Management of congenital tracheal stenosis by means of slide tracheoplasty or resection and reconstruction, with long-term follow-up of growth after slide tracheoplasty

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Objective: The difficult problem of congenital tracheal stenosis is infrequent and has been managed with several methods. Patch tracheoplasty has been favored in recent years. Alternative experience with a simpler program of slide tracheoplasty for long-segment stenosis or resection and reconstruction for short-segment stenosis is described and proposed as preferable. Long-term growth after slide tracheoplasty was studied.

Methods: Eleven consecutive patients aged 10 days to 23 years with varied patterns of stenosis (including concurrent pulmonary artery sling, anomalous right upper lobe bronchus, and bridge bronchus) had their stenoses corrected, 8 by means of slide tracheoplasty and 3 by means of resection and anastomosis. Retrospective review was made of hospital course, complications, and long-term results, with observation of growth in 4 patients (from more than 1½-7¼ years).

Results: All patients are alive and enjoy good airways. Only 3 patients who needed concomitant cardiovascular procedures and 1 with poor ventricular function required bypass. Eight were extubated immediately or on the day of the operation, 1 at 3 days, and 1 at 8 days. A patient with complex anomalies needed 10 days of ventilation. Three had anastomotic granulomas successfully treated by means of a single bronchoscopy. Long-term airway growth was entirely satisfactory after slide tracheoplasty in 4 infants and small children (aged 10 days, 3 months, 6 months, and 3½ years, respectively).

Conclusions: Slide tracheoplasty gives excellent short- and long-term results because long congenital stenosis is reconstructed with native tracheal tissue and is therefore immediately stable and lined with normal epithelium, and the operation is accomplished more simply and with a generally more benign postoperative course. Wholly satisfactory growth of the repaired segment occurs. Less common short congenital stenosis is effectively managed with resection and anastomosis.

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Congenital tracheal stenosis occurs in varied lengths, which are most often characterized by complete cartilaginous O rings. The stenotic segment may be located in upper or lower trachea, may be funnel shaped, and may involve different percentages of the length of trachea.¹ Stenosis may also involve the main bronchi and may be accompanied by an anomalous right upper lobe bronchus or by a

Figure 1. Technique of slide tracheoplasty. A, The extent of stenosis is identified precisely. The stenotic segment is divided transversely in its midpoint after circumferential dissection at that locus only. The upper stenotic segment is incised vertically posteriorly, and the lower segment is incised anteriorly for the full length of stenosis. B, The right-angled corners produced by these divisions are trimmed above and below. A stay suture near the tip of the superior flap is helpful, as are traction sutures at the tracheobronchial angles or main bronchi below. Minimal dissection of lateral blood supply is performed. C, The two ends are slid together after placement of individual anastomotic sutures around the entire oblique circumference of the tracheoplasty. D and E, The circumference is doubled, resulting in quadrupled cross-sectional area. Reprinted with permission from the Society of Thoracic Surgeons (*The Annals of Thoracic Surgery* 1994;58:613-21.)

bridging bronchus below, such an anomalous bronchus connecting with horizontal bronchi to the remainder of the right and left lungs.² A left pulmonary artery sling may be found with either a short segmental stenosis or a more complex form of stenosis.³ Other variants also occur. Multiple anomalies, including cardiac malformations, are frequently associated. Patients may be symptomatic immediately after birth or may manage with limited exercise tolerance until later in life.

