# Safety and Feasibility of Same-Day Discharge Following Pediatric Cardiac Catheterization: A Single-Center Retrospective Study

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**Abstract**

**Background:** Pediatric cardiac catheterization is crucial for diagnosing and treating heart conditions in children, especially those with congenital heart defects (3). Advancements in surgical techniques have reduced mortality rates, leading to more frequent catheterizations in the first few years of life (13). This study aimed to address the feasibility and safety of same-day discharge after cardiac catheterization at Aswan Heart Centre in Egypt, focusing on criteria and protocol development. **Materials and Methods:** The study involved a retrospective cohort study conducted at a single medical cardiac center, focusing on pediatric patients with congenital heart disorders who underwent cardiac catheterization between January 1, 2022, and June 30, 2023.

The study had three distinct phases: proving specific criteria for the discharge of pediatric patients on the same day following cardiac catheterization, piloting project implementation, and evaluating the efficacy of same-day discharge criteria in minimizing complications following catheterization. **Results:** The study involved 1034 pediatric patients who underwent cardiac catheterization. 95.2% met same-day release criteria, while 4.7% were ineligible. 5.3% were admitted to the hospital, while 95.7% were safely discharged. Vascular damage was the most common complication leading to hospital admission, followed by bleeding. **Conclusion:** The results showed that most patients were eligible for discharge on the same day, with a small percentage requiring hospital admission due to complications. Vascular damage and bleeding were the most common reasons for hospitalization, highlighting the importance of careful monitoring post-procedure to prevent adverse events. Thus, same-day discharge after cardiac catheterization in pediatrics is safe and possible.

**Keywords:** Pediatric Cardiology, Cardiac Catheterization, Same-day discharge, Outcome,congenital heart disease

## Introduction

Pediatric cardiac catheterization plays a vital role in diagnosing and treating heart conditions in children, particularly those with congenital heart defects or other cardiovascular conditions such as Atrial Septal Defects (ASD), Ventricle Septal Defects (VSD), Patent Ductus Arteriosus (PDA), Valvular Pulmonary Stenosis (VPS), etc (10). Advancements in surgical and perioperative techniques have substantially reduced mortality rates associated with these

procedures (3). Additionally, the improved survival of patients with complex cardiac anatomy has resulted in the need for more frequent catheterizations within the first few years of life (13).

Pediatric cardiac catheterization is a widely used diagnostic and therapeutic procedure for congenital heart disease (7). Pediatric cardiac catheterization is a procedure used to diagnose and treat certain heart problems such as Atrial Septal Defects closure, Ventricle Septal Defects closure, Patent Ductus Arteriosus closure or stent, Valvular Balloo Pulmonary Valvuloplasty (BPV), etc (10). During this minimally invasive procedure, a long, flexible tube (catheter) is inserted into a blood vessel and guided into the heart to assess heart function and address issues (5). Imaging techniques are then used to gather detailed information about the structure and function of the heart. It plays a crucial role in evaluating both congenital and acquired heart conditions in children (15). Cardiac catheterization is performed by a pediatric cardiologist. Although traditionally this procedure requires an overnight stay.

This study aimed to address the feasibility and safety of same-day discharge in Aswan Heart Centre (AHC), Aswan, Egypt. It is a tertiary cardiac center in Egypt that treats 1000 – 1500 annually of pediatric patients, 700- 800 treated through cardiac catheterization. Studies have shown that same-day discharge for adult patients post percutaneous coronary intervention can be safe and feasible for select patients, leading to potential cost savings and improved patient satisfaction. However, further research is needed to prove clear guidelines and criteria for figuring out eligibility for same-day discharge after pediatric cardiac catheterization based on limited research findings.

Additionally, addressing concerns about potential complications and ensuring proper follow-up care are crucial aspects to consider when implementing same-day discharge protocols for

pediatric patients undergoing cardiac catheterization. Incorporating input from multidisciplinary teams and developing standardized protocols may help streamline the process and ensure successful outcomes for patients. By addressing these key considerations, healthcare providers can work towards improving care delivery and improving overall patient experience in this specific setting (17).

