ORIGINAL ARTICLE

A surgical approach to iatrogenic vascular injuries in pediatric cases

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ABSTRACT

BACKGROUND: Surgical intervention is mandatory in many children who present with vascular trauma or in complicated cases after medical interventions. In this study, surgical interventions applied after vascular injuries in children were analyzed.

METHODS: Between January 2002 and December 2012, 17 patients (aged under 18) who were admitted to the emergency room with vascular injuries were retrospectively analyzed. The data was collected through hospital records. Preoperative and postoperative data of the patients were recorded and analyzed.

RESULTS: Of the total, 11 patients were female (64.7%) and 6 patients were male (35.3%) with a range of 4–192 months. In total, 14 (82.3%) injuries were due to angiographic interventions, 1 (5.9%) was due to external trauma, 1 (5.9%) was due to preoperative trauma, and 1 (5.9%) was due to a catheterization complication in the intensive care unit. Additionally, 11 (64.7%) injuries were located in the right femoral artery, 3 (17.6%) were located in the left femoral artery, 2 (11.8%) were located in the left brachial artery, and 1 (5.9%) was located in the left external iliac vein. Also, 5 (29.4%) patients were managed under local anesthesia and 12 (70.6%) patients were managed under general anesthesia. With respect to treatment, 15 (88.2%) injuries were repaired with primary sutures, 1 (5.9%) injury was repaired with an end-to-end anastomosis, and 1 (5.9%) injury was repaired with a saphenous vein graft interposition. In addition, 16 (94.1%) patients underwent a thrombectomy prior to the repair. The total hospital stay was calculated as 2.7±1.4 days. The intensive care unit stay was calculated as 1.1±0.4 days. There was no mortality, a loss of an injured extremity, or an infection. No other complication was detected.

CONCLUSION: Iatrogenic interventional procedures seem to be responsible for the majority of pediatric vascular injuries. The results of surgical repairs in these injuries are successful and efficient.

Keywords: Injury; pediatric; surgical approach; vascular.

INTRODUCTION

Vascular traumas are seen in 0.06% of all of the children admitted due to a trauma as recorded in the United States of America.[1] Pediatric vascular trauma cases are rare in occurrence although they may lead to serious morbidity and mortality.[2–4] Iatrogenic interventional procedures seem to be responsible for a majority of pediatric vascular injuries.[5,6] Interventional diagnostic tools are widely used in the diagnoses of congenital heart diseases; thus, approximately one-third of pediatric vascular traumas are due to iatrogenic causes.[5,6]

Pediatric vascular injuries are harder to manage compared to vascular injuries in adults due to the anatomical and physiologic differences. Thus, managing these cases can be harder than expected because weak surrounding supportive tissue, the spasmodic tendency of the vessels, and a thinner and more fragile vessel structure may easily complicate the injury even further in these cases.[5] A loss of intravascular volume should also be managed accordingly in pediatric cases. We analyzed the data of previously operated patients due to a vascular trauma in our clinic.

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MATERIALS AND METHODS

Between January 2002 and December 2012, 17 patients (aged under 18) who were admitted to the emergency room with vascular injuries were retrospectively analyzed. The data was collected through hospital records. The preoperative and postoperative data of the patients were recorded and analyzed.

The following data were recorded: preoperative age, gender, the route of the injury, the site of the injury, the perioperative management of the anesthesiology, the surgical procedure, and the hospital and intensive care unit (ICU) stay.

An arterial-venous duplex ultrasound and a physical examination were the main tools in the diagnosis. However, some patients were taken into operation theaters immediately because they were admitted with a pre-established diagnosis of vascular injuries, and some patients did not receive imaging modalities because they were accepted directly from the angiography rooms. In these patients, only the physical examination was performed.

All the patients received low molecular weight heparin until they left the hospital.

Those patients whose conditions improved after conservative heparin treatments were excluded from the study.

Technique

Embolectomy: After local or general anesthesia, the artery that was to be operated on was explored. After the artery was encircled with the vascular tape following heparinization, vas-

Table 1. Preoperative data

	n	%	Mean±SD
Gender			
Female	11	64.7	
Male	6	35.3	
Age (months)			60.7±54.4
Etiology			
After angiographic interventions	14	82.3	
After intra-arterial catheterization (for blood pressure)	1	5.9	
Peroperative injury*	1	5.9	
External injury	1	5.9	
Additional disease			
Atrial septal defect	3	17.6	
Ventricular septal defect	2	11.8	
Ventricular septal defect+pulmonary stenosis	2	11.8	
Tetralogy of Fallot	4	23.6	
Patent ductus arteriozus	2	11.8	
Aortic stenosis	2	11.8	
Inguinal hernia	1	5.9	
None	1	5.9	
Localization of the injury			
Right femoral artery	11	64.7	
Left femoral artery	3	17.6	
Left brachial artery	2	11.8	
Left external iliac vein	1	5.9	
Symptoms on admission			
Acute ischemia	10	58.8	
Acute ischemia + puncture-induced bleeding	5	29.4	
Retroperitoneal hematoma and ecchymosis	1	5.9	
Active bleeding	1	5.9	

*Left external iliac vein injury during inguinal hernia surgery. SD: Standard deviation.

cular clamps were applied. An embolectomy was performed using a Fogarty catheter, and the anastomosis was performed by the separated suture technique with 6/0 or 7/0 prolene.

