

ORIGINAL RESEARCH ARTICLE

Diagnostic cardiac catheterization in a modified cardiac catheterization laboratory: The LASUTH experience

Alaba Busola Oladimeji¹, Oluwaseye Michael Oladimeji²,
Adeola Olubunmi Ajibare^{2,3*}, Oluwafemi Tunde Ojo²,
Ramon Kolade Moronkola³, Ayo Raheem², Abdulazeez Olanrewaju²,
Damilare Adewale Olusanya², Onomen Oluwaseyi Ehizojie²,
Oluwaseyi Ajimotokan², Abdulrahman Idris², Adenike Olufunke Akalagini²,
Moriom Omolola Lamina¹, Oluwaseun Oyeyemi Okunuga²,
Alaba Philips Adebola^{2,3}, Folashade Adeola Daniel^{2,3},
Oluwarotimi Ireti Akinola^{4,5}, and Adetokunbo Olusegun Fabamwo^{4,5}

¹Department of Paediatrics, Lagos State University Teaching Hospital, Ikeja, Lagos, Nigeria

²Department of Medicine, Lagos State University Teaching Hospital, Ikeja, Lagos, Nigeria

³Department of Medicine, Faculty of Clinical Sciences, Lagos State University College of Medicine, Ikeja, Lagos, Nigeria

⁴Department of Obstetrics and Gynaecology, Lagos State University Teaching Hospital, Ikeja, Lagos, Nigeria

⁵Department of Obstetrics and Gynaecology, Faculty of Clinical Sciences, Lagos State University College of Medicine, Ikeja, Lagos, Nigeria

Abstract

Cardiac catheterization is useful in the diagnosis and treatment of congenital and acquired cardiac diseases. However, it is rarely done in Nigeria because of the limited cardiac catheterization laboratories in the country. Transforming the existing operating theaters to modified catheterization laboratories may bridge the gap of limited cardiac catheterization. This study reviewed the procedures, outcomes, and challenges of a modified catheterization laboratory in Nigeria. A retrospective review of all diagnostic cardiac catheterizations at the modified catheterization laboratory of Lagos State University Teaching Hospital (LASUTH) between January and May 2022 was performed. A total of 8 adult and 4 pediatric patients had cardiac catheterization, and the mean age was 23.7 ± 16.9 (range: 2 – 52) years. The most common lesion was the ventricular septal defect. Complex congenital heart disease was seen in 16% of subjects, whereas pulmonary hypertension was found in 83% (10). The most common complication was transient bradycardia. Good surgical outcome was recorded in the patients who subsequently had corrective surgeries. A modified catheterization laboratory may be a suitable alternative to the standard catheterization laboratory in low-resourced countries.

Keywords: Cardiac catheterization; Nigeria; LASUTH; Catheterization laboratory

***Corresponding author:**
Adeola Olubunmi Ajibare
(adeola.ajibare@lasucom.edu.ng)

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1. Introduction

Diagnostic cardiac catheterization is a useful diagnostic tool in the assessment of cardiovascular diseases^[1,2]. It helps in the accurate diagnosis of cardiac diseases in the

case of difficult echocardiography or complex shunts and the detection and assessment of the severity of the complications of these cardiac diseases^[1-4]. It is also useful in evaluating the hemodynamics of the right and left sides of the heart, as well as in measuring pulmonary pressures^[5].

Pulmonary pressure evaluation is important in patients' workup for open heart surgery because pulmonary hypertension is a major complication of both congenital and acquired heart diseases in children and adults^[5,6]. The prevalence of pulmonary artery hypertension has been reported to range from 28% to 80%^[5,6]. Diagnosis of pulmonary artery hypertension can be made through echocardiography; nonetheless, diagnostic catheterization is the gold standard^[6]. Furthermore, diagnostic catheterization is also a pre-operative assessment tool to verify the fitness for surgical treatment of complex cardiac lesions^[6,7].

Congenital and acquired heart diseases are the major disease burdens in Nigeria^[7-14]. The prevalence of congenital heart disease varies from 4.6 to 18.1/1000 children and 2.5/1000 adults, as reported in tertiary health-care centers in Nigeria^[7,8,14]. On the other hand, the prevalence of acquired heart disease varies from 0.7 to 3/1000 children^[6-8].

