



Indications and Outcomes of Cardiac Catheterization Following Congenital Heart Surgery in Children

Raymond N. HADDAD, Juan Manuel LANGE, Olivier RAISKY, Regis GAUDIN, Claudio BARBANTI, Damien BONNET, Sophie MALEKZADEH-MILANI

M3C-Necker, Hôpital Universitaire Necker-Enfants malades, AP-HP, Paris, France.



Background

In complicated postoperative courses after pediatric congenital heart surgery, cardiac catheterization stands out as a reasonable recourse to diagnose and intervene on surgically-acquired or unaddressed lesions that may be life-threatening or may contribute to delayed recovery.

There is always a concern among clinicians that some of these procedures may be associated with excessive risk especially when patients are hemodynamically vulnerable or when manipulations have to be done during the very early postoperative period.

Indeed, POCCPs have been associated with increased morbidity and survival inconvenient while only few reports highlighted the potential interest of TCIs across fresh suture lines with promising clinical outcomes.

Study Objectives

To evaluate our POCCP institutional experience

To identify patients characteristics requiring POCCP

To classify POCCP main indications

To assess POCCP impact on outcomes

To evaluate the need for reinterventions

To describe POCCP safety and efficiency

Abbreviations

- POCCP: Post-operative cardiac catheterization procedure
- TCI: Transcatheter Intervention
- CHD: Congenital Heart Disease
- ECMO: Extracorporeal Membrane Oxygenation
- IPCCC: International Pediatric Congenital Cardiac Code
- CRISP: Catheterization Risk Score for Pediatrics
- IQR: Interquartile Range
- PCI: Percutaneous Coronary Intervention.

Study Design

- From January 2013 to July 2019, children with CHD who had cardiac surgeries and unplanned POCCPs before hospital discharge were included
- All patients had diagnostic POCPP for anatomy and hemodynamic
- 6281 consecutive CHD surgeries and 4116 cardiac catheterization procedures were done during that period
- Excluded procedures
 - Preoperatively planned POCCPs
 - Hybrid procedures
 - Procedures performed in the catheterization lab without hemodynamic assessment or cardiac interventions
- Heart defects, illness course, surgeries and risk categories of POCCPs were classified
- IRB Approval (MR004: 2020-091152926)

POCCP Classification

- Anatomical diagnoses were classified as:
 - Residual at surgical site: persistent anomaly despite surgical correction or untreated defect at surgical site
 - Acquired at surgical site: newly created anastomotic stenosis
 - Residual remote from surgical site
- Physiological diagnoses were classified as:
 - Evaluation of intentionally left residual shunt
 - Evaluation of the hemodynamical significance of an obstacle (pressure gradient)
 - Restrictive atrial shunt/insufficient blood mixing
 - Reverse Qp/Qs equilibrium
 - Suspicion of left-to-right shunt without an anatomical diagnosis
 - Suspicion of right-to-left shunt without an anatomical diagnosis
 - Pulmonary hypertension
 - Left ventricular diastolic dysfunction

POCCPs were grouped into confirmatory or non-confirmatory of preoperative suspected diagnosis

Unexpected new diagnosis was defined as POCCP providing new diagnosis not delineated by other tests.

Results

PATIENTS' CLINICAL CHARACTERISTICS	
Male, N (%), n=192	110 (57.3)
Age (months), median (IQR)	2.3 (0.6 – 15.8)
Weight (Kg), median (IQR)	4.2 (3.2 – 9.5)
CHD of great complexity, N (%), n=179*	143 (79.9)
High index of disease severity N (%), n=179	89 (46.4)
Aristotle Complexity Level, N (%), n=192	
I	4 (2.1)
II	44 (22.9)
III	53 (27.6)
IV	91 (47.4)
Time from surgery, median (IQR)	8 (2 – 20)
Open chest, N (%), n=217	30 (13.8)
ECMO support, N (%), n=217	41 (18.9)
Procedure type risk categories**, N (%), n=217	
1	25 (11.5)
2	44 (20.3)
3	51 (23.5)
4	97 (44.7)
CRISP score, median (IQR)	13 (11 – 15)
Procedure risk categories***, N (%), n=217	
CRISP 1	2 (0.9)
CRISP 2	19 (8.8)
CRISP 3	61 (28.1)
CRISP 4	86 (39.6)
CRISP 5	49 (22.6)