There is no effective medical treatment. Forceful dilation may result in splitting the cartilage O rings, with the possibility of perforation or restenosis. Three surgical techniques have been used for correction. First, early reports of tracheal resection and reconstruction in children by DeLorimier and colleagues,⁴ Grillo and Zannini,⁵ and Carcassonne and coworkers⁶ included patients with congenital stenosis. It was demonstrated experimentally and clinically^{7,8} that anastomosis of the juvenile trachea grew satisfactorily. However, only a finite length of trachea, approximately 25% to 30%, can be resected and followed by end-to-end suture before excessive anastomotic tension may result in separation.⁹

Second, long congenital stenosis beyond the compass of safe resection and reconstruction was treated by Kimura,¹⁰ Tsugawa,¹¹ and their associates by means of a linear anterior incision of the stenotic segment and insertion of a patch of costal cartilage. Idriss and colleagues¹² and successors

modified this approach by substitution of a pericardial patch. The flexible pericardial insert must be suspended to the mediastinum, and all patch techniques require prolonged stenting with intubation during early healing. Patch techniques were also reported by Bando,¹³ Jaquiss,¹⁴ and their associates. Granulation tissue arising from the mesenchymal surface of the patches required multiple bronchoscopic debridements and necrosis or collapse of the patch sometimes occurred.^{15,16} Reoperation was necessary in 7 of 28 patients.¹⁷

Third, to solve this vexing problem, Tsang and associates¹⁸ proposed slide tracheoplasty. The stenotic segment is transected at its midpoint, the upper and lower stenotic segments are incised vertically anteriorly in one segment and posteriorly in the other, the corners of these splayed segments are trimmed, and the two are slid together and sutured (Figure 1). The circumference of the trachea is doubled, and the cross-sectional area is quadrupled.¹⁹ The stenotic segment is shortened by half. The trachea is thus repaired with tracheal wall containing native cartilages and is immediately lined with normal tracheal epithelium. Satisfactory subsequent growth was demonstrated experimentally and clinically.^{20,21}

Since the introduction of slide tracheoplasty at Massachusetts General Hospital in 1991, 8 patients ranging in age from 10 days to 19 years with stenoses varying in

Figure 2. Diagrams of anatomic findings in 8 patients who underwent slide tracheoplasty. Figures indicate percentage of stenotic trachea. Scale differs because of wide range of age and tracheal size. Details are listed in Table 1.

Figure 3. Diagram of anatomic findings and reconstruction performed in 3 patients who underwent resection. Details in Table 2.

TABLE 1. Patients undergoing slide tracheoplasty

	Patient No.				
	1	2	3	4	5
Age at operation	19 y	19 y	3 mo	3½ y	15 y
Sex	F	F	M	M	M
Length of stenosis/ tracheal length (cm)	6/8	7.5/9	2.7/5.5	2/5.5	6.5/12
Length of stenosis (%)	75	83	49	36	54
Minimum tracheal diameter (mm)	3-4	5	2	2-3	6
Anomalous RUL bronchus	—	+	—	—	+
Bridge bronchus	—	—	—	—	—
LPA sling	—	—	—	—	—
Associated anomalies	Absent thyroid isthmus	Common trunk R and L innominate arteries	—	—	Malacia above carina; pulmonary stenosis, ASD, PDA (repair 1980)
Date of operation	4/10/91	8/20/92	11/3/92	5/4/93	6/28/95
Approach	Cervical	Cervicomedial	Cervical	Cervicomedial	Cervicomedial
Cardiopulmonary bypass	—	—	—	—	—
Cardiovascular procedures	—	—	—	—	—
Site (d) extubation	OR	OR	OR	OR	OR
Postoperative hospital stay (d)	10	12	10	8	9
Complications	Granuloma	—	—	Subcutaneous suture	Granuloma
Treatment Outcome	Single bronchoscopy No recurrence			Removed Healed	Single bronchoscopy No recurrence
Length of follow-up	10 y	8 y, 6 mo	8 y, 5 mo	7 y, 9 mo	5 y, 9 mo
Result	Good	Good	Good	Good	Good

Patients 1 to 4 and 6 were previously reported.^{19,24} NA, Not applicable; RUL, right upper lobe; LPA, Left pulmonary artery; ASD, atrial septal defect; PDA, patent ductus arteriosus; SVC, superior vena cava; DORV, double-outlet right ventricle; VSD, ventricular septal defect; LVC, left vocal cord; OR, operating room; ICU, intensive care unit.