Diagnostic catheterization is usually performed in a standard catheterization laboratory; however, this is not readily available nationwide due to the challenges of the cost of setup, logistics of personnel, and technicality of maintenance^[2-4]. Modified laboratories have been proposed as an alternative to a standard catheterization laboratory for diagnostic cardiac catheterization^[2-4]. Modifying the existing operating theaters with C-arm fluoroscopy machines and invasive blood pressure monitors can be adopted as a start-up for simple diagnostic cardiac catheterization procedures^[2,3].

This study aimed to review the experiences, outcomes, and challenges of diagnostic cardiac catheterization in the modified catheterization laboratory of Lagos State University Teaching Hospital (LASUTH), Ikeja, Lagos, Nigeria.

2. Methods

2.1. Study design and study site

The study is a retrospective study of the diagnostic cardiac catheterization done at the cardiology unit of Lagos State University Teaching Hospital (LASUTH), Ikeja, from January 2022 to May 2022. LASUTH is a tertiary health-care centers that receives referrals from all parts of Lagos State and its environs. The adult cardiology unit of LASUTH runs various activities, including

the performance of interventional procedures such as diagnostic catheterization. The cardiac catheterizations were performed in the main operating theater of LASUTH using the C-arm fluoroscopy machine, invasive blood pressure monitor, and transducer.

2.2. Study population

All patients who had diagnostic cardiac catheterization during the study period were recruited into the study, while patients with incomplete data were excluded.

2.3. Data collection

A self-designed pro forma was used to collect the information from the recruited subjects' case files. The extraction of data from case files was carried out by two independent senior registrars in the unit. Any disparity between the extracted data of the two senior registrars was checked and verified by the interventional cardiologist. Socio-demographics (age, sex, and tribe), primary diagnosis/indications for diagnostic cardiac catheterization, hemodynamics, untoward complications, and outcome were documented.

The diagnostic cardiac catheterizations were done at the main theater of LASUTH, which had a C-arm machine adapted for cardiac catheterization procedures. The pediatric subjects did not have solid food for 8 h. Milk or infant formula was given for 4 – 6 h, and clear liquids for 2 h prior to the procedure. At the time of the procedure, general anesthesia was induced by intravenous administration of midazolam and maintained by inhalation of isoflurane. The adult subjects had only local anesthesia with 2% lidocaine at the site of catheterization. Venous and arterial accesses were obtained after the puncture of femoral vessels by the Seldinger technique. Following the advancement of the sheaths and dilators (no.5–6 Fr), intravenous heparin (100 U/kg) was given. Multipurpose angiographic (MPA) and Judkin's left (JR) 4 catheters were used for the right heart catheterization, while a pigtail catheter was used for the left side of the heart. The hemodynamic state of the heart was assessed by obtaining pressures and samples for blood gases. Pulmonary artery hypertension was defined as mean pulmonary artery pressure ≥ 20 mmHg and pulmonary vascular resistance as >2 Wood units.

After the procedure, children were given antibiotics as a routine prophylactic measure, monitored for the next 48 – 72 h and discharged. The adult patients were discharged home 6 h after the procedure.

2.4. Ethical considerations

Adult patients and parents/caregivers of the children for the study gave consent for diagnostic cardiac catheterization to

be done at the time the diagnostic cardiac catheterizations were carried out. Ethical approval was sought and obtained from the Health Research Ethics Committee of Lagos State University Teaching Hospital (LASUTH) with approval number LREC/06/10/1898.

2.5. Data Analysis

The data were entered and analyzed using a Statistical Package for the Social Sciences version 26 IBM Chicago. Patients' identifiers were removed. Categorical variables were presented as frequencies and percentages, whereas quantitative variables were expressed as mean and standard deviation if normally distributed. The quantitative variables were expressed as median and interquartile range if data are skewed. Independent Student *t*-test was used to compare two means and Mann–Whitney U-test was used to compare two medians. The level of statistical significance was defined as $P < 0.05$ and a confidence interval of 95%.

3. Results

A total of 12 patients had diagnostic catheterization over the 5-month period. The mean age was 23.7 ± 16.9 years, and the age range was 2 – 52 years. There was equal gender distribution, and the majority were from the Yoruba tribe, as shown in Table 1.

