed jointly with the pediatric cardiologists as inpatients either on a cardiac Intensive Care Unit or on the wards, dependent upon the general condition of the child. All children were followed up clinically at 1, 3, and 6 months and then as per patient’s convenience. A Duplex scan was repeated at 2 weeks, and the cardiology team followed up the children. During outpatient follow-up, children were assessed clinically for palpable pedal pulses with ankle-brachial index, any tissue loss or limb shortening, and arterial color Doppler of affected limb if required.

**Results**

Twenty-six children were referred for suspected limb ischemia. Median age of this group was 21 months with 14 males and 12 females (m:f = 1.17:1). In this group, three were neonates with a median age of 10 days (range 3–26 days) and 12 were infants with a median age of 5.5 months (range, 3–11 months). Twenty-two patients (84.62%) had low body weight for their age while all 26 patients (100%) had congenital cardiac disease. Out of 26, five patients (19.2%) died, four due to underlying cardiac disease, and one due to septicemia, which were not directly related to limb ischemia [Table 3]. One patient (3.85%) had developed groin hematoma, which was managed conservatively.

Among these patients, the most common reason for referral was absent pulses in 12 patients (46.2%), followed by pregangrenous changes in 9 patients (34.6%) and cold limb in 5 patients (19.2%). All patients were in the age group of <5 years (3 neonates, 12 infants), and because of that, it was not possible to differentiate them according to the Society for Vascular Surgery Acute Limb Ischemia (ALI) Classification. No patient had frank gangrene extending above ankle level, except few patchy areas of skin gangrene in leg and foot in three patients. Thirteen patients (50%) had developed limb ischemia postarterial line insertion. Other 13 (50%) patients developed ALI in association with an endovascular procedure requiring arterial sheath placement. All 26 patients (100%) had lower limb ischemia related to femoral artery access. Out of 26, six were related to superficial femoral artery (SFA) puncture while 20 were related to common femoral artery (CFA) puncture [Tables 2 and 3].

**Outcomes**

No patient required any surgical intervention. Out of 26 children, 24 were status postcardiac intervention (11 open heart surgery and 13 endovascular intervention for congenital cardiac disease). Out of 26, five patients (19.2%) died, four due to underlying cardiac disease, and one due to septicemia, which were not directly related to limb ischemia [Table 3]. One patient (3.85%) had developed groin hematoma, which was managed conservatively. Mean duration of follow-up was 11 months. On clinical longer-term follow-up, no patient had any major complication, limb loss, or further progression of pregangrene or any limb circumference or functional discrepancy.

**Discussion**

In pediatric patients, catheterization of the femoral artery is done mainly for therapeutic interventions, diagnostic angiograms and sometimes performed in critically ill children for invasive hemodynamic monitoring when other peripheral arteries are unsuitable. IACs are used for monitoring of arterial pressures and to provide an easy access site for sampling. They may be inserted at various sites; insertion through the umbilical artery is often used for preterm and term neonates, whereas in infants and older children, the preferred site is the radial artery; however, the femoral artery may be used where radial artery cannulation is not possible or has already failed or is unreliable due to congenital anomalies. For endovascular interventions, the femoral artery is the preferred site for access.[1]

In adults, IACs are considered to have a low complication rate with appropriate insertion technique and adequate catheter care.[2] In contrast for children, the insertion of IACs requires a high level of technical skill as vessels are much smaller, and hence, IAC placement in children is associated with a greater frequency of multiple puncture attempts.[3]

ALI is a catastrophic event that may result in limb loss if not treated appropriately. ALI in the young is a rare clinical event,
and consequently, consensus management guidelines do not exist.\textsuperscript{[10,11]} Vessel cannulation is known to be the major cause of thrombosis in the pediatric age group.\textsuperscript{[6-8]}

There are few published papers showing good results of medical management for iatrogenic limb ischemia, but (little-published data on acute arterial occlusion after arterial line or sheath insertion in the children [<5 years]) consensos on appropriate interventions and management protocols is still evolving.\textsuperscript{[7-9]} Low cardiac output, younger age, low body weight and increased hematocrit, larger catheter size, and repeated cannulations have been described as risk factors for peripheral artery cannulation-induced limb ischemia.\textsuperscript{[10,11]} The available guidelines recommend treatment with unfractionated heparin or therapeutic low molecular weight heparin for 5–7 days.\textsuperscript{[12,13]} Surgical interventions is recommended if symptoms are worsening or if the thrombus extends.