An end-to-end anastomosis: The patient had external iliac vein injury. The external iliac vein was repaired with 6/0 prolene by using an end to end anastomosis.

A saphenous vein interposition: An interposition of the saphenous vein was applied to a 48-month-old patient with a brachial artery cut. By considering the growth progress of the patient, a saphenous vein interposition was performed with 7/0 prolene by the separated suture technique.

RESULTS

From the total, 11 patients were female (64.7%) with the mean age of 60.7±54.4 months, 16 (94.1%) patients had vascular injuries due to interventional procedures, invasive imaging, and perioperative trauma, and 1 (5.9%) had an external trauma. Excluding the patient with an external trauma, 16 (94.1%) patients had additional diseases as follows: 3 (17.6%), atrial septal defects; 2 (11.8%), ventricular septal defects; 2 (11.8%), ventricular septal defects + pulmonary stenosis; 4 (23.6%), Tetralogy of Fallot; 2 (11.8%), patent ductus arteriosus; 2 (11.8%), aortic stenosis; and 1 (5.9%), inguinal hernia. Additionally, 11 (64.7%) injuries were located in the right femoral artery, 3 (17.6%) were located in the left femoral artery, 2 (11.8%) were located in the left brachial artery, and 1 (5.9%) was located in the left external iliac vein. Acute ischemic findings were present in 10 (58.8%) patients, and 5 (29.4%) patients had an additional hemorrhage in the arterial access site. In addition, 1 (5.9%) patient had a retroperitoneal hemorrhage and ecchymosis due to perioperative trauma, and 1 (5.9%) patient with external trauma had an active hemorrhage. The preoperative data of the patients are summarized in Table 1.

Of the total, 7 patients (41%) were under the age of 24 months. Of these, 6 patients were operated on due to a femoral arterial thrombosis following transcatheter interventions, and one patient was operated on for a brachial arterial thrombosis during invasive arterial monitoring in the ICU. All of the 7 patients were observed in follow-up visits for 12 months. There were no complications or any need for additional intervention.

Also, 10 patients (58.8%) received surgical treatments for acute limb ischemia. These patients were transferred from various centers after failing to respond to conservative heparin treatments.

Local anesthesia was applied to 5 (29.4%) patients, and general anesthesia was applied to 12 (70.6%) patients. In addition, 15 (88.2%) injuries were repaired with primary sutures, 1 (5.9%) injury was repaired with an end-to-end anastomosis, and 1(5.9%) injury was repaired with a saphenous vein graft interposition. Also, 16 (94.1%) patients underwent thrombectomy prior to the repair. The total hospital stay was calculated as 2.7±1.4 days. The ICU stay was calculated as 1.1±0.4 (1–3) days.

The patients received 0.4±1.2 (0–4) units of blood transfusions. The perioperative data of the patients are summarized in Table 2.

There was no mortality, loss of an injured extremity, or an infection. No other complication was detected. None of the patients needed secondary interventions.

Due to the fact that the patients who were operated on had distal pulses positive at palpation, we did not measure the ankle brachial indexes. All the patients were followed-up with a duplex ultrasound instead of an ankle brachial index.

Table 2. Peroperative data

	n	%	Mean±SD
Type of anesthesia			
Local	5	29.4	
General	12	70.6	
Type of operation			
Primary repair	15	88.2	
End to end anastomosis	1	5.9	
Interposition of the saphenous vein	1	5.9	
Thrombectomy (as additional surgery)	16	94.1	
Blood utilization (IU)			0.4±1.2
Duration in intensive care unit (days)			1.1±0.4
Duration of hospitalization (days)			2.7±1.4

SD: Standard deviation.

