

- [15] Bautista-Hernandez V, Marx GR, Bacha EA, del Nido PJ. Aortic root translocation plus arterial switch for transposition of the great arteries with left ventricular outflow tract obstruction: intermediate-term results. *J Am Coll Cardiol* 2007;49:485–90.
- [16] Morell VO, Jacobs JP, Quintessenza JA. Surgical management of transposition with ventricular septal defect and obstruction to the left ventricular outflow tract. *Cardiol Young* 2005;15 (Suppl 1):102–5.
- [17] Brown JW, Ruzmetov M, Huynh D, Rodefeld MD, Turrentine MW, Fiore AC. Rastelli operation for transposition of the great arteries with ventricular septal defect and pulmonary stenosis. *Ann Thorac Surg* 2011;91:188–93; discussion 93–4.
- [18] Alsoufi B, Awan A, Al-Omrani A, Al-Ahmadi M, Canver CC, Bulbul Z *et al.* The Rastelli procedure for transposition of the great arteries: resection of the infundibular septum diminishes recurrent left ventricular outflow tract obstruction risk. *Ann Thorac Surg* 2009;88:137–42; discussion 42–3.
- [19] Rubay J, Lecompte Y, Batisse A, Durandy Y, Dibie A, Lemoine G *et al.* Anatomic repair of anomalies of ventriculo-arterial connection (REV). Results of a new technique in cases associated with pulmonary outflow tract obstruction. *Eur J Cardiothorac Surg* 1988;2:305–11.
- [20] Lange R, Cleuziou J, Horer J, Holper K, Vogt M, Tassani-Prell P *et al.* Risk factors for aortic insufficiency and aortic valve replacement after the arterial switch operation. *Eur J Cardiothorac Surg* 2008;34:711–7.
- [21] Losay J, Touchot A, Capderou A, Piot JD, Belli E, Planche C *et al.* Aortic valve regurgitation after arterial switch operation for transposition of the great arteries: incidence, risk factors, and outcome. *J Am Coll Cardiol* 2006;47:2057–62.
- [22] Emani SM, Beroukhim R, Zurakowski D, Pigula FA, Mayer JE, del Nido PJ *et al.* Outcomes after anatomic repair for D-transposition of the great arteries with left ventricular outflow tract obstruction. *Circulation* 2009;120 (11 Suppl):S53–8.
- [23] Dasmahapatra HK, Freedom RM, Moes CA, Musewe M, Sherret H, Coles JG *et al.* Surgical experience with left ventricular outflow tract obstruction in patients with complete transposition of the great arteries and essentially intact ventricular septum undergoing the Mustard operation. *Eur J Cardiothorac Surg* 1989;3:241–8; discussion 9.
- [24] Reddy VM, Rajasinghe HA, Teitel DF, Haas GS, Hanley FL. Aortoventriculoplasty with the pulmonary autograft: the 'Ross-Konno' procedure. *J Thorac Cardiovasc Surg* 1996;111:158–65; discussion 65–7.

APPENDIX. CONFERENCE DISCUSSION

Dr M. Hazekamp (Leiden, Netherlands): Especially in situations where the pulmonary valve is small and cannot be used for arterial switch, sometimes it's very difficult to decide beforehand what will be the best option - Rastelli, REV,

Nikaidoh operation or univentricular palliation. And I think it's important that you tried to make a complexity score of LVOTO and get some system into it. I think that's very worthwhile for the individual surgeon. It seems that in many instances, particularly with a small and not usable pulmonary valve, Nikaidoh seems to be the best option, but I think you should not forget to mention the REV or the modified REV operation which, in the multicentre study that we did with the European Congenital Heart Surgeons Association, came out as also a very good option. And while for some reason it's only used in French-speaking countries, probably for historical reasons, it merits attention because it's a good operation as well.

I agree with you fully that when the pulmonary valve is reasonably big, not too dysplastic, in almost all cases you can do an arterial switch operation with resection of the outflow tract obstruction.