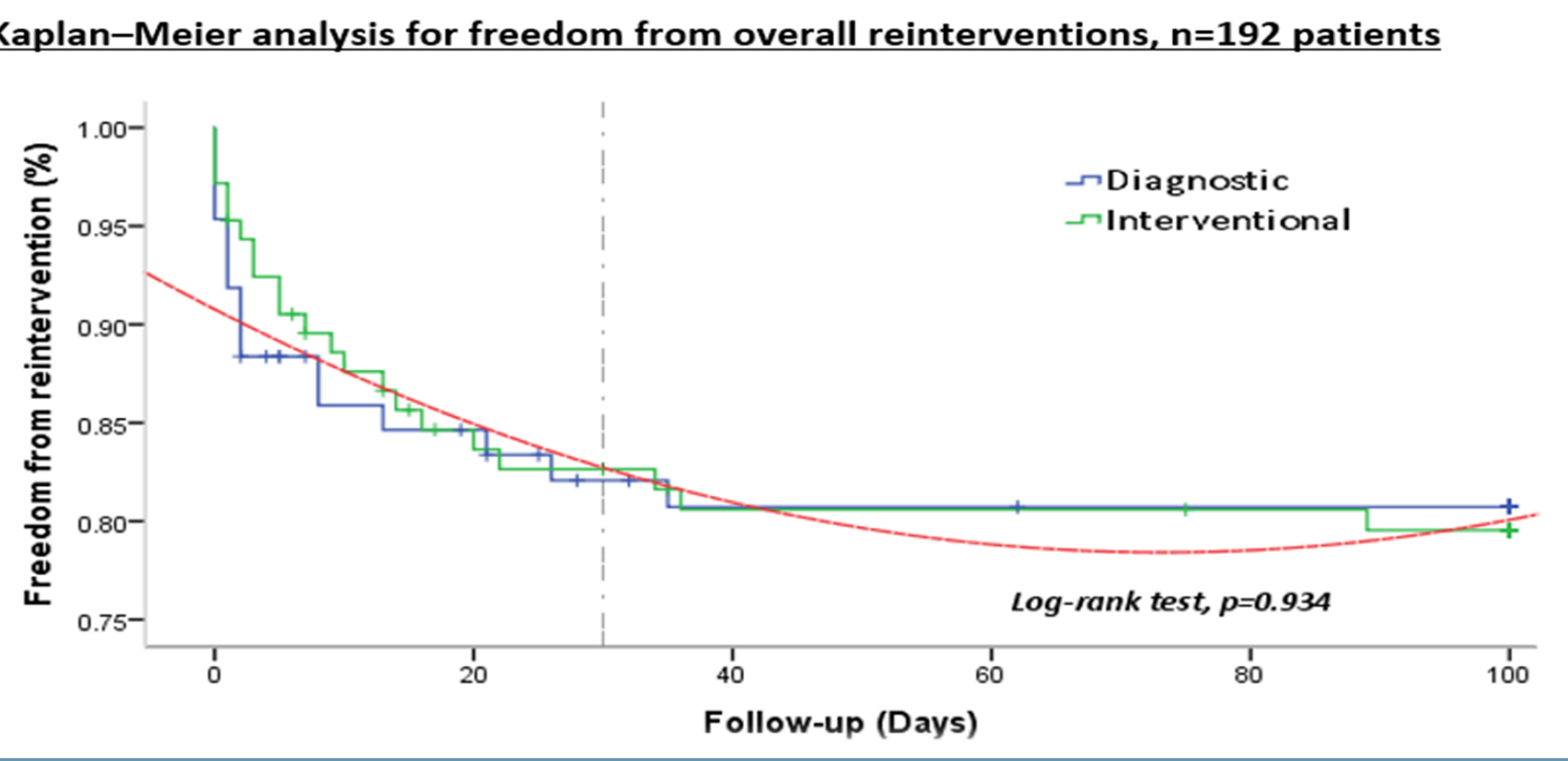
IQR= Interquartile range; CHD: congenital heart disease; ECMO: Extracorporeal membrane oxygenation

* According to the classification of Task Force 1 of the 32nd Bethesda Conference

** International Pediatric Congenital Cardiac Code

*** CRISP: Catheterization RISK Score for Pediatrics: A Report from the Congenital Cardiac Interventional Study Consortium

TRANSCATHETER INTERVENTIONS	
	N (%), n=133
TCI failure	3 (2.2)
TCI complications	1 (0.7)
Non-anticipated TCI	51 (38.3)
TCI across fresh suture lines	40 (30.1)
TCI during re-catheterizations	19 (14.3)
Embolization	65 (50.4)
Stenting	29 (22.5)
Angioplasty	11 (8.5)
Balloon atrial septostomy/ ASD enlargement	23 (17.8)
Balloon aortic valvuloplasty	1 (0.8)



