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by Mariam M. Madany

Submission date: 26-Feb-2026 04:53PM (UTC-0600)
Submission ID: 2889391417
File name: intervention_complication.docx (33.32K)
Word count: 3279
Character count: 19490

Vascular Complications of Transcatheter Interventions in Congenital Heart Disease: A Single-Center Experience in Benghazi

Mariam M. Madany [1*]. Amal O. Khazm [2]. Rasmia H. Feituri[1], Hajir FAlkeelani

1. Pediatric Department, Faculty of Medicine, University of Benghazi/ Libya

*Corresponding Author: Mariam. Madany, mohammedmariam70@yahoo.com,ORCID 0009-0003-6140-4105

Abstract: Vascular complications are still considered a significant risk factor for transcatheter intervention in congenital heart disease (CHD). A previous study conducted in Benghazi primarily evaluated short-term outcomes, with insufficient assessment of issues related to the intervention procedures. Complications of vascular access remain a major concern as they occur during pediatric cardiac intervention. This study aims to evaluate the types and frequency of vascular complications post-transcatheter cardiac interventions in patients with congenital heart disease (CHD) & investigate risk factors of the vascular complications resulting from transcatheter procedures in CHD patients in Benghazi, Libya. **Methods:** A retrospective cross-sectional descriptive analysis was conducted at the National Heart Center in Benghazi from 2020 to 2025. The study included 256 patients with coronary heart disease (CHD) who underwent either diagnostic or interventional cardiac catheterization. The analysis examined the correlations among the patients' attributes, procedural factors, and vascular complications**. Results:** 57.8% of the patients were female, whereas 42.2% were male. Patients below the age of three constituted the most prevalent group (31.3%), while adults (25.4%) came in next. Most prevalent procedures were transcatheter closure of atrial septal defects (34%), followed by transcatheter closure of patent ductus arteriosus (23.8%) and pulmonary valvoplasty (18.8%). Diagnostic catheterizations account for 16%. This study revealed a significant association between complications and patients of lower ages (below 3 years), a lower weight (<10 kg), the larger delivery sheath, and arterial access ($p < 0.05$). The odds ratio (OR) for arterial access, delivery sheet/ weight ratio for the risk of vascular complication was (4.1, 2.5). A majority of the patients (95.7%) reported no complications. Major complications were 3.1%, including femoral artery injury, hematoma, and device mobilization.

Conclusion: Transcatheter interventions for CHD remain safe; however, vascular challenges have been impacted by patient age, weight, and procedural factors, highlighting caution in patient selection and appropriate device size.

Keywords: Congenital Heart Disease (CHD), Cardiac Catheterization Complications,

Benghazi, Libya

Introduction: -

Congenital heart disease (CHD) remains one of the most prevalent birth defects, affecting 1.8 in every 100 live births. Parcutaneous cardiac catheterization was initially utilized in 1962 for managing patients with CHD (Ali et al., 2023; Alsherif et al., 2024). Over the past two decades, this field included major developments with rapid advancements in technology and expanded access to resources, especially an emphasis on quality improvement (QI) in CHD catheterization, resulting in a reduction in overall annual mortality rates (Ali et al., 2023 & Tokel et al., 2018). Cardiac catheterization is still crucial in CHD despite advancements in non-invasive diagnostic techniques like cardiovascular computed tomography(CT) and cardiac magnetic resonance imaging (MRI). With fewer complications and a shorter hospital stay than open heart surgery, its role has expanded from diagnostics to encompass various interventions to substitute open heart surgery for certain types of congenital heart disease. Diagnostic catheterization allows for the comprehensive hemodynamic evaluation during the preoperative assessment of patients with CHD and guides appropriate surgical strategy & optimizes outcomes. Transcatheter techniques have advanced since 1970, with advancements in intervention catheterization that have revolutionized strategies for the treatment of CHD, which includes transcatheter device closure of atrial septal defects (ASD) and ventricular septal defects (VSD), patent ductus arteriosus (PDA), stent coarctation of the aorta (CoA) angioplasty, balloon valvuloplasty for pulmonary and aortic valve stenosis, stent placement for vessel narrowing, and embolization of collateral vessels (Quinn et al .,2024&Gamboa et al 2022). With expanded options and improved outcomes, cardiac catheterization remains an invasive procedure with associated risks. (Fattouh et al., 2017 & Mbabazi et al.,2024). The chance of issues is limited; it still occurs. Vascular complications are the most common and frequent complications that occur during catheterization, which include vascular injury, heart or vascular perforation, vascular thrombosis, hematoma and thrombosis at the catheterization site, and device mobilization and bleeding (AFKAR et al,. 2018& Gerçeker et al,. 2022). Kou et al,. 2020 revealed that the most prevalent complication is femoral artery thrombosis, which occurred in 11% of patients who underwent transcatheter intervention. However, the incidence of complications in cardiac catheterization is still minimal. Although it is still clinically relevant, risk variables, such as age and procedure type, were evaluated in an effort to predict potential complications for employing preventive strategies and interventions.

