島根大学学術情報リポジトリ
SWAN
Shimane University Web Archives of kNowledge

Title
Intraoperative fluorescence angiography after arterial switch operation

Author(s)
MIURA Norito / NAKATA Tomohiro / TACHI Maiko / YASUDA Kenji / NAKASHIMA Shigeki / YAMAZAKI Kazuhiro

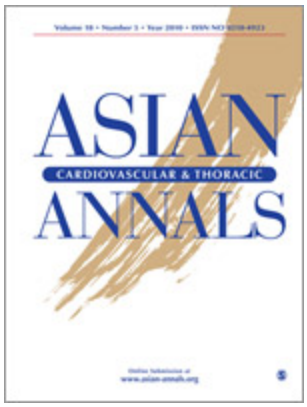
Journal
Asian Cardiovascular and Thoracic Annals 33 (1) , 55 - 58

Published
2025-02-23

URL (The Version of Record)
https://doi.org/10.1177/02184923251322821

この論文は出版社版でありません。
引用の際には出版社版をご確認のうえご利用ください。

This version of the article has been accepted for publication, but is not the Version of Record.



Intraoperative fluorescence angiography after arterial switch operation

Journal:	*Asian Cardiovascular and Thoracic Annals*
Manuscript ID	AAN-24-0273.R1
Manuscript Type:	Case Study (CARDIAC)
Keywords:	intraoperative fluorescence angiography, indocyanine green, arterial switch operation, mitral regurgitation
Abstract:	A full-term neonate with d-transposition of the great arteries and an intact ventricular septum was referred to our institution. We successfully performed an arterial switch operation with the LeCompte maneuver. Intraoperative transesophageal echocardiography revealed moderate mitral regurgitation immediately after weaning from cardiopulmonary bypass. Indocyanine green, diluted 20 times with saline and blood, was injected through the arterial line to perform contrast imaging and check for problems with the reconstructed coronary arteries. Clear coronary visualization was achieved. Mitral regurgitation improved over time and had almost disappeared by the time the patient returned to the intensive care unit.

SCHOLARONE™
Manuscripts

Abstract

A full-term neonate with d-transposition of the great arteries and an intact ventricular septum was referred to our institution. We successfully performed an arterial switch operation with the LeCompte maneuver. Intraoperative transesophageal echocardiography revealed moderate mitral regurgitation immediately after weaning from cardiopulmonary bypass. Indocyanine green, diluted 20 times with saline and blood, was injected through the arterial line to perform contrast imaging and check for problems with the reconstructed coronary arteries. Clear coronary visualization was achieved. Mitral regurgitation improved over time and had almost disappeared by the time the patient returned to the intensive care unit.

Keywords: intraoperative fluorescence angiography, indocyanine green, arterial switch operation, mitral regurgitation

For Peer Review

Introduction

Indocyanine green (ICG) fluorescence has recently been used for intraoperative navigation in evaluations of coronary arteries, cerebrovascular vessels, lymph vessels, and biliary tracts. However, there are few reports in the field of pediatric cardiac surgery [1–3]. We report a case in which we used ICG to evaluate the reconstructed coronary arteries after an arterial switch operation (ASO).

For Peer Review

Case report

A full-term male infant (weight: 3234 g) was transferred with cyanosis. Transthoracic echocardiography and enhanced computed tomography (CT) confirmed d-transposition of the great arteries (Shaher classification type 1) with an intact ventricular septum.

On day 9 after birth, he underwent an ASO with the LeCompte maneuver. He was placed on cardiopulmonary bypass (CPB), using ascending aortic (8 Fr) and bicaval cannulation. The left coronary artery was implanted using the trap-door technique and the right coronary artery was implanted in the high position.