Table 2 shows that the most common indication for diagnostic catheterization was congenital heart disease, in which ventricular septal defect predominates.

The overall mean values of the hemodynamics and oxygen saturation pre- and post-administration of oxygen are shown in Table 3. The mean values of oxygen saturation in the aorta, pulmonary artery, and vein increased significantly with oxygen administration. No significant difference in the median values of pulmonary vascular resistance and the ratio of total pulmonary blood flow to total systemic blood flow (Qp/Qs ratio) pre- and post-oxygen administration.

Pulmonary artery hypertension was found in 16.7% of the patients, while pulmonary vascular resistance was normal in the majority of the patients (80%), as shown in Figures 1 and 2, respectively. Less than half (36.3%) of the patients were inoperable, as shown in Figure 3.

4. Discussion

Lagos State University Teaching Hospital (LASUTH) commenced open heart surgeries about 18 years ago, with foreign cardiac surgeons performing most of the procedures during scheduled cardiac missions^[6]. The situation has, however, progressed over the years to our local surgeons now performing routine and regular open heart surgeries^[6]. Most of our patients who were worked up

Table 1. Socioeconomic data

Variables	Male <i>n</i> (%)	Female <i>n</i> (%)	Total	<i>P</i> -value
Age	6 (50)	6 (50)	12	0.67
<10	2	2	4	
11–30	0	2	2	
>30	4	2	6	
Religion				
Christianity	4	2	6	0.21
Islam	1	4	5	0.59
Others	1	1	1	0.89
Tribe				
Yoruba	3	3	6	0.60
Hausa	1	0	1	0.45
Igbo	2	1	3	0.67
Others	0	2	2	0.64

Table 2. Indications for diagnostic catheterization

Indication	Frequency (%)
Congenital heart disease	
AVSD (intermediate type)	2 (16.7)
VSD with double chamber right ventricle	1 (8.3)
VSD	2 (16.7)
ASD	2 (16.7)
PDA	1 (8.3)
Lutembacher's syndrome	1 (8.3)
Acquired heart disease	
Severe AR and MS from rheumatic heart disease	1 (8.3)
Cor pulmonale secondary to PE	1 (8.3)

AVSD: Atrioventricular septal defect; AR: Aortic regurgitation; ASD: Atrial septal defect; MS: Mitral stenosis; PDA: Patent ductus arteriosus; PE: Pulmonary embolism; VSD: Ventricular septal defect

for these surgical interventions usually needed a diagnostic cardiac catheterization to ascertain suitability for surgery^[6]. Prior to now, most diagnostic cardiac catheterization has been done in the few privately owned catheterization laboratories available in Lagos, which therefore adds more financial burden to these patients and relatives who majorly pay out-of-pocket for cardiac surgeries and medications^[2]. It has been a major logistic challenge to cardiac surgeries until modified cardiac catheterization was adopted.

To the best of our knowledge, LASUTH is the first state-owned teaching hospital to perform and report the experience of a modified diagnostic catheterization suit. The patients recruited in our study were children and adults, similar to what was previously reported at a private center in Lagos^[2]. Contrary to the other study,

Table 3. Mean values of hemodynamics and oxygen saturation pre- and post-vasodilator administration

Parameters	Mean±SD (pre-oxygen)	Mean±SD (post-oxygen)	t-value	P-value
mPAP (mmHg)	36.8±14.9	41.5±14.7	0.778	0.445
Aorta (%)	93.2±4.5	98.7±2.3	3.770	0.001
SVC (%)	73.2±14.1	78.3±15.2	0.852	0.403
IVC (%)	68.7±16.4	77.3±26.3	0.961	0.347
Pulmonary artery (%)	82.8±14.7	93.0±3.0	2.355	0.029
Pulmonary vein (%)	96.3±2.8	99.0±1.7	2.855	0.009
	Median (IQR) (Pre-oxygen)	Median (IQR) (Post-oxygen)	U-value	P-value
PVR (woods unit)	0.92 (0.3–1.2)	1.35 (0.68–4.25)	8.000	0.569
Q _p /Q _s ratio	3.27 (1.1–9.0)	2.75 (2.46–3.37)	11.500	0.919

IQR: Interquartile range; IVC: Inferior vena cava; mPAP: Mean pulmonary artery pressure; PVR: Pulmonary vascular resistance; Q_p/Q_s ratio: The ratio of total pulmonary blood flow to total systemic blood flow; SVC: Superior vena cava

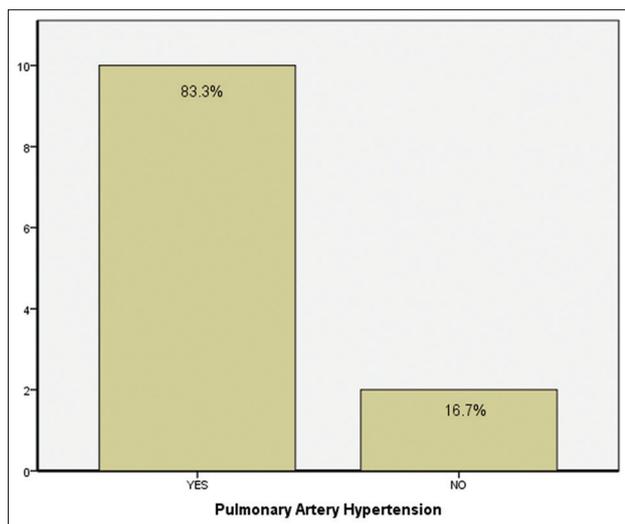


Figure 1. The proportion of patients with pulmonary artery hypertension.

a tertiary healthcare center in Ibadan only reported its initial diagnostic catheterization experience in children^[3]. Rwebembera *et al.* in Uganda reported collaboration between adult and pediatric cardiac interventional teams for diagnostic and therapeutic cardiac catheterization^[1]. The report suggested that catheterization procedures can be fully utilized for effective patient management with effective adult and pediatric collaboration. The effective collaboration in LASUTH has helped to address the delay in getting early surgical treatment by eliminating the high costs of diagnostic procedures at private facilities.

The major indication for diagnostic catheterization in our study was congenital heart disease in adults and children, similar to earlier studies^[2-4]. The other indications were cor pulmonale from pulmonary embolism and rheumatic heart disease with aortic and mitral valve diseases. Ventricular and atrial septal defects were the most common congenital heart defect, which is at variance with

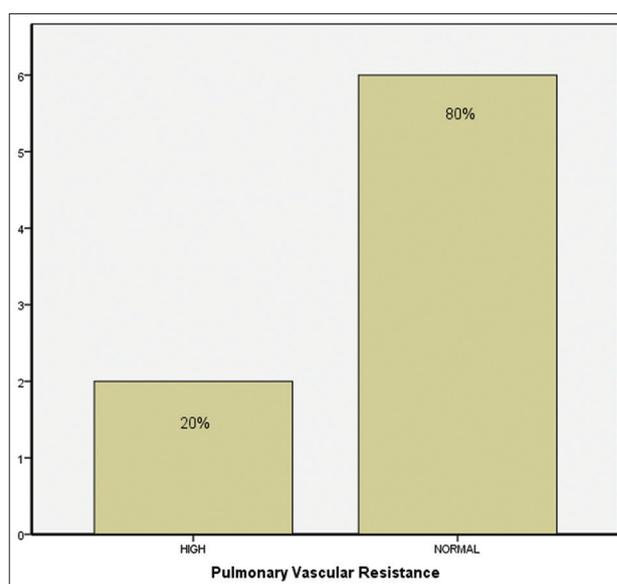


Figure 2. The proportion of patients with pulmonary vascular resistance.

some reports from previous studies that suggested patent ductus arteriosus (PDA) and tetralogy of Fallot (TOF) as the most common heart defects^[2-4]. The difference is probably because most of our patients were adults, considering that PDA and TOF would have been detected and corrected in early life, while the atrial septal defect is usually asymptomatic in childhood and thus may not be detected until adulthood^[14].