This study aims to analyze the frequency and variety of vascular complications arising from transcatheter cardiac procedures in CHD, and to identify predictor factors of vascular injury during these procedures in patients with CHD in Benghazi, Libya.

Patients and Methods:

This is a cross-sectional and retrospective study, analyzing the medical records of 256 patients with congenital heart disease (CHD). The patients, who ranged in age from neonates to adults, underwent diagnostic and interventional catheterizations at the National Heart Center in Benghazi between 2020 and 2025.

Exclusion Criteria: All procedures performed outside the center, and Patients who underwent open-heart surgery are excluded from this study.

The Statistical Package for Social Sciences (SPSS) version 27 was used to analyze the data. In tables, descriptive statistics for categorical variables are presented in frequencies and percentages. The Chi-square test assesses associations between categorical variables, while the Mann-Whitney test is employed for continuous variables. Appropriate statistical tests are used to analyze the results. A p-value of less than 0.05 indicates statistical significance, and the odds ratio (OR) is calculated for the predicted risk factors.

Ethical considerations: This retrospective observational, non-interventional study was undertaken utilizing anonymized medical data, with formal consent acquired from the heads of the departments at Benghazi National Heart Center.

Result:

Table 1 illustrates transcatheter procedures conducted on 256 patients. At 31.3% (n = 80) of the entire sample, the largest number of patients were in the age group below three years. Children aged 4–10 made up 25.4% of the total (n = 65). 18% (n = 46) were older children and adolescents (10–18 years old). Adults 18 years and older constructed the remainder of the age group, representing 25.4% (n = 65). The current pattern implies that a significant number of transcatheter procedures have been carried out in adult CHD patients, which is consistent with the patient population's growing therapeutic requirements. Males represent 41.88% (n = 98) of patients, while females account for 58.12% (n = 136). The patients' geographical distribution revealed that Benghazi accounted for over 50 percent of the patients (54.27%), while patients from other regions accounted for 46%.

Table (1): - The demographics of patients: -

Patients (N: 256)	Frequency (n)	Percentage (%)
Male	108	42.2
Female	148	57.8
Less than 3 years	80	31.3
4 – 10 years	65	25.4
10 – 18 years	46	18
More than 18 years	65	25.4
< 10 kg	30	11.8
10 – 20 kg	70	27.6
20 – 50 kg	81	31.9
> 50 kg	73	28.7

Benghazi	137	53.5
Other Regions	119	46.5

The annual frequency of cardiac catheterization procedures varied within the study period. As described in the table. 2. The highest rate was recorded in the years 2022-2023 (37.7%), followed by 2020 - 2021 (37.7%). Based on medical data, the most common indication of cardiac catheterization was ASD (34%, n = 87), followed by PDA (23.8%, n = 61) and pulmonary stenosis (48%, n = 18.8). PFO accounted for 10.2% (n = 26) of the cases, in addition to congenital heart defects representing 7.4% (n = 19). AS 2.3% (n = 6), COA 2.8% (n = 7), and the least frequent procedure, right heart pressure measurements (PHT), 0.8% (n = 2)