Transesophageal echocardiography immediately after weaning from CPB revealed slightly sluggish ventricular contraction and moderate mitral regurgitation (MR) (central regurgitation) (Fig. 1), which was not present preoperatively. There was no need to

reintroduce CPB due to stable hemodynamic condition with inotropic agents. We supposed that the cause of central MR was ventricular dysfunction and therefore we did not perform epicardial echocardiography.

We decided to perform intraoperative fluorescence angiography using ICG to check for problems with the reconstructed coronary arteries. ICG was diluted with normal saline and blood (0.125 mg/ml). The diluted ICG (10 ml) was delivered from the side branch of the CPB circuit through the arterial cannula. Fluorescence was captured by the PDE-neo® system (Hamamatsu Photonics K.K., Shizuoka, Japan). Clear coronary visualization was achieved (Fig. 2). There were no adverse events from the ICG injection.

MR and cardiac function improved over time, and MR had almost disappeared by the time the patient entered the intensive care unit. Postoperative enhanced CT also revealed good coronary arteries (Fig. 3A and 3B). The patient was discharged on postoperative day 25 without any major complications. His 1-year follow-up cardiac catheterization also demonstrated excellent coronary arteries (Fig. 3C–3F).

Discussion

ICG imaging is a widely used technology across various surgical fields. However, its application in pediatric cardiac surgery has been quite limited [1–3]. Said et al.

For Peer Review

demonstrated that ICG fluorescence imaging was beneficial in evaluating coronary arteries and anastomotic site patency [3].

There are two possible routes for ICG injection: intravenous [1] or just proximal to the reconstructed vessel [2, 3]. Comparing the two, the success rate of adequate imaging was 60% in the former and almost 100% in the latter [1–3]. Therefore, we supposed that the latter method was better.

However, there is no fixed dose and dilution rate of ICG for each specific situation in pediatric patients. During the ASO with the LeCompte maneuver, we routinely remove the aortic root cannula immediately after declamping. Therefore, we injected ICG through the arterial cannula. We diluted the ICG with normal saline and blood considerably, because the volume needed to fill the CPB line (the arterial cannula) was larger than that of the cardioplegia line (the aortic root cannula).

SPY Imaging System (Novadaq Technologies Inc, Toronto, Canada) is used for ICG imaging in many institutions [1–3]. However, our hospital uses the PDE-neo® system. Adequate intraoperative images were obtained using the PDE-neo® system.

To the best of our knowledge, a comparison between ICG imaging and other standard imaging modalities, such as postoperative CT and angiography, has not been reported previously. We found that one of the limitations of ICG imaging was its poor

For Peer Review

penetration [3]. To obtain complete coronary visualization after the ASO and the LeCompte maneuver, we needed to retract the reconstructed pulmonary artery. However, compression and/or kinking might be released with the traction for exposure. Therefore, we performed ICG imaging *in situ* (without traction).

Significant MR after a neonatal ASO for transposition of the great arteries is rare [4–6]. We suspected coronary trouble when slightly sluggish ventricular contraction and moderate MR were recognized. Therefore, we adopted ICG imaging for on-table assessment. Because favorable coronary runoff was observed and MR improved over time, we determined that there was no need to reimplant the coronary arteries.

The advantages of ICG imaging are as follows: (1) Rapid on-table assessment with good visualization. (2) Few reported complications related to ICG injection, with the exception of iodine hypersensitivity [7].

However, ICG imaging also has some disadvantages: (1) It is less precise than conventional angiography, as it cannot visualize deeper structures due to limited penetration. (2) There is a risk of overdosing or underdosing, as there is no fixed dose, which can lead to over-saturation of contrast in the images if too much ICG is administered.

For Peer Review

Declaration of conflicting interests

The author(s) declared no potential conflicts of interests with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for this research, authorship, and/or publication of this article.

For Peer Review

References

1. Kogon B, Fernandez J, Kanter K, Kirshbom P, Vincent B, Maher K, et al. The role of intraoperative indocyanine green fluorescence angiography in pediatric cardiac surgery. Ann Thorac Surg. 2009;88:632-6.