I have several comments. I also agree with you that whenever the right coronary artery crosses in front of the aortic valve, then probably it's better not to do a Nikaidoh operation because you may get into big problems.

I thank you for using the Leiden classification of coronary anatomy, but maybe in your manuscript you should change it slightly, because when you talk about a right coronary crossing over the RVOT towards the right, you name it, for example, 1LR-2CX, but it should be 1RL-2CX, because you have the observer in the facing sinus and he looks anticlockwise. Then the first one you encounter you should name first. So maybe you should correct that in the manuscript. Furthermore, in your manuscript you describe one patient who received arterial switch with relief or resection of LVOT obstruction with the pulmonary valve z-score of minus 5.6. And that's, for me, a little bit difficult to believe, so maybe you can comment on that. That's the first question.

You also describe in your manuscript that this complexity score has one weak point and that's something you didn't mention here but I think it's very important to name it, because if you have, for example, mal-attachment of the tension apparatus of the mitral valve, you have only one point in the complexity score because everything else can be okay, but you are unable to do biventricular repair, so you go to the worst side of surgery. Opposed to that, you may have a patient with points on the pulmonary valve, on the septum, etc, etc, but still you can go for biventricular repair. So that must be addressed. So these were the two questions, pulmonary valve z-score minus 5.6 and this limitation of the complexity score.

Dr Kotani: Regarding your first question, that patient had a very small pulmonary valve measured at about z-score minus 5 on preoperative echo. Sometimes it's difficult to exactly measure the pulmonary valve in the setting of complex LVOTO. In fact, in the OR, the pulmonary valve was a reasonable size with a z-score of minus 2, which allowed us to proceed with the switch operation.

For the second question, I totally agree with your comment regarding the limitations of this scoring system. The patient with mild multi-level obstruction, and the patient with one significant single-level obstruction could end up with the same score, so I think we need to refine the complexity score.

Arterial switch, Réparation à l'étage ventriculaire, Rastelli or Nikaidoh?

René Prêtre*

Cardiac Surgery Unit, University Hospital of Lausanne (CHUV), Lausanne, Switzerland

* Corresponding author. Cardiac Surgery Unit, University Hospital of Lausanne (CHUV), 46 Rue du Bugnon, CH-1011 Lausanne, Switzerland.
Tel: +41-21-3140641; fax: +41-21-314-2879; e-mail: rene.pretre@chuv.ch (R. Prêtre).

Keywords: Transposition of the great arteries • Left ventricular outflow tract obstruction • Nikaidoh procedure • Rastelli operation • Coronary artery pattern

Honjo and co-workers, from the Toronto group, proposed an anatomical complexity score of the left ventricular outflow tract

obstruction (LVOTO) to help in choosing between a variety of surgical corrections in face of dextro-transposition of the great

arteries (d-TGA) and LVOTO [1]. The decision on the best repair in the presented series of 28 patients was actually made in a standard fashion— with preoperative and intraoperative assessments—and the results were simply fantastic, apparently with no error of judgement. The proposed echocardiographically-derived scoring system was applied retrospectively and was subsequently correlated to the surgical procedure chosen. Not surprisingly, a correlation between the echocardiographic findings and the surgical option applied was found and coefficients of obstruction were further set.

Will this new scoring system truly help us? We are not sure. The critical decision in this group of patients is mostly whether an arterial switch operation (ASO), with opening of the outflow tract, can still be achieved instead of an 'intracardiac repair', like the 'Réparation à l'étage ventriculaire' (REV), Rastelli or Nikaidoh procedures. The choice between these operations or a single ventricle pathway will continue to be guided by an 'eyeballing' of the LVOT in echocardiographic views and will ultimately be influenced by intraoperative findings, as acknowledged by the surgical results of this study [2–4]. The preoperative echocardiography (with or without an obstruction scoring system) gives a clue—often a strong one—as to the possible options. Its value is certainly the clear definition of the multiple components of the obstruction, but a surgeon needs more than a crude anatomy to definitively plan his operation. He needs information on the resectability of these components, something that often appears only during surgery. A straddling papillary muscle will get a low obstructive score but will cause more trouble than an extensive tissue tag formation or a bulging conal septum.