Table (2): catheterization characteristics

Patients (N: 256)	**Frequency (n)**	**Percentage (%)**
Year of Catheterization		
2020 – 2021	94	36.7
2022 – 2023	96	37.5
2024 – 2025	66	25.8
Type of Catheterization		
Diagnostic	41	16
Interventional	215	84
Vascular Access type		
Venous	157	61.3
Arterial	99	38.7
Diagnosis		
ASD	87	34
PDA	61	23.8
PS	48	18.8
PFO	26	10.2

COA	7	2.8
AS	6	2.3
PHT	2	0.8
Other CHD	19	7.4

ASD (Atrial Septal Defect), PDA (Patent Ductus Arteriosus), PS (Pulmonary Stenosis), PFO (Patent Foramen Ovale), AS (Aortic Stenosis), PHT (Pulmonary Hypertension), COA (Stent or Balloon)

In Table(3) analysis of procedure-related issues revealed that, in 95.7% (n = 244) of cases, no complications occurred. With 4.1% (n = 10) of the recorded complications, femoral artery injury and device mobilization were the most common, in addition to the category of major issues (3.4%). Others are categorized as minor complications (0.7%) requiring just follow-up and medical treatment. The findings demonstrate that although complications can occur, it's typically manageable and relatively uncommon.

Table (3): Types of procedure-related complications:

Complication Type	Frequency (n)	Percentage (%)
No Complications	251	95.7%
Femoral Artery Injury(major)	3	1.1%
Hematoma (minor)	2	0.7%
Femoral Vein Injury (major)	2	0.7%
Device Embolization/Mobilization	3	1.1%
Complication in the diagnostic group	1/41	2.4%
Complication in the intervention group	9 /215	4.1%
Total	256	100%

We revealed that weight and the frequency of complications had a statistically significant association (p = 0.012). Table 4 and Table 5. There were additionally considerable correlations between different procedure variables and complications. Weight, delivery sheath/weight ratio, and arterial access were statistically associated (p = 0.042, 0.031, 0.044). Overall, these results illustrate that vascular complications are impacted both by procedure-related parameters (e.g., vascular access route) and patient-specific variables (e.g., age, weight), which highlights the importance of particular procedural strategies, particularly for higher-risk patients. Weight, arterial

access, and delivery sheet/weight ratio odds ratios were 4.1, 2.5, and 3.5, respectively; the possibility increased four times when arterial vascular access was employed.

Table (4) The relationship between the Age, Gender, Vascular access, sheet/weight ratio, and vascular complications

Patient (n=256)	With Complication (n = 11)	No Complication (n = (n=247)	P-value
	Vascular Access Route		0.008*
Arterial Access (n = 99)	8 (8.1%)	91 (91.9%)	
Venous Access(n = 157)	2 (1.3%)	155 (98.7%)	
	Age (Years)		0.012*
Mean ± SD	4.00 ± 2.16	9.85 ± 6.42	
	Body Weight (kg)		0.042*
Mean ± SD	21.25 ± 14.8	35.60 ± 22.4	
Mean ± SD	0.028 ± 0.04	0.011 ± 0.02	

A p-value below 0.05 is considered statistically significant.

Table (5) Risk factors of vascular complications: -

Risk Factor	Total (N)	P-value	(OR)	95%
Weight < 10 kg	35	0.050*	3.5	(0.92 – 13.41)
Age < 3 Years	80	0.029*	2.6	(0.69 – 10.14)
DS/W Ratio	39	0.031*	2.5	(0.62 – 10.11)
Artery / Combined Access	96	0.044*	4.1	(1.04 – 16.31)

Odds Ratio (OR). Confidence Interval(CI). Delivery sheet /weight ratio (DS/W)

Discussion:

Transcatheter procedures for congenital heart disease (CHD) are currently studied in Libya, whereas attention has mainly focused on the procedural rate of success and short-term outcomes. Notably, previous Libyan studies about transcatheter intervention in CHD have not comprehensively covered a variety of complications,

particularly the prevalence and risk factors associated with vascular complications and device-related issues (Madany., et al. 2022).