2. Feins EN, Si MS, Baird CW, Emani SM. Intraoperative coronary artery imaging for planning. Semin Thorac Cardiovasc Surg Pediatr Card Surg Ann. 2020;23:11-6.

3. Said SM, Marey G, Hiremath G. Intraoperative fluorescence with indocyanine green in congenital cardiac surgery: Potential applications of a novel technology. JTCVS Tech. 2021;8:144-55.

4. Camarda JA, Harris SE, Hambrook J, Frommelt MA, Tweddell JS, Frommelt PC. Abnormal mitral valve anatomy in d-transposition of the great arteries: Anatomic characterization and surgical outcomes. Pediatr Cardiol. 2013;34:70-4.

5. Gabriel J, Scheld HH, Tjan TDT, Osada N, Krasemann T. Is the function of all cardiac valves after arterial switch operation influenced by an associated ventricular septal defect? Cardiol Young. 2011;21:383-91.

6. Angeli E, Raisky O, Bonnet D, Sidi D, Vouhe PR. Late reoperations after neonatal arterial switch operation for transposition of the great arteries. Eur J Cardiothorac Surg. 2008;34:32-7.

For Peer Review

7. Kim M, Lee S, Park JC, Jang DM, Ha SI, Kim JU, et al. Anaphylactic shock after indocyanine green video angiography during cerebrovascular surgery. World Neurosurg. 2020;133:74-9.

For Peer Review

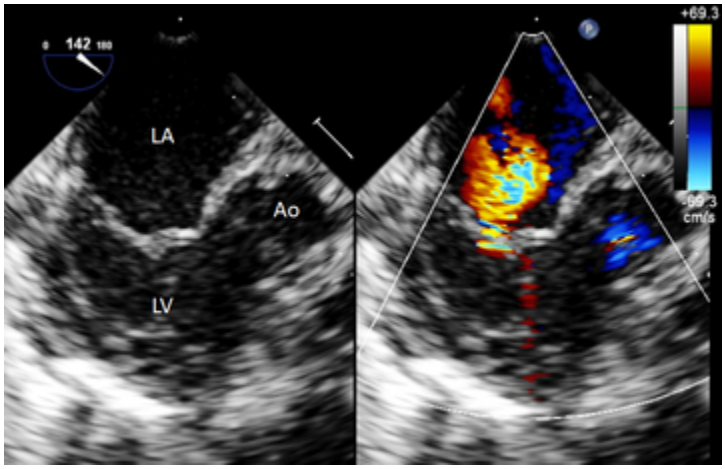
Figure Legends

1. Intraoperative transesophageal echocardiography (immediately after weaning from cardiopulmonary bypass) revealed moderate mitral regurgitation (central regurgitation). Ao: Aorta, LA: left atrium, LV: left ventricle.

2. Intraoperative indocyanine green fluorescence image. Diluted indocyanine green was delivered through the side branch of the cardiopulmonary bypass circuit via arterial cannula.