**Importance of same-day discharge for patient and family satisfaction**

By allowing pediatric patients to return home on the same day, families can experience reduced stress and the financial burden associated with overnight hospital stays is decreased (16). This can lead to higher satisfaction levels among both patients and their families, ultimately improving the overall healthcare experience (8). Impact on healthcare resources: Same-day discharge can also help alleviate strain on hospital resources by freeing up beds for more critical patients and reducing unnecessary use of healthcare services (12). This can contribute to more efficient use of resources and better allocation of staff time, ultimately benefiting the healthcare system. By ensuring that care is provided to those who truly need it.

**The rationale for developing a new protocol for same-day discharge.**

Developing a new protocol for same-day discharge can help streamline the discharge process, reduce length of stay, and improve patient satisfaction. It can also lead to cost savings for both patients and healthcare facilities by minimizing unnecessary hospital stays.

**Research question:** What effects might a new same-day discharge protocol have on patient outcomes, safety, practicality, and use of medical resources?

**Aim and goals**: **Significance of the study:** This study aims to evaluate the impact of implementing a new same-day discharge protocol on patient outcomes, safety, practicality, and use of medical resources. The aims include assessing any changes in readmission rates, patient satisfaction levels, and overall efficiency of the discharge process.

There are limited studies on pediatric cardiac catheterization with same-day discharge protocols, especially regarding patient outcomes and satisfaction. However, existing research on adult populations undergoing similar procedures has shown promising results in terms of cost savings and patient satisfaction (3). This study aims to fill the gap in the literature by specifically focusing on pediatric cardiac catheterization and its potential for same-day discharge protocols. This gap in the literature highlights the need for further investigation into the feasibility and outcomes of same-day discharge for pediatric cardiac catheterization patients. By examining existing research on adult populations, we can better understand the potential benefits and challenges of implementing such protocols in pediatric settings. This research will offer valuable insights into the safety and efficacy of same-day discharge for pediatric cardiac catheterization patients, ultimately contributing to improved healthcare delivery for this vulnerable population. Additionally, findings from this study may inform future guidelines and protocols for pediatric cardiac catheterization procedures.

## Methodology

This study is a retrospective cohort study conducted at a tertiary cardiac center. The study specifically targets pediatric patients with congenital heart diseases who have undergone cardiac catheterization at AHC from January 1, 2022, to June 30, 2023. The study has three discrete phases: The first step involves setting precise criteria for the discharge of pediatric patients on the

same day after undergoing cardiac catheterization (*See Figure 1*). The second step was conducting a pilot phase to implement the criteria. The third phase entailed assessing the effectiveness of the criteria for discharging patients on the same day in reducing problems after catheterization. The study aims to analyze patient characteristics, details of catheterization, and outcomes after the procedure to evaluate the impact of early discharge on patient care and results. The study is to investigate the incidence of complications, such as bleeding, infection, and vascular injury, which occur after catheterization. The study aims to collect and assess data on the attributes of patients, the particulars of the operations they undergo, and the outcomes they meet. The goal is to evaluate the effect of same-day discharge rules on reducing the duration of hospital stays for these patients.

The hospital has implemented a same-day discharge strategy, which includes diligent post-procedure monitoring and scheduled follow-up visits to the outpatient clinic two days after the procedure. The diagram in Figure 1 illustrates the AHC-designed protocol for same-day discharge following cardiac catheterization, which is based on two specific criteria: low clinical risk and favorable procedure outcomes.

Figure (1): ***AHC Pediatric Catheterization Same-day Discharge Criteria***.

**The pilot phase**

The pilot phase was implemented in 2021, with a total of 405 pediatric admissions during that year. A total of 167 pediatric patients met the requirements for being discharged on the same day following catheterization. A total of 100 were discharged on the same day, accounting for 60% of the total. The remaining 40% fulfilled the requirements, but they were not discharged as the physician requested their continued presence.

It had a lower same-day discharge rate (60%) in the pilot compared to the later study (94.7%). 40% of eligible patients in the pilot stayed in the hospital because the doctor asked them to stay overnight in the hospital (22). Some potential reasons why doctors might have asked eligible patients to stay during the pilot phase, even though they met the criteria: During the pilot phase, doctors were more cautious than usual, and preferred to keep patients for observation if they have even minor concerns. This was due to a lack of complete confidence in the new protocol or a desire to gather more data before fully trusting the criteria. There were unforeseen logistical issues during the pilot, such as limited staffing or transportation problems, that made same-day discharge more difficult in some cases.However, reflecting on the pilot and adjusting to improve the protocol is excellent practice, there were changes in research: there was no modification of any inclusion or exclusion criteria based on the pilot experience. The discharge decision-making through meeting with pediatric cardiologists to enhance the implementation of this protocol. Printed the criteria protocol and distributed it to all departments in AHC. Use Google Forms to collect responses to follow the decision-making of same-day discharge. Post-discharge follow-up by adding the call phone interview follow-up 24 hr. after discharge to check for any complications.

**The rationale for these changes:** The low same-day discharge rate during the pilot suggested a need to provide more guidance and support to physicians in implementing the discharge criteria. By distributing the protocol details and using a digital tool to track decision-making, we aimed to increase adherence to the guidelines and reduce variability in discharge practices. After implementing the standardized discharge checklist or criteria, the rate of same-day discharge increased from 60% in the pilot phase to 94.7% in the full study, suggesting improved consistency in decision-making among physicians. As the protocol is further refined and doctors

gain more experience with it, the same-day discharge rate is expected to improve in the full implementation phase of the study.

**Criteria for inclusion**

Cardiac catheterization was performed on all individuals diagnosed with congenital heart disease at our facility from January 1, 2022, to June 31, 2023. The Aswan Heart Centre database was searched for all patients under the age of 18 who underwent catheterization. Only newborns who arrived at the procedure from an outpatient setting and were in good health (define it as the absence of fever, and normal vital signs on presentation) at the start were included. An example of a procedure includes the closure of the atrial septal defect, ventricular septal defect, and patent ductus arteriosus, as well as hemodynamic catheterization and balloon pulmonary valvuloplasty.

**Criteria for exclusion:**

Patients who met any of the following criteria were excluded from the study: being older than 18 years, being critically ill, experiencing acute hypoxemia, having duct-dependent cyanotic heart disease, having critical pulmonary stenosis with right to left shunt across patent foramen oval, or having a planned admission following cardiac catheterization for scheduled surgery. Transcutaneous Procedure: Pulmonary valve replacement, Closure of coronary fistula ,Closure of major aortopulmonary collateral arteries (MAPCAs) in patients with pulmonary atresia variations, stenting of the patent ductus arteriosus, balloon atrial septectomy, and treatment of cardiac electrophysiological conditions.

The hospital's strategy is to discharge patients after a 6- to 8-hour period of observation following the procedure. Patients who are hospitalized after 9:00 pm and stay in the hospital for 6 hours or more are held overnight. This is because many of patients come from distant cities and face transportation challenges based on far distance. These patients are discharged at 7 o'clock the next day, but for statistical purposes, they are considered as part of the same-day discharge group. The decision to discharge the patients was made by the operators, who were supervised by two physicians. The decision was based on general guidelines, which included factors such as the patient appearing well (hemodynamically stable) such as having normal oxygen saturation, respiratory pattern, and heart rate, proper perfusion, absence of fever, bleeding, and vascular complications, as well as the outcome of the procedures. Parents were given instructions for leaving the hospital and were informed about safeguards to take upon returning. There was a call phone interview after 24 hours of discharge to ensure no complications on the puncture site.

**Quantitative analysis:** The data was analyzed using the Statistical Package for Social Science (SPSS), specifically version 26.0 for the Windows operating system. Univariate analysis was used to describe the study population. Continuous variables were presented as means and standard deviations, while categorical variables were shown as frequencies and percentages. The degree of statistical significance was decided with a threshold of a P value less than 0.05.

**Qualitative analysis:** Parents were asked about their overall satisfaction with the same-day discharge protocol using a short survey consisting of five questions on a Likert scale.