The majority of the patients within the current study were female. Ibrahim et al,.2020 revealed a similar result. Since certain disorders, such as ASD, are reported to impact females more frequently than males, the reported variation may be attributed to variations in prevalence and timing of the detection of specific CHD among both genders. The most common procedure is a transcutaneous closure of ASD; it is then followed by pulmonary balloon valvuloplasty and transcutaneous PDA closure.

The result is in contrast to the study by Habeeb., et al. (2021) , which revealed PDA was the most commonly performed procedure, while the study conducted in 2018 by Qawasmeh .,et al. and his colleagues also reported PDA to be the most common procedure, followed by ASD closure and balloon valvuloplasty. In our study, the therapeutic intervention procedures were more crucial compared to the diagnostic procedure, similar to Habeeb., et al. (2021) and their colleagues. However, Tokel et al,. (2018) demonstrated that the diagnostic catheterization procedure was more relevant than the intervention procedure. The main finding in this study was the association between body weight and introducer sheet size and complications, which is consistent with Praditukrit., et al. (2025), who reported that 6.2% of 390 patients experienced vascular issues and the most frequent outcome was temporary pulse loss (72%), which was followed by hematoma (12%) and hemorrhage (16%). A crucial prediction of vascular access site injury in 0.9% of 2,084 patients was the introducer sheath size, which was correlated with the patient's vessel diameter, according to research by Kou et al,. (2020) . Amoozgar., et al. (2019), in a study of 390 inpatients, found that 6.2% had vascular issues and observed that this conclusion was significant for younger patients and those with lower body weights. In accordance with Ibrahim,. et al,. (2020), complications occurred in 5.2% of the patients in their study of 32 patients, having a much higher prevalence (13.3%) among newborns and patients under the age of one year. Also, he demonstrated arrhythmia (15.6%) was the most frequently reported result, followed by device embolization (12.5%), which is similar to this study we also found that device embolization and arterial injury occurred in 1.1%.

Similar to our findings, a variety of studies demonstrated that intervention catheterization demonstrated a higher vascular complication incidence compared with diagnostic intervention. As an illustration, Moustafa et al,. (2016) concluded that patients who underwent intervention catheterization experienced a higher complication rate (8.2%) than those who had diagnostic procedures (1.5%).The results of this study are consistent with a previous study carried out by Praditukrit et al. (2025) & Abalı et al. (2022) to identify the risk factors that contribute to vascular complications. The researchers revealed that younger age and a higher ratio of sheath size to weight were significantly associated with predicting vascular complications during catheterization. these observation aligns with a prior study carried out by Amoozgar et al. (2019), which reported arterial complications and venous complications, with 5% and 4%, respectively, in 179 patients who underwent transcatheter intervention.

This study has several limitations; the first is the relatively small number of cases, which is dependent on the annual workshop program. The number of procedures performed is determined according to the availability of cardiac catheterization materials during these workshops. This is similar to what was previously reported by Mbabazi et al. (2024) & Gelaw et al. (2025) Their works depended on the availability of equipment, resulting in delayed management of patients with CHD. However, to improve procedural safety in future practice, the focus should be on reducing access-related risks. For the routine use of ultrasound-guided vascular access is strongly recommended, as it significantly lowers the incidence of arterial puncture and hematoma formation. In addition, selective use of clip-based vascular closure devices, particularly for large-bore access, may enhance hemostasis and reduce late vascular complications.

Conclusion

The vascular complications after transcatheter procedures in CHD had a significant association with procedural factors (vascular access and delivery sheath-weight ratio) and patient-related characteristics (weight and age). Vascular injury and device embolization represent the most frequent procedure complications. While limited by the small number of patients included in this study as compared to internationally widespread centers, these findings require careful patient selection, appropriate device size and sheet, and continuous improvement of procedures and techniques to ensure safety and favorable results. Subsequent procedures should focus on reducing procedure-related complications that occur if large-bore access is performed utilizing clip-based vascular closure devices, to achieve secure hemostasis for the safety of patients. Larger sample sizes and multicenter studies are additionally needed for confirming these findings and further improving risk stratification the result.

FINANCIAL SUPPORT AND SPONSORSHIP:

Nil

CONFLICTS OF INTEREST:

There are no conflicts of interest

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