Clinical Perspectives

- This largest European cohort presents relevant information for better approach to this complex group of patients.
- In CHD surgeries with complicated courses, POCCP confirms the diagnosis, refines it, or completes it in identifying new information
- POCCP can be safely performed in the early postoperative period and even on high-risk patients.
- Anatomical and hemodynamics information obtained from POCCP guides subsequent treatment strategy
- POCCP allows immediate TCI that can be done in residual or surgically-acquired lesions with limited risk.
- It is important to decide timely to help intensivists in tailoring proper care, improving outcomes and survival.
- POCCP should be discussed thoroughly for the objective: use non-invasive diagnostic tools first, plan the procedure, be ready to intervene with surgical and ECMO back-up with guidance to shorten the time in the catheterization laboratory.

POCCP INDICATIONS AND RESULTS					
	Total	Confirmation	Exclusion	F	p-value
Pre-procedure suspected diagnosis, n=386					
Anatomical diagnosis	214 (55.4)	119 (55.6)	95 (44.4)	30.603	<0.01*
Abnormalities in physiology/Hemodynamics	172 (44.6)	140 (81.7)	32 (18.6)		
Anatomical diagnosis, n=214					
Residual at surgical site	24 (11.2)	19 (79.2)	5 (20.8)		
Residual remote from surgical site	32 (15)	31 (96.9)	1 (3.1)	30.218	<0.01*
Acquired at surgical site	158 (73.8)	69 (43.7)	89 (56.3)		
Abnormalities in physiology/Hemodynamics, n=172					
Evaluation of significance of intentionally left residual shunt	19 (11)	18 (94.7)	1 (5.3)		
Evaluation of hemodynamical significance of an obstacle (pressure gradient)	49 (28.5)	34 (69.4)	15 (30.6)		
Restrictive atrial shunt/insufficient blood mixing	23 (13.4)	23 (100)	--		
Reverse Qp/Qs equilibrium	9 (5.2)	5 (55.6)	4 (44.4)	38.738	<0.01*
Left-to right shunt without anatomical diagnosis	54 (31.4)	51 (94.4)	3 (5.6)		
Right-to-left shunt without anatomical diagnosis	2 (1.2)	2 (100)	--		
Pulmonary hypertension	7 (4.1)	2 (28.6)	5 (71.4)		
Left ventricular diastolic dysfunction	9 (5.2)	5 (55.6)	4 (44.4)		

*: Chi-square test, *: Fisher's exact test

TREATMENT STRATEGY OF DOCUMENTED DIAGNOSIS				
	Total	TCI	Redo Surgery	Change in clinical management/medication
Confirmed pre-procedure suspected anatomical diagnosis, n=117				
Residual at surgical site	19 (16.2)	14 (73.7)	2 (10.5)	3 (15.8)
Residual remote from surgical site	29 (24.8)	27 (93.1)	1 (3.4)	1 (3.4)
Acquired at surgical site	69 (59)	35 (50.7)	11 (15.9)	23 (33.3)
Confirmed pre-procedure suspected hemodynamics without anatomical diagnosis				
Pulmonary hypertension	2	--	--	2 (100)
Left ventricular diastolic dysfunction	4	--	--	4 (100)
New diagnostic information, n=70				
Collateral	47 (67.1)	43	1	3
Sequestration	3 (4.3)	3	--	--
Veno-venous fistula	4 (5.7)	3	--	1
Coronary arteries fistula	5 (7.1)	1	--	4
Coronary arteries anatomical anomaly	5 (7.1)	--	1	4
Underestimated ventricular septal defect	2 (2.9)	--	--	2
Pulmonary artery branch hypoplasia/distal stenosis	3 (4.3)	--	--	3
Arterial duct	1 (1.4)	1	--	--
Total, n=193	127 (65.8)	16 (8.3)	50 (25.9)	

*: Fisher's exact test

- 217 POCCPs were done on 192 patients to confirm 386 suspected diagnoses
- 67.1% of suspected diagnosis were confirmed
- Anatomical lesions were less likely to be confirmed when compared to physiological diagnosis.
- Surgically-acquired lesions were less likely confirmed when compared to residual lesions.
- POCCPs identified new diagnosis in 32.3% of cases.
- POCCP indicated interventions (74.1%) and changes in medical management (25.9%).
- Interventions (133 TCI, 16 redo-surgeries) were successful (97%) and immediate (92.6%).
- 30.1% of TCIs were performed across fresh suture lines
- 8 significant adverse events were recorded
- Overall 30-days freedom from reinterventions, survival to discharge, and 12-months overall survival were 82.4%, 87.5%, and 84.4%