## Results / Findings

1. **Same-day discharge eligible cases:**

Table 1 depicts the frequency of heart lesions in the population under investigation. The study comprised a total of 1034 pediatric patients who underwent cardiac catheterization. The predominant diagnosis was ASD, with 353 cases (34.1%), followed by PDA with 269 cases (26%), severe Pulmonary stenosis with 155 cases (14.9%), complex congenital heart diseases requiring Hemodynamic catheterization with 124 patients (11.9%), and ventricular septal defect with 113 cases (10.9%). There were 20 cases (1.9%) of complex congenital heart diseases that required emergency procedures such as PDA stent, balloon atrial septectomy, percutaneous pulmonary valve implantation, right ventricular outflow tract stent, interatrial stent, and MAPCAs closure or MAPCAs stenting, which was the lowest number of cases.

Based on the previously stated inclusion and exclusion criteria, table 2 displays that the total of 49 patients (4.7%) were deemed ineligible for same-day discharge. Conversely, 985 patients (95.2%) met the necessary criteria and were eligible for same-day discharge.

Out of the group of patients who were discharged on the same day, 933 patients (94.7%) were safely discharged after being observed for a period of 6 to 8 hours following the procedure. Nevertheless, a total of 52 patients, accounting for 5.3% of the sample, were unable to be discharged on the same day and were instead confined to the hospital for various reasons, which will be elaborated upon later. None of the patients were readmitted after being discharged in this research.

2. **Comparison of the basic characteristics of patients who were discharged and those who were admitted**

   table 3 compared the basic characteristics in both groups. The minimum and maximum age in both groups was 1 month to 16 years, however there were a significant difference in the median age between the 2 groups. (2 years in the admitted group and 3 years in the discharge

group The P value =0.004). The minimum and maximum weight in the admitted group were 3.8 kg and 48 kg, respectively, while In the discharged group the minimum and maximum weight were 2.55 kg and 58 kg, respectively. However there were a significant difference in the median weight between the 2 groups ( The median age in the admitted group was lower 9 kg while in the discharged group was 14 kg, The P value = 0.001). In terms of gender, there were no significant difference between the 2 groups, (males accounted for around 43% of the admitted group and 49% of the discharged group , P value = 0.175).

### 3. Length of hospitalization in the studied groups

Table 4 show average length of hospital stay. The average length of hospitalization in the admitted group was 72 hours (minimum of 30 hours to a maximum of 398.4 hours), In contrast, the average

length of hospitalization in the discharged group was much shorter about 18 hours, ( minimum 5.5 hours and a maximum of 22.4 hours). (P value < than 0.001) .

### 4. Diagnoses and procedures among the admitted group

Table 5 shows the Frequency of diagnosis and procedures for the admitted group. It was noticed that most of the admitted patients had undergone transcutaneous VSD closure. The percentage breakdown is as follows: VSD 34.6% ,PDA closure 30.7% , ASD closure 13.4% , hemodynamic catheterization 11.5% , balloon pulmonary valvuloplasty 5.7%, Lastly pulmonary artery branch dilatation and stenting 3.8%.

### 5. Complications in the admitted group

Table 6 aimed to identify the underlying causes and associated issues that contributed to the failure of same-day discharge. Vascular injury, including arterial or venous thrombosis requiring heparin or streptokinase infusion, vascular tear, arteriovenous fistula, or perforation, was the most prevalent complication, accounting for 52.7% of all complications. This high percentage can be attributed to the fact that 86% of the affected patients weighed less than 10 kg. The second most prevalent consequence observed was bleedinng, which included hematoma formation at the catheter insertion site, as well as major bleeding requiring blood transfusion. This event occurred in approximately 14.5% of cases. The third most prevalent cause, accounting for around 9% of cases, was challenging extubation ,hemodynamic instability and anesthesia related causes . This was followed by post-procedure arrhythmias, which accounted for roughly 7.2% of instances. Failed operations and referral to surgery were also common, each accounting for 7.2% of cases. Fever was the next most frequent cause, accounting for 5.4% of cases. Lastly, occurrences involving device instability accounted for 3.6% of cases.

Table 7 presents the procedures associated with vascular damage ,The findings indicated that vascular injury emerged as the predominant problem, prompting us to investigate the procedure most closely linked to it. The closure of the patent ductus arteriosus (PDA) was the technique most frequently linked to vascular damage, accounting for around 48% of cases. The closure of ventricular septal defects (VSD) accounted for approximately 31% of cases, making it the second most frequent procedure. This was followed by atrial septal defects (ASD), which accounted for 10% of cases.

## Discussion & Conclusion

Cardiac catheterization is a complex operation in children, and same-day discharge (SDD) further complicates matters. This retrospective analysis focused on patients under 18 years old with

congenital heart disease (CHD) who received cardiac catheterization. The hospital adhered to a protocol of discharging patients following a period of observation lasting 6-8 hours. This protocol was accompanied by clearly defined criteria for determining which patients were eligible for discharge and which were not.

This study examines the practicality and safety of same-day discharge (SDD) following cardiac pediatric catheterization. The data indicates that approximately 95% of the participants were suitable for SDD, with an average hospital stay of 8 hours and no instances of readmission. In contrast, the average hospital stay for the admitted group was 72 hours, with most of the admitted patients having undergone ventricular septal defect (VSD) closure. The rate of complications in pediatric cardiac catheterization was 5.5%. The occurrence of vascular damage was the prevailing complication. No deaths were reported in this group of individuals.

1. **Assent and dissent about previous reviews and research**

   Same-day discharge following cardiac catheterization is a widely accepted clinical practice for adults. In 2021, the American College of Cardiology published an Expert Consensus Decision Pathway on Same-Day Discharge After Percutaneous Coronary Intervention (3). Nevertheless, there is a scarcity of research on the topic of same-day release in the pediatric population.

   In 1982, Waldman and his colleagues conducted a retrospective study at the Children's Hospital of San Diego. They found that out of a total of 645 pediatric cardiac catheterizations performed between January 1977 and December 1980, 233 cases met the criteria for same-day discharge. Only one child required readmission due to psoas tendinitis caused by retrograde aortography (4).

The study conducted by Arpagaus et al at the Swiss children's hospital from January 1998 to December 1999 revealed that 52% of children who underwent catheterization were potential candidates for SDD. Out of these candidates, 77% were successfully discharged, while 23% required admission due to complications (5). The study results revealed that vascular injury was the predominant problem associated with post-catheterization issues leading to SDD failure. Other reported complications included bleeding, arrhythmias, pulmonary hypertension, fever, and several others. In 2008, Mehta et al conducted a review of the medical records of 11,073 children who had cardiac catheterization at The Hospital for Sick Children in Toronto, Canada. Post-pediatric catheterization issues were discovered within the initial 24-hour period. Out of all the patients, 7.3% experienced complications, with vascular complications accounting for the bulk at 32.4% (6). The authors of this study are Mehta, Lee, Chaturvedi, and Benson (2008). A further study conducted by Vitiello et al revealed that out of a total of 4,952 catheterizations performed on pediatric patients, 8.8% experienced both severe and mild complications. The most often seen adverse event was vascular damage (7).

2. **Importance of the research**

AHC, a charitable hospital with limited resources and limited bed capacity, considers the implementation of this protocol to be of utmost importance. Ensuring its safety, feasibility, and cost-effectiveness is vital in fulfilling its purpose of providing high-quality healthcare services and optimizing resource utilization. This study proposed that same-day discharge following pediatric cardiac catheterization is both safe and feasible, while also being cost-effective. Additionally, it enables us to enhance the availability of inpatient beds. In addition, same-day discharge helps to avoid additional complications

associated with hospitalization. Research indicates that 8% of patients who are hospitalized are at risk of developing hospital-acquired illnesses or experiencing falls resulting in injuries (8). Post-procedure admission is considered more cost-effective and has a greater negative influence on the psychological and emotional well-being of patients and their relatives compared to same-day discharge (9). It is crucial to understand that the successful implementation of such a program requires extensively trained medical teams and a hospital administrative system that performs with utmost efficiency.

3. **Strengths and limitations**

This study possesses multiple strengths: The study benefits from a large sample size of 1034 pediatric patients who underwent cardiac catheterization, encompassing a wide age range and various indications. This provides an advantageous opportunity to assess the safety and effectiveness of SDD in many circumstances. AHC has established specific requirements for same-day discharge following pediatric cardiac catheterization, as previously noted, to assure the safety of children and the effectiveness of the procedure.

There are certain constraints in this study: The investigation was done in a solitary center, potentially impacting the data regarding the demographic, environmental, and genetic aspects specific to the region. It is advisable to conduct a multi-centric study to ensure the generalizability of the findings. The data did not provide detailed post-catheterization follow-up outcomes to verify the long-term effectiveness of the SDD in pediatric patients.

The findings indicate that same-day discharge following pediatric cardiac catheterization is both safe and feasible. Furthermore, it is equally effective as hospital admission after catheterization for various heart conditions and across different age groups, provided that the patient meets the requirements for the procedure.

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**Conflicts of Interest**: None.

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## Tables

Table (1): **Frequency of cardiac lesions in the studied population**

| **Frequency of cardiac lesions in the studied population (total 1034)** | | |
|---|---|---|
| **ASD** | 353 | 34.1% |

| | | |
|---|---|---|
| **PDA** | 269 | 26% |
| **PS** | 155 | 14.9% |
| **HD** | 124 | 11.9% |
| **VSD** | 113 | 10.9% |
| **Others** | 20 | 1.9% |

Table (2): Outcome of the studied group

| **Total number (n=1034)** | | |
|---|---|---|
| **Not eligible for same-day discharge** | | 49(4.7%) |
| **Eligible for same-day discharge** | | 985(95.2 %) |
| | Discharged | 933(94.75%) |
| | Failed same-day discharge | 52(5.5%) |
| | Readmission | Zero |

Table (3): ***Baseline characteristics of discharged versus admitted patients.***

| | **Admitted patients. n= (52)** | **Discharged patients. n= (933)** | |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Age, days** | Min 1 months<br>Max 16 years<br>Median 2 years | Min 1 month.<br>Max 16 years<br>Median 3 years | P value = 0.0267 |
| **Weight, kg** | Min 3.8 kg<br>Max 48 kg<br>Median 9 kg | Min 2.5 kg<br>Max 58 kg<br>Median 14 kg | P value= 0.001 |
| **Male gender** | n=25 (43.1 %) | n=463(49.6 %) | P value = 0.175 |

Table (4): ***Duration of hospital stay in the studied groups.***

| **Mean hospital stay** | | |
|---|---|---|
| Admitted patients.<br>n= (52) | Discharged patients.<br>n= (933) | |
| 72 hours | 18 hours | P value < 0.001 |

Table (5): ***Distribution of diagnoses and procedures among the admitted group***

| Procedure | Admitted group n=52 |
|---|---|
| **VSD closure** | 18 (34.6%) |
| **PDA closure** | 16 (30.7%) |
| **ASD closure** | 7 (13.4%) |
| **HD Cath** | 6 (11.5%) |
| **BPV in severe PS** | 3 (5.7%) |
| **RPA or LPA stent** | 2 (3.8%) |

Table (6): ***Causes of admission (frequency of complications) in the admitted group.***

| Complications | n=55 (more than one complication in the same patient) | Percentage % |
|---|---|---|