The femoral vessels were the major access used for our diagnostic catheterization, similar to a previous study^[2]. Only one of the patients had internal jugular access because of associated persistent left superior vena cava that might pose difficulty in accessing the pulmonary artery. Two of our patients had additional diagnoses of other congenital heart abnormalities missed on echocardiography, which included persistent left superior vena cava and

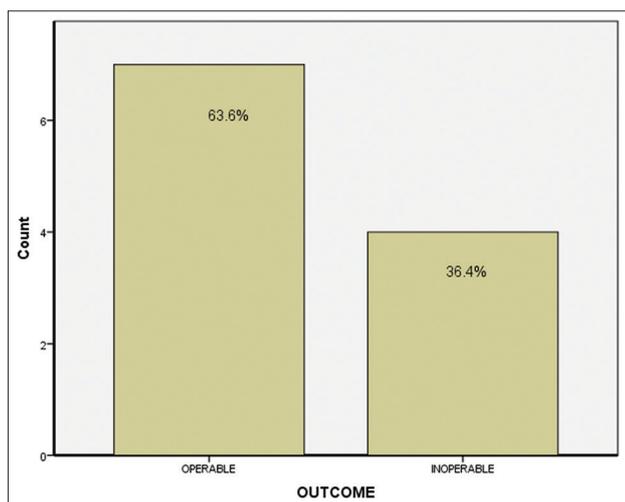


Figure 3. Outcome of patients.

sinus venosus atrial septal defect (SVC type). Cardiac catheterization has been shown to have higher sensitivity in the diagnosis of cardiac lesions^[1]. A comparison of the results of cardiac catheterization in two of our subjects with the earlier result from a privately owned standard catheterization suit showed similarities.

Irreversible elevated pulmonary vascular resistance was found in two of our patients, probably due to delayed presentation, making them inoperable. This is similar to the findings of a previous study^[13]. Delayed presentation of patients with congenital heart disease is still a problem of concern in our locale^[15,16]. Bradycardia and severe metabolic acidosis were the only complications encountered in one of our patients, which was corrected by the administration of atropine and sodium bicarbonate. Arrhythmias have been reported as complications of cardiac catheterization^[17]. Finally, three of our patients (two with high but reversible pulmonary vascular resistance) have had a surgical correction and are presently stable.

Our experience showed that diagnostic catheterization using the modified option is feasible in a state-owned teaching hospital where there may be multiple needs for the available scarce resources. The diagnostic catheterization was termed “modified” because it was carried out in the operating theater using a C-arm machine and an invasive blood pressure monitor with a transducer as against the standard cardiac catheterization laboratory. Our catheterization laboratory was under construction at the commencement of the modified option; however, it is now completely installed and fully functional. The experience with the modified catheterization was precious and helped medical personnel transition into the new catheterization suit quickly. Consequently, interventional cardiology procedures are expected to make a remarkable

contribution and collaboration to our open heart surgery program to tackle the increasing cases of cardiac lesions that require interventions and/or open heart surgery.

5. Conclusion

A modified catheterization laboratory is a good alternative to a standard catheterization suit for diagnostic cardiac catheterization. The idea could be employed as a temporary alternative to standard catheterization suits in low-resource settings while the quest to establish a standard cardiac catheterization laboratory continues. The collaborative partnership that brings specialists from within and outside the country could also help in establishing these laboratories and propagate local training.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Author contributions

Conceptualization: Alaba Busola Oladimeji, Oluwaseye Michael Oladimeji, Adeola Olubunmi Ajibare, Ramon Kolade Moronkola.

Format analysis: Oluwafemi Tunde Ojo, Ayo Raheem, Abdulazeez Olanrewaju, Damilare Adewale Olusanya, Onomen Oluwaseyi Ehizojie, Oluwaseyi Ajimotokan, Abdulrahman Idris, Adenike Olufunke Akalakini.

Investigation: Oluwaseye Michael Oladimeji, Adeola Olubunmi Ajibare, Ramon Kolade Moronkola, Moriam Omolola Lamina, Oluwaseun Oyeyemi Okunuga, Alaba Philips Adebola, Folashade Adeola Daniel.

Writing – original draft: Oluwaseye Michael Oladimeji, Adeola Olubunmi Ajibare, Ramon Kolade Moronkola, Oluwarotimi Ireti Akinola, Adetokunbo Olusegun Fabamwo.

Writing – review & drafting: Adeola Olubunmi Ajibare, Oluwafemi Tunde Ojo, Oluwaseye Michael Oladimeji, Ramon Kolade Moronkola.

Ethics approval and consent to participate

Ethical approval was sought and obtained from the Health Research Ethics Committee of Lagos State University

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Consent for publication

Not applicable.

Availability of data

All the data are as presented in the manuscript.

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