DISCUSSION

In the United States, trauma in children older than 1 year of age is the leading cause for morbidity and mortality. A lack of the appropriate use of diagnostic and interventional techniques in these patients may result in catastrophic mortalities and morbidities, such as a loss of the related limb.[4] Vascular trauma etiologies in pediatric trauma patients vary in different studies. Some studies suggested the vascular penetrating injuries secondary to bone fractures is the most common underlying factor (31.8%).[6–8] In contrast, de Virgilio et al.[2] suggested that the most common etiological factor for vascular injuries is firearm incidences (70.8%). However, Jaipuria et al. suggested in their series that the most common etiological factor is blunt trauma due to crush injuries (56%), followed by traffic accidents and penetrating glass wounds (44%).[9] In the last decade, interventional imaging techniques have become the core imaging modalities in the diagnosis of congenital heart diseases; thus, they play a major role in the etiology of vascular traumas in this group. Recently, it has been suggested that the interventional imaging modalities are responsible for one-third of pediatric vascular traumas.[5] Lin et al. also suggested that arterial catheterization is the leading underlying factor in vascular injuries in children.[10] Interventional pediatric vascular injuries are at the present even being categorized in some studies. Bergqvist et al. divided the injuries in two groups, namely, iatrogenic vascular and non-iatrogenic vascular injuries, in their study.[11] Underlying etiological factors in vascular injuries may vary among various centers. In our clinic, we also found that the iatrogenic vascular trauma is the leading etiologic factor. In this study, we found that the main etiological factor for vascular injures is determined as iatrogenic vascular traumas (94.1%).

As per literature, the site of injuries varies, according to the underlying etiology. In interventional procedures, the general choice for a vascular access is the femoral artery; thus, the iatrogenic vascular injuries are naturally located in the femoral region.[10] There is one study excluding iatrogenic injuries that listed the most common sites of injuries as follows: the femoral artery (25%), the brachial artery (22%), the tibial artery (16%), and the radial and ulnar arteries (12%).[5]

Jaipuria et al gathered a diverse group together and reported the site of injuries as follows: the brachial artery (26%) and the femoral artery (18%).[9] In our patient pool, we encountered mainly iatrogenic vascular traumas; thus, the most common site of injury was the femoral artery and the femoral region (82.3%).

Lin et al had a similar patient population when we compare the condition of the patients at their first admittance to the hospital. They presented with the following conditions: acute ischemia (41%), chronic ischemia (20%), an arteriovenous fistula (15%), and hematoma/hemorrhage (12%).[10] In our clinic, all of the patients were immediately taken to the operating room and operated on; thus, in our group we did not have any patients with chronic ischemic findings and an arteriovenous fistula. In this study, 5.8% of the patients had acute ischemic findings and 29.4% had a hemorrhage and acute ischemic findings in the affected limb.

Surgical management of these cases can be more difficult than expected since weak surrounding supportive tissue, a spasmodic tendency of the vessels, and a thinner and more fragile vessel structure may easily complicate the injury even further in these cases.[5]

Because the long-term morbidity of a thrombosed limb artery in infants and neonates is uncertain and because there is a great potential for the rapid development of adequate collateral circulation in these age groups, an avoidance of an open repair with conservative treatment consisting of heparin administration has been suggested.[8] The decision for medical or surgical treatment depends on the type of lesion. Arterial lesions that present with bleeding, false aneurysms, and arteriovenous fistulae require an open repair. However, if distal ischemia is the only finding many surgeons prefer to use heparin or thrombolytic agents with an additional careful observation and thus, avoid an open repair unless the limb viability is jeopardized.[12] In our study, we only included the patients who were transferred to our clinic after failing to respond to conservative treatments in various centers. The patients with iatrogenic limb ischemia are often managed with conservative heparin treatments as a first line approach in our clinic.

A surgical approach may vary according to the site of injury and the route, but the most common techniques generally include ligation, the primary repair of the vessel, an end-to-end anastomosis, and a repair with a graft interposition.[1,3,5,10,11,13] It is also common practice to perform thrombectomy in these cases with an accompanying thrombosis.[8,11–14] The thrombectomy catheter should be carefully chosen, and it is also suggested not to reach a full inflation to prevent a possible endothelial catheter-induced injury.[11,13,14] We also applied a similar therapeutic approach in this study. The mode of anesthesia was mostly general anesthesia as appearing in many of the various reports.[10,11,14,15] In our study, 70.6% of the patients underwent general anesthesia.

As seen in recent literature, the length of the hospital stay varies among clinics. It is mostly due to the nature of the traumatic event itself and the complications of the surgical procedures applied. Nazem et al. reported the mean hospital stay in their study of non-iatrogenic vascular injuries as 9.55±7.1 days. Their group included 6 patients who also underwent a fasciotomy.[13] Shah et al. also conducted a study including vascular injuries accompanied by many traumatic bone fractures and reported the mean hospital stay as 5.00±5.08 days and the mean ICU stay as 4.14±4.05 days.[3]

In our study, the mean hospital stay was found to be shorter

than expected compared to that in these reports. We believe that the shorter hospital stay is related directly to the nature of the injuries and the accompanying complications. The majority of the cases in our study were iatrogenic in nature, and there were no complications.