length and location and with and without additional bronchial or cardiac anomalies, including left pulmonary artery sling, have undergone surgical correction with this technique (Figure 2). Three additional patients with congenital stenosis underwent tracheal resection and reconstruction by means of direct end-to-end anastomosis during this period (Figure 3). In these 3 patients simple anastomotic technique seemed to be safely applicable, and in 2

patients it was judged that slide tracheoplasty was inappropriate for additional reasons. The patients were operated on by members of the General Thoracic Surgical Division (H.C.G. and C.D.W.) with cooperation of the Cardiac Surgical Division (G.J.V. and T.E.M.) when required. Complete preoperative delineation of airway and cardiovascular abnormalities is essential. Critical studies include bronchoscopy, spiral computed tomography,

Patient No.		
6	7	8
6 mo	10 d	10½ y
M	M	M
2.5/NA	2/4	7.5/11.5
Bridge only	50	65
<2	1.9	2-3
+	—	—
+	—	—
+	+	+
Anomalous SVC	Imperforate anus, hypospadias, radial dysplasia, vertebral anomaly, ASD, syringomyelia	Anomalous pulmonary artery Single-ventricle physiology, DORV, VSD, hypoplastic left ventricle, tricuspid regurgitation, prior pulmonary artery band, Glenn operation
3/25/96	9/3/99	2/5/01
Cervicomedial (complete sternotomy)	Cervicomedial (complete sternotomy)	Cervicomedial (complete sternotomy)
+	+	+
Divide ligamentum, reimplant LPA	Divide ligamentum, reimplant LPA	—
ICU (3)	ICU (8)	ICU (operative day)
13	24	10
L vocal palsy, LPA flow 25%	Low LPA flow	—
LPA dilation	Observation	
LPA flow 37%, LVC recovery		
5 y	1 y, 6 mo	2 mo
Good	Good	Good

echocardiography, and cardiac catheterization with angiography in some patients.

Patients and Methods

Patients

Slide tracheoplasty. Data on patients undergoing slide tracheoplasty are given in Table 1. The 4 younger patients (operated on at ages 10 days, 3 months, 6 months, and 3½ years) were seriously

symptomatic (patients 7, 3, 6, and 4). The 10-day-old infant was transferred from another hospital intubated and in respiratory distress. The 3-month-old child had stridor and episodes of cyanosis and desaturation. The 6-month-old child had a similar history and was received intubated receiving heliox with elevated PCO₂. The 6-month-old had respiratory arrest and was transferred intubated from another hospital. A 10½-year-old (patient 8) had dyspnea, stridor, cyanosis, and impaired ventricular function. She had undergone a bidirectional Glenn procedure earlier in life. Her airway was corrected in anticipation of a Fontan procedure. Maximal stenosis in these patients was between 1.9 and 3 mm in diameter. The 3 teenaged patients (patients 1, 2, and 5) were severely limited in activities of all types. One had been seen previously, but repair initially was deferred because only patch procedures were then available.

Stenoses varied in length from 36% to 83% of tracheal length (Figure 2). Of these 8 patients, 3 had an anomalous right upper lobe bronchus, 1 associated with a bridging bronchus and also left pulmonary artery sling. Another anomalous pulmonary artery was in conjunction with 50% of length lower tracheal stenosis. He had a constellation of anomalies that occur with congenital tracheal stenosis, including imperforate anus. The 10½-year-old had an anomalous retrotracheal pulmonary artery (anastomosed previously to the superior vena cava at the time of a bidirectional Glenn procedure), but it did not curve around or impinge significantly on the trachea. One showed a degree of malacia in the short segment of trachea below a bronchus suis and also in both main bronchi.