The two opposing philosophies in the repair of TGA-LVOTO relate to the choice of the second-best option after the ASO, namely either the REV/Rastelli procedure or the Nikaidoh procedure and its variant 'the double root rotation' [2–5]. Strong proponents of the Nikaidoh procedure, such as the Toronto group, do not really need a scoring system for the obstructive components as, *per definition*, they will reposition the aortic root beneath them. As a matter of fact, the decision between the two procedures in the presented study was not influenced by the obstructive components, but by the pattern of the coronary arteries alone. Strong proponents of the REV/Rastelli procedure consider that the relief of the obstructive components can be achieved in virtually all patients with an operation performed at the right time. To them, the Nikaidoh procedure is indicated mostly in cases of a restrictive ventricular septal defect, of a small right ventricle or when

the whole 'double root' can be rotated, and the scoring system will merely remain an academic tool [5]. In their experience, the gap of the mitro-aortic discontinuity correlates more with the magnitude of the intracardiac repair (to ensure a wide open left outflow tract) than with the pattern of the obstructing components [6]. In this controversy, only surgeons undecided between these two schools of thought might take an interest in the scoring system [7].

Still, the scoring system is a valuable new tool, mostly in cases where it can identify these patients with a potential complete or partial function of the pulmonary valve. As for any scoring system established retrospectively, it must now be validated prospectively and further fine-tuned—especially in respect of the characteristics of the sub-pulmonary area and the pulmonary root and leaflets—because this is the component of the proposed complexity score that will reveal the patients for whom a successful ASO is still possible or on whom a 'double root rotation' can be performed [5].

Conflict of interest: none declared.

REFERENCES

- [1] Honjo O, Kotani Y, Bharucha T, Mertens L, Caldarone CA, Redington AN *et al.* Anatomic factors determining surgical decision-making in patients with transposition of the great arteries with left ventricular outflow tract obstruction. *Eur J Cardiothorac Surg* 2013;44:1085–94.
- [2] Brown JW, Ruzmetov M, Huynh D, Rodefeld MD, Turrentine MW, Fiore AC. Rastelli operation for transposition of the great arteries with ventricular septal defect and pulmonary stenosis. *Ann Thorac Surg* 2011;91:188–93; discussion 93–4.
- [3] Di Carlo D, Tomasco B, Cohen L, Vouhe P, Lecompte Y. Long-term results of the REV (reparation a l'etage ventriculaire) operation. *J Thorac Cardiovasc Surg* 2011;142:336–43.
- [4] Yeh T Jr., Ramaciotti C, Leonard SR, Roy L, Nikaidoh H. The aortic translocation (Nikaidoh) procedure: midterm results superior to the Rastelli procedure. *J Thorac Cardiovasc Surg* 2007;133:461–69.
- [5] Mair R, Sames-Dolzer E, Vondrys D, Lechner E, Tulzer G. En bloc rotation of the truncus arteriosus—an option for anatomic repair of transposition of the great arteries, ventricular septal defect, and left ventricular outflow tract obstruction. *J Thorac Cardiovasc Surg* 2006;131:740–41.
- [6] Raissy O, Vouhe PR. Pitfalls in repair of conotruncal anomalies. *Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu* 2013;16:7–12.
- [7] Hazekamp MG, Gomez AA, Koolbergen DR, Hraska V, Metras DR, Mattila IP *et al.* Surgery for transposition of the great arteries, ventricular septal defect and left ventricular outflow tract obstruction: European Congenital Heart Surgeons Association multicentre study. *Eur J Cardiothorac Surg* 2010;38:699–706.