Many reports stated that non-iatrogenic vascular traumas in a pediatric group may have high mortality and morbidity rates. Shah et al. presented 3 pediatric patients with non-iatrogenic vascular traumas who had complications postoperatively.[3] In this study, 2 patients required a fasciotomy, and 1 patient had venous congestion, but there was no mortality. Another report also suggested high mortality and morbidity rates in pediatric patients with lower extremity non-iatrogenic traumas.[8] In this study, 2 (4%) patients with a blunt trauma died, and 73% of the patients with multiple fractures suffered from neurologic deficits. Mommsen et al.[5] reported their mortality rate as 6.8% and postoperative complication rate as 18.2%. Jaipuria et al.[9] reported 2 (2.5%) mortalities and 6 (7.5%) amputations as complications in an 82-patient non-iatrogenic vascular trauma group. In this group, a majority of the cases were crashfallings and traffic accidents. Lin et al. conducted a study with only iatrogenic vascular traumas and reported their postoperative mortality rate as 3% and postoperative morbidity rate as 12%6. There is no postoperative fasciotomy or amputation reported in this study. In our study, there is no mortality and morbidity. These results can be expected because the iatrogenic vascular traumas may have clean-cut traumas with no additional organ injuries. On the other hand, Lin et al.[10] also studied a similar group; however, their mortality and morbidity rates are higher in comparison with our study.

We believe there are some limitations to this study, such as a small patient pool, heterogeneity in the patient group, and the lack of a control group including non-iatrogenic vascular trauma patients.

Iatrogenic vascular traumas are seen more often than we had anticipated in pediatric patients. However, the general outcome of these patients is favorable when compared with the non-iatrogenic trauma group because injuries are generally confined to one area, and they tend to be clean sharp wounds that can be more easily managed.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

İyatrojenik pediatrik damar yaralanmalarına cerrahi yaklaşım

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AMAÇ: Çocuklarda travma ya da girişimsel işlemlere bağlı olarak meydana gelen vasküler yaralanmaların birçoğu cerrahi müdahale gerektirir. Bu çalışmada herhangi bir nedenle vasküler yaralanmaya maruz kalınan çocuklarda uygulanan cerrahi işlemler incelendi.

GEREÇ VE YÖNTEM: Ocak 2002–Aralık 2012 yılları arasında vasküler yaralanma nedeniyle acil operasyona alınan 18 yaş altı 17 hasta geriye dönük olarak incelendi. Çalışma verilerine hastane kayıtlarından ulaşıldı. Çalışmaya alınan hastaların ameliyat öncesi ve ameliyat sırasındaki verileri kaydedildi.

BULGULAR: Hastaların 11'i kız (%64.7) ve yaş ortalaması 60.7±54.4 ay idi. Vasküler yaralanmaların 14'ü (%82.3) anjiyografik işlemlere bağlı, biri (%5.9) eksternal travmaya, biri (%5.9) ameliyat sırasında travmaya, biri (%5.9) ise yoğun bakım takibi sırasındaki invaziv arter takibine bağlı olarak meydana gelmiştir. Bu yaralanmaların 11'i (%64.7) sağ femoral arterde, üçü ise (%17.6) sol femoral arterde, ikisi (%11.8) sol barakiyal arterde ve biri (%5.9) sol eksternal iliak vende gerçekleşmiştir. Anestezi yöntemi olarak beş (%29.4) hastada lokal, 12 (%70.6) hastada ise genel anestezi kullanıldı. Yaralanmaların 15'i (%88.2) primer olarak tamir edilirken, birinde (%5.9) uç-uca anastomoz, birinde (%5.9) safen ven interpozisyonu gerekmiştir. Ayrıca 16 (%94.1) olguda ilave olarak trombektomide uygulanmıştır. Hastanede yatış süresi ortalama 2.7±1.4 gün, yoğun bakım kalış süresi ise 1.1±0.4 gün olarak tespit edilmiştir. Hiçbir hastada mortalite görülmemiş olup ekstremite kaybı, yara yeri enfeksiyonu gibi herhangi bir komplikasyon da gelişmemiştir.

TARTIŞMA: Pediatrik vasküler yaralanmaların etiyolojisinde sıklıkla girişimsel işlemlere bağlı iyatrojenik nedenler görülmektedir. Bu tip yaralanmalarda acil olarak uygulanan cerrahi işlemlerin sonuçları oldukça iyidir.

Anahtar sözcükler: Cerrahi; damar; pediyatrik; yaralanma.

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