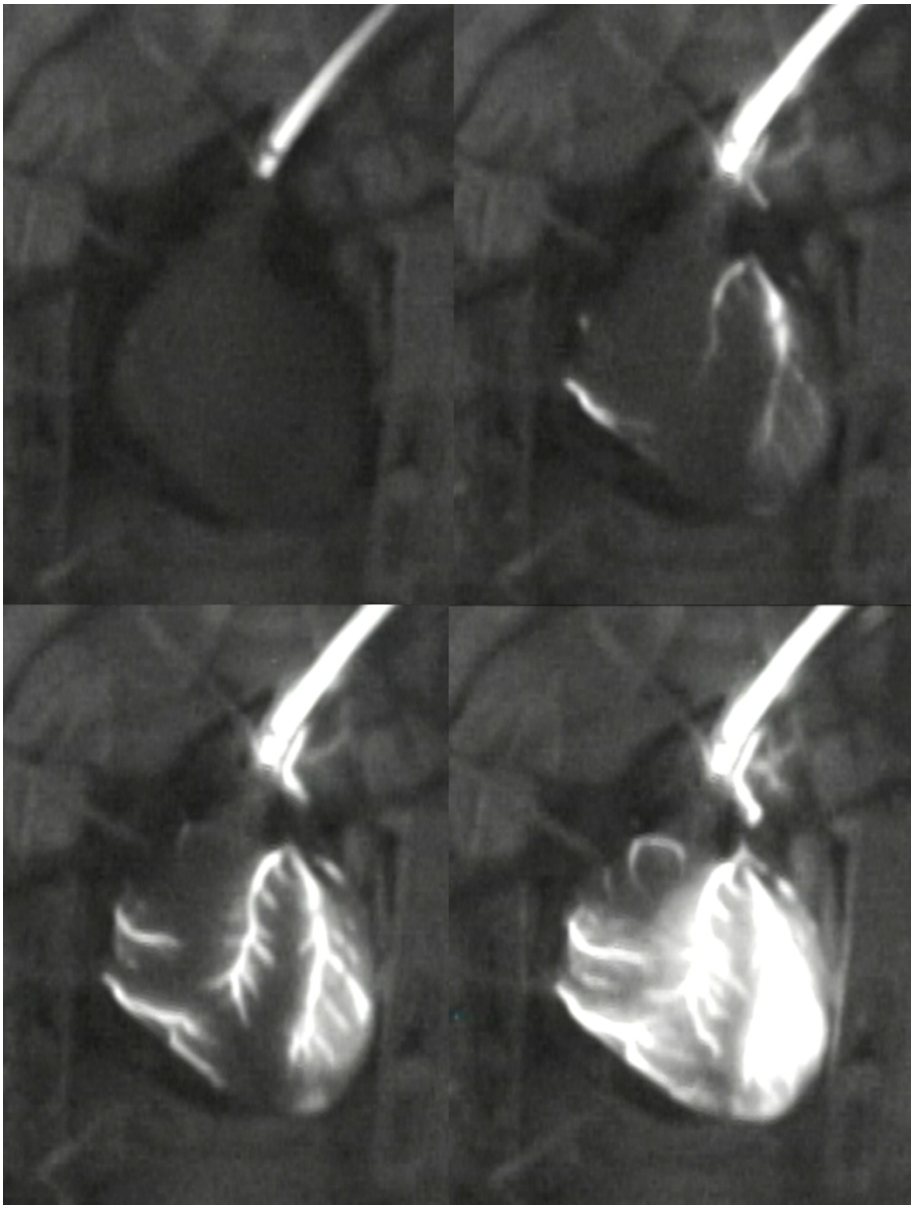
3. Postoperative enhanced computed tomography before discharge. (A) Aorta and reconstructed coronary arteries; (B) Aorta, reconstructed coronary arteries, main pulmonary artery and right ventricular outflow tract. Postoperative 1-year follow-up cardiac catheterization. Left coronary angiography (frontal view: C and lateral view: D) and right coronary angiography (frontal view: E and lateral view: F).