Resection and reconstruction. Data on patients undergoing resection and reconstruction are given in Table 2. The 3-month-old had severe symptoms from birth and had a complex of stenosis and malacia over a short tracheal segment just above the carina (patient 9). The shortness of the segment and the accompanying malacia were indications for resection and anastomosis. The 7-month-old with VACTERL* association was transferred intubated and ventilated by means of tracheostomy after tracheoesophageal fistula repair, modified Blalock-Taussig shunt for single-ventricle congenital heart disease, gastric fundoplication, and colostomy. He had air trapping and episodes of airway obstruction (patient 11). A bridging bronchus was very narrow throughout but showed maximal stenosis at its proximal end, making it unsuitable for slide tracheoplasty, as was done in patient 6. The segment was short enough to permit complete resection and anastomosis. The 23-year-old had been observed since infancy, when the stenosis was deemed too long for resection. He had undergone several surgical procedures for other malformations. The stenotic segment remained narrow but grew proportionally to the normal trachea. Resection was done to enhance his performance capabilities (patient 10).

Procedures

The technique of our modification of Tsang and Goldstraw's procedure for slide tracheoplasty has been described in detail.¹⁹ The first 5 tracheoplasties were performed without need for cardiopulmonary bypass. Two patients who required reimplantation of the

*Vertebral abnormalities, Anal atresia, Cardiac abnormalities, Tracheoesophageal fistula and/or Esophageal atresia, Renal agenesis and dysplasia, and Limb defects.

TABLE 2. Patients undergoing resection and reconstruction

	Patient No.		
	9	10	11
Age at operation	3 mo	23 y	7 mo
Sex	M	M	M
Length of stenosis (cm)	1.5	3	1
Minimum tracheal diameter (mm)	2	10	<2
Anomalous RUL bronchus	—	—	+
Bridge bronchus	—	—	+
LPA sling	—	—	—
Associated anomalies	Malacic main bronchi	Radial dysplasia, megaureters, hypoplastic kidney, inguinal hernias	TEF, imperforate anus, hypoplastic kidney, hydronephrosis, pulmonary atresia, ASD, VSD, hypoplastic left heart (single ventricle)
Date of operation	12/23/94	4/16/96	12/7/98
Approach	Cervicomedial (complete sternotomy)	Cervical	Cervicomedial (complete sternotomy)
Cardiopulmonary bypass	—	—	+
Cardiovascular procedures	—	—	Atrial septectomy
Site (d) extubation	OR	OR	Prior tracheostomy, CPAP for 10 d
Hospital postoperative stay (d)	10	5	13 (transfer)
Complications	Late granuloma	—	Atelectasis, tracheostomy granuloma
Treatment	Single bronchoscopy	—	Bronchoscopic aspiration, removal of granuloma
Outcome	No recurrence	—	Cleared
Length of follow-up	6 y, 3 mo	5 y	2 y, 3 mo
Result	Good	Good	Fair (airway: good)

RUL, Right upper lobe; LPA, left pulmonary artery; TEF, tracheoesophageal fistula; ASD, atrial septal defect; VSD, ventricular septal defect; OR, operating room; CPAP, continuous positive airway pressure.

TABLE 3. Slide tracheoplasty for congenital tracheal stenosis

Reference	Year	No.	Deaths
Tsang and associates ¹⁸	1989	2	1
Dayan and associates ²³	1997	2	1
Houël and associates ²⁵	1998	1	0
Muraji and associates ²⁸	1998	1	0
Lang and associates ²⁶	1999	2	0
Lipshutz and associates ²⁹	2000	1	0
Matute and associates ²⁷	2001	4	0
Garabedian and associates ³⁰	2001	1	0
Grillo and associates*	2001	8	0
Total		22	2

Repetitive case reports excluded.

*Original report of 4 patients, 1994.¹⁹

left pulmonary artery also needed a period of normothermic bypass. Because the left pulmonary artery was divided early for access, the tracheoplasty was also performed during bypass before pulmonary arterial reanastomosis. In patient 6 a segment of mild stenosis proximal to the severely stenotic bridging bronchus was not modified, and tracheoplasