Anterior Translocation of the Right Pulmonary Artery to Avoid Airway Compression in Aortic Arch Repair

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Background. Airway compression caused by an enlarged right pulmonary artery (RPA) in patients with a large shunt can usually be managed with intracardiac repair and concomitant anterior aortopexy. However, anterior aortopexy can be less effective or even dangerous in patients with coexisting arch anomaly due to excessive tension at the arch repair site. We have adopted anterior translocation of RPA without aortic transection in the group of patients with a high risk of postoperative airway compression. We reviewed the early and midterm results of this technique.

Methods. From February 2006 to January 2013, 8 patients underwent RPA anterior translocation as a concomitant procedure in one-stage repair of ventricular septal defect (VSD) and aortic arch anomaly to avoid postoperative airway problems. The enlarged RPA was disconnected from the main pulmonary artery (MPA) at its origin and was relocated anterior to the ascending aorta, and subsequently reimplanted to the U-shaped trapdoor incision at the anterolateral MPA wall. The mean age at operation was 34 days (median, 14 days, 6 to 77 days), and the mean body weight was 3.6 kg (2.15 to 5.5 kg). All patients had coarctation of the aorta and VSD except 1 who had aortic arch interruption. Five patients were dependent on a ventilator preoperatively. Six patients had evidence of preoperative bronchial compression (left; 4, right and left; 2), and 2 had a high probability of postoperative bronchial compression due to unusual anterior location of the descending aorta.

Results. There was no early or late death. There were no postoperative airway problems such as reintubation or left lung atelectasis. Widely patent RPA was confirmed on postoperative computed tomographic angiography in all patients. The mean follow-up duration was 54.0 ± 17.1 months. One patient required balloon angioplasty for mild stenosis at the clamping site 3 years after the operation. All patients had no RPA stenosis at the latest follow-up evaluation.

Conclusions. Anterior translocation of the RPA as a concomitant procedure in one-stage repair of VSD and arch anomaly is a safe and effective procedure to avoid postoperative airway problems in high-risk patients.

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Institutional Review Board approval was obtained from Pusan National University Yangsan Hospital to collect the clinical data. The mean age at operation was 34 days (median, 14 days, 6 to 77 days), and the mean body weight was 3.6 kg (2.15 to 5.5 kg). We had the same number of male and female patients. Seven patients had coarctation of the aorta, and 1 patient had interrupted aortic arch associated with distal aortopulmonary window. Five patients were dependent on mechanical ventilation preoperatively, and 6 were put on prostaglandin E1 infusion. Six patients had evidence of bronchial compression on their computed tomographic (CT) angiography; compression of the left main bronchus in 4 patients (Fig 1A), compression of both main bronchi in 2 (Fig 2A). Two patients had a high probability of postoperative bronchial compression due to unusual anterior location of the descending aorta, even though airway compression was not so significant (Fig 3A).

**Operative Technique**

Cardiac anomaly was repaired under cardiopulmonary bypass and regional cerebral perfusion through median sternotomy. Prior to arterial and venous cannulations, the head vessels, patent ductus arteriosus, and RPA were mobilized with the help of electrocautery. Systemic and regional cerebral perfusions were performed through the innominate artery. Under hypothermic cardiopulmonary bypass after bicaval cannulations, the patent ductus arteriosus and upper thoracic descending aorta were fully mobilized. Another arterial cannula was put into the descending aorta through the patent ductus arteriosus if necessary. After inducing cardiac arrest with cold blood cardioplegic solution, VSD closure and arch repair were performed. Translocation of the RPA was then carried out under beating heart conditions. The extensively mobilized RPA was excised from the posterolateral wall of the main pulmonary artery (MPA), and the resultant defect was closed with a glutaraldehyde-treated autologous pericardial patch. A U-shaped trapdoor incision was made on the anterolateral aspect of the MPA (Fig 4B), and the anteriorly translocated RPA was anastomosed to this trapdoor incision (Figs 4C, 4D). In 7 patients with VSD and coarctation of the aorta, no patch augmentation was required (Figs 4A–4D). In the patient with interrupted aortic arch associated with aortopulmonary window, the RPA was not long enough to make a direct anastomosis to the MPA because the RPA originated from the ascending aorta (Fig 5A). Therefore, we developed a large flap from the anterior wall of the MPA for native tissue anastomosis (Fig 5B). The posterior half of the RPA was anastomosed to the MPA anterior wall flap (Fig 5C), and the anterior half of the RPA and the large trapdoor opening were redundantly covered with an untreated autologous pericardial patch (Fig 5D). The mean cardiopulmonary bypass time, aortic cross-clamp time, and regional cerebral perfusion time were 180 ± 35.4 minutes, 92.9 ± 14.6 minutes, and 31.6 ± 5.7 minutes, respectively.