For Peer Review



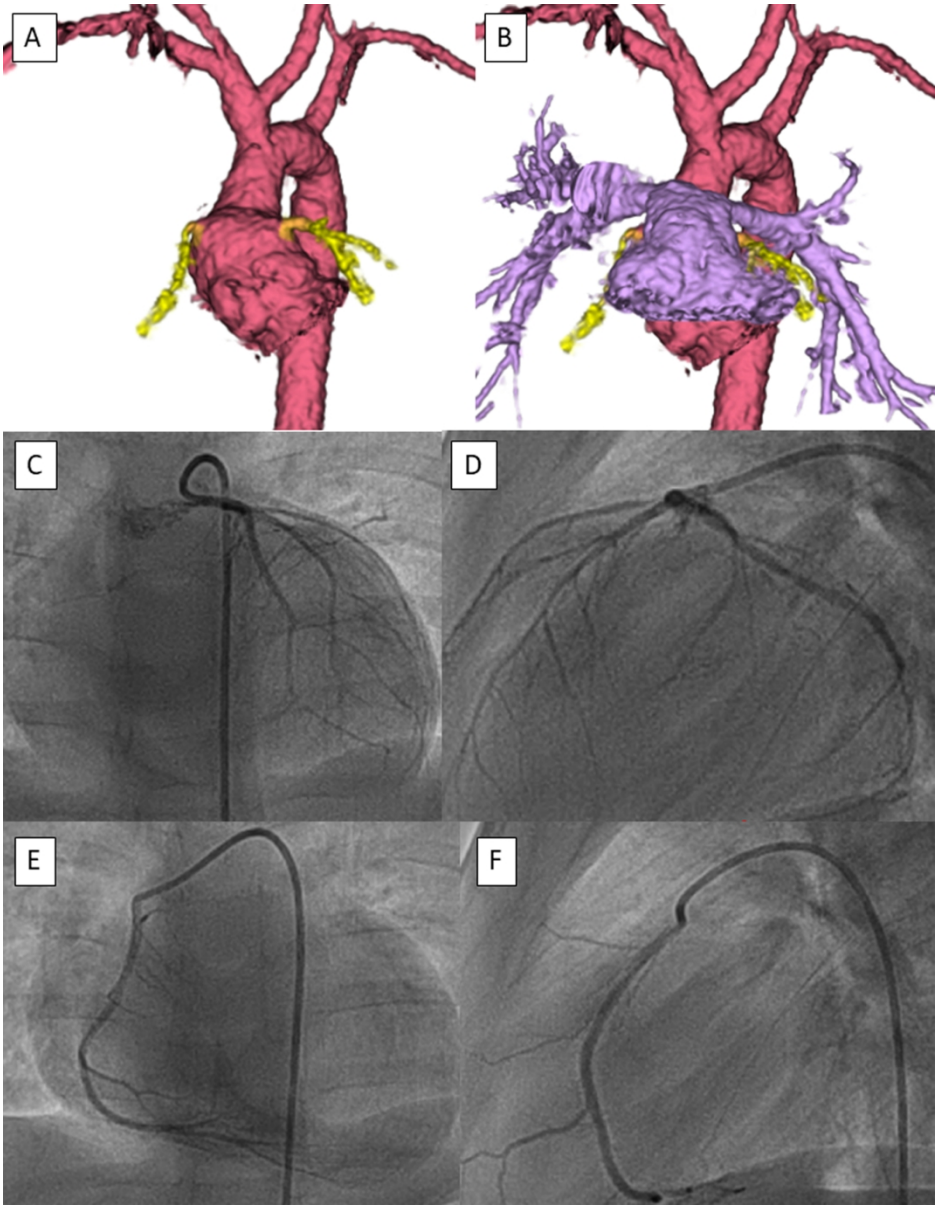
Intraoperative transesophageal echocardiography (immediately after weaning from cardiopulmonary bypass) revealed moderate mitral regurgitation (central regurgitation). Ao: Aorta, LA: left atrium, LV: left ventricle.

30x19mm (300 x 300 DPI)



Intraoperative indocyanine green fluorescence image. Diluted indocyanine green was delivered through the side branch of the cardiopulmonary bypass circuit via arterial cannula.

189x250mm (300 x 300 DPI)



Postoperative enhanced computed tomography before discharge. (A) Aorta and reconstructed coronary arteries; (B) Aorta, reconstructed coronary arteries, main pulmonary artery and right ventricular outflow tract. Postoperative 1-year follow-up cardiac catheterization. Left coronary angiography (frontal view: C and lateral view: D) and right coronary angiography (frontal view: E and lateral view: F).

190x245mm (300 x 300 DPI)