In this study, we describe a single institution experience of the management of peripheral artery cannulation-induced limb ischemia in pediatric patients (<5 years) during a 16-month interval. At our center, each month, over 200 children undergo open or endovascular cardiac procedures and this series only includes children referred to the vascular surgery unit.
The majority of patients in our series were infants and neonates; there was no significant variability in evaluation, management, or outcomes between those patients and older children (<5 years). We are unable to comment regarding the incidence of ischemia being different by age group, as not all patients with vessel occlusion would have been referred to the vascular surgical service. All children had underlying congenital heart disease and 22 out of 26 children were on inotropic support because of low blood pressure.

Among our patient group, 22 of the 26 had a low body weight as per the age and weight nomograms. In a review of the management of limb ischemia in neonates and children <3 years by Arshad and McCarthy, they had shown that in this age group, any therapeutic intervention using catheters larger than 6 Fr and increased number of catheterizations to be risk factors for ischemic complications following femoral artery catheterization.[11]

The initial diagnosis of arterial thrombosis is clinical with absent distal pulses, cold extremities, and pregangrenous changes. We used Duplex ultrasonography to confirm the diagnosis and site of thrombosis or occlusion. On ultrasound, 6 (23%) patients had SFA occlusion while 20 (77%) patients had distal CFA occlusion. Although angiography remains the theoretical gold standard, in expert hands, duplex ultrasound provides adequate details and is noninvasive, readily available, easily performed at the bedside, and repeatable to monitor progress. Angiography is useful when thrombolysis is being considered. [14] This is especially useful if the diagnosis of vessel occlusion is made during an interventional procedure and there is no contraindication to the use of thrombolysis. However, arterial access may put a previously uninvolved vessel at risk.

Thrombolysis has been used selectively for salvage of ischemic limbs. Weiner et al. in their series described the use of thrombolysis in seven patients, while Ade-Ajayi et al. used thrombolysis for 10 patients.[15,16] Thrombolysis was not utilized in our series due to a variety of reasons. The majority of our children had undergone a major surgical or endovascular procedure with sheath removal shortly before the vascular review and were thought to be at a major risk of bleeding from thrombolysis as has been reported in the literature.[12,13] Thrombolysis was not felt to be required in any of the patients who did not have a contraindication to thrombolysis. This is different from the series of Weiner et al. and Ade-Ajayi et al. and is likely due to be because the majority of children had presented with acute medical illness which is not commonly associated with contraindications to thrombolysis.

One patient had severe thrombocytopenia after 4 days of anticoagulation, for which anticoagulation was stopped without any adverse outcome. One patient developed a groin hematoma that was managed conservatively. There were no adverse long-term sequelae on follow up. There were five deaths in this group of patients, all due to associated comorbidities.

Findings in this study suggest that limb ischemia after arterial catheterization in pediatric patients (<5 years) can generally be managed successfully with anticoagulation, unlike in adults, where acute occlusion of the major inflow to the limb is generally required surgical intervention. This is likely to be attributed to difference in physiology, pharmacologic responses to anticoagulation, long-term consequences of thrombosis, and an enhanced ability to form a collateral supply to the limbs in children compared to adults.[17] Based on our experience, our protocol of management is outlined in Chart 1. This protocol may differ from others since our experience involves children who have undergone major cardiac surgery or endovascular interventions unlike most series that deal with medically unwell children who have not undergone invasive procedures.

Management of these sick children with multiple comorbidities is challenging and needs frequent discussion among the pediatric cardiac team, pediatric cardiac intensivists, and vascular surgeons as even assessment of ischemia and oxygenation is complicated in the presence of congenital heart disease and inotropes and often uncertain prognosis.

![Chart 1: Management chart for iatrogenic limb ischemia in pediatric patients (<5 years)](image-url)
CONCLUSION

In our experience, a protocol of heparin infusion and antiplatelet therapy for neonates, infants, and children (<5 years) presenting with nonthreatened ischemic extremity after arterial cannulation and surgical intervention is successful. These children remain a high-risk group for adverse outcomes primarily due to the underlying cardiac condition.

Surgical management should be reserved for patients where anticoagulation has failed or thrombolysis is contraindicated as surgical treatment can be challenging in small, thin-walled vessels with tendency to go into spasm and having poor tissue support. No specific guidelines exist for the use of surgical treatment in children. This is in keeping with the limited literature that suggests high recurrence rates with a risk of long-term vascular damage.[17]

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Conflicts of interest

There are no conflicts of interest.

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