**Results**

There was no postoperative mortality or major morbidity. The mean postoperative mechanical ventilation time was 59.2 ± 27.5 hours (median; 55.2 hours, range; 28.3 to 117 hours). No patient required endotracheal reintubation. There were no postoperative problems such as left lung total atelectasis or pneumonia related to the airway. The mean hospital stay was 20 days (8 to 47 days). No RPA stenosis or airway compression was observed on the CT scan taken at discharge in all patients (Figs 1B–3B). The mean follow-up duration was 54.0 ± 17.1 months. In 1 patient, mild RPA stenosis was observed at its clamping site 3 years after the operation, which was simply managed with balloon dilatation. All patients had no RPA

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Fig 1. (A) Preoperative chest computed tomographic (CT) scans of the patients with left main bronchus compression (black arrow) by enlarged right pulmonary artery (R). (B) Postoperative chest CT scans shows widely patent left main bronchus (red star) after anterior translocation of right pulmonary artery (R). (AA = ascending aorta; DA = descending aorta.)
stenosis and were in New York Heart Association class I at the latest follow-up evaluation.

**Comment**

Airway compression due to a dilated right pulmonary artery in infants with a large left-to-right shunt can cause severe respiratory insufficiency and increased postoperative morbidity [1–3]. In such a situation, airway compression usually responds well to concomitant simple anterior aortopexy with intracardiac repair, even though anterior translocation of the RPA has also been reported to be successful in relieving airway compression [5–7]. However, the clinical situation of patients with aortic arch obstruction may be more complicated. In fact, airway compression in patients with aortic arch obstruction and a large intracardiac shunt is not uncommon [8]. A normal aortic arch produces a wide and harmonious curve that encircles the origin of the RPA and the left main bronchus. Direct repair of arch obstruction inevitably produces narrowing of the space between the ascending and descending aortas, which can cause an added condition of significant airway compression to the already dilated right pulmonary artery.

Neonates are particularly susceptible to significant extrinsic airway compression because their already small bronchi have a relatively large impact on airway

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**Fig 2.** (A) Preoperative chest computed tomographic (CT) scans of the patients with both main bronchi compression (black arrows) by enlarged right pulmonary artery (R). (B) Postoperative chest CT scans shows widely patent both main bronchi (red stars) after anterior translocation of right pulmonary artery. (AA = ascending aorta; DA = descending aorta.)

**Fig 3.** (A) Preoperative chest computed tomographic (CT) scans of the patient with abnormally anterior location of the descending aorta (DA). Left main bronchus compression might occur after aortic arch repair. (B) Postoperative chest CT scans after anterior translocation of right pulmonary artery (R). (AA = ascending aorta.)
resistance even by a small reduction in the caliber of the airway. Large left-to-right shunts can compress the airway due to the close proximity of enlarged pulmonary arteries to the bronchi. The size and pressure of the pulmonary artery can be reduced after closing the shunt lesions, which may ameliorate the airway compression. However, correction of only a cardiac defect is often insufficient for the relief of severe airway compression, especially in the early postoperative period. Moreover, the bowstring effect of a repaired arch can make the situation worse. If there are symptoms related to airway compression or findings suggestive of airway compression in imaging studies before surgery, concurrent procedures to relieve airway compression should be considered to avoid postoperative airway problems. It is important to emphasize that airway complications in small infants prolong mechanical ventilatory support and result in permanent lung damage. Therefore, we have adopted an aggressive policy to perform concomitant procedures to relieve airway compression at the initial operation. Anterior aortopexy is thought to be a simple and effective procedure to avoid postoperative airway problems, but this procedure may be ineffective and even dangerous in patients who require arch reconstruction. We have been performing anterior translocation of the RPA since 2006 as a concomitant procedure with one-

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**Fig 4.** Anterior translocation of right pulmonary artery (RPA) without patch augmentation. (A) Regional cerebral perfusion. (B) RPA excision and trap-door incision on the MPA. (C,D) RPA anastomosis to trapdoor incision. (MPA = main pulmonary artery.)