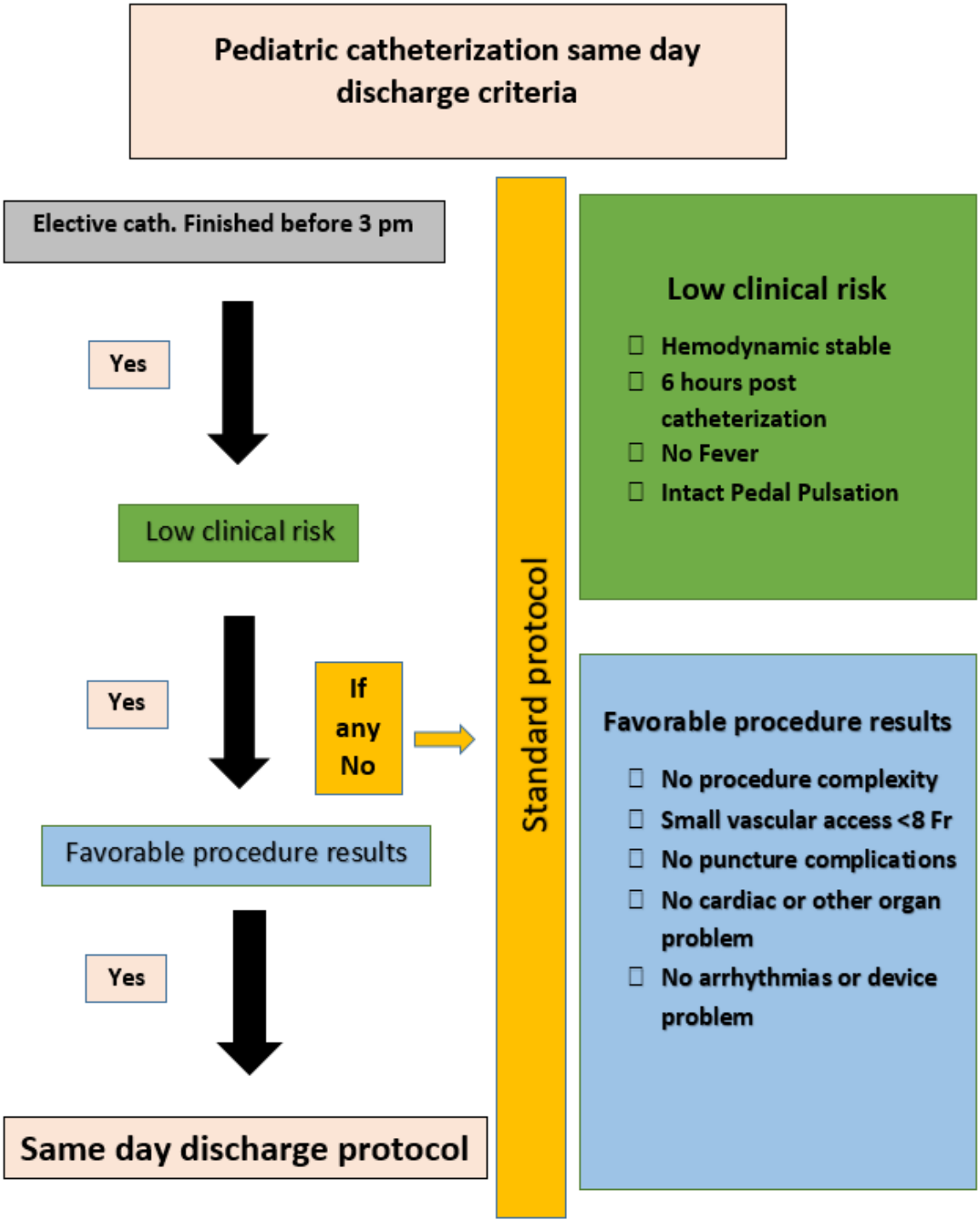
| | | |
|---|---|---|
| **Vascular injury** | 29 | 52.7 % |
| **Major or minor bleeding and blood transfusion** | 8 | 14.5 % |
| **Delayed and difficult extubation** | 5 | 9 % |
| **Arrhythmias** | 4 | 7.2 % |
| **Failed and referred to surgery** | 4 | 7.2 % |
| **Fever** | 3 | 5.4 % |
| **Device mobilization and re-catheterization** | 2 | 3.6 % |

Table (7): ***Procedure associated with vascular injury.***

| **The procedure associated with vascular injury** (N 29) | | |
|---|---|---|
| **PDA** | 15 | 51.7 % |
| **VSD** | 10 | 34.4 % |
| **ASD** | 3 | 10.3 % |
| **LPA/RPA stent** | 1 | 3.4 % |

**Figure Legends**

Figure (1): ***AHC Pediatric Catheterization Same-day Discharge Criteria***


Pediatric catheterization same day discharge criteria
Elective cath. Finished before 3 pm
Yes
Low clinical risk
Yes
If any No
Favorable procedure results
Yes
Same day discharge protocol
Standard protocol
Low clinical risk
Hemodynamic stable
6 hours post catheterization
No Fever
Intact Pedal Pulsation
Favorable procedure results
No procedure complexity
Small vascular access <8 Fr
No puncture complications
No cardiac or other organ problem
No arrhythmias or device problem