**Fig 5.** Anterior translocation of right pulmonary artery (RPA) with patch augmentation. (A) RPA originated from the ascending aorta. (B) Large MPA flap with trapdoor incision. (C) Posterior half anastomosis of RPA to MPA anterior wall flap. (D) Covering of anterior half of RPA and the large trap-door opening with autologous pericardial patch. (MPA = main pulmonary artery.)
stage repair of aortic arch anomaly and VSD in patients with airway obstruction or those who are at risk of postoperative airway compression. Since we adopted this policy we have not detected any significant airway problems after one-stage repair of arch anomaly and VSD. We have performed this procedure in 8 of 81 patients with arch anomaly and VSD since we adopted this policy. Six patients had preoperative airway compression, which was effectively relieved after the operation in all cases. Two patients were anticipated to have postoperative airway problems because of unusual anterior location of the descending aorta. These 2 patients also had no problem with their airway after the operation (Fig 3B). Our recent indication of RPA anterior translocation is clear; which is a significant compression of airway by an enlarged right pulmonary artery at preoperative CT scan.

The anterior translocation of pulmonary arteries has been proven to be a safe procedure in clinical practice [9]. We think that extensive mobilization of both pulmonary arteries is very important as it is in the arterial switch operation for the prevention of posterior compression of the RPA and a tension-free anastomosis between the anteriorly translocated RPA and MPA. A large space anterior to the ascending aorta is usually created after arch repair. Thus, posterior compression of the RPA by the ascending aorta seldom occurs. However, we believe it is critical that the RPA be placed tensionless anterior to the ascending aorta; otherwise, it can be compressed by the high pressure generated by the posteriorly located ascending aorta or narrowed by tension. The RPA anterior to the ascending aorta should be sufficiently redundant and not be compressed by the ascending aorta. As a result, the RPA should always be connected to the anterolateral aspect of the MPA after patch closure of the original site of the RPA. We developed a U-shaped flap on the anterolateral aspect of the MPA to make a wide tissue-to-tissue anastomosis without distortion of the RPA in 7 patients (Fig 4). We devised a large trapdoor flap from the anterior wall of the MPA in a patient who had the RPA originating from the ascending aorta and distal aortopulmonary window with a resultant short RPA in addition to the interrupted aortic arch and VSD. The anastomotic site was augmented with a redundant autologous pericardial patch (Fig 5).

Our technique is quite different from the typical Lecompte maneuver. In the typical Lecompte maneuver, the ascending aorta and main pulmonary artery should be divided. The ascending aorta in the patients with aortic arch anomaly and VSD is usually small. The division and re-anastomosis of such a small ascending aorta can result in stenosis of the ascending aorta in the future. Moreover, the most important reason not using a typical Lecompte maneuver is the high probability of RPA compression by a posteriorly located high pressure ascending aorta when the typical Lecompte maneuver is adopted. Our technique is simple. Posterior compression of the RPA can be avoided by reattachment of the RPA to the right anterolateral wall of the MPA after closing the original defect created by excision of the RPA at the posterolateral wall of the MPA with a patch. We observed complete relief of airway compression and confirmed a widely patent RPA by CT angiography in all cases. Only 1 patient required balloon angioplasty for mild RPA stenosis at the clamping site 3 years after the operation. There have been no significant problems with RPA anterior translocation so far, even though the follow-up duration was not long. We think that anterior translocation of the RPA is a highly effective and safe procedure to avoid postoperative airway problems in selected cases with arch anomaly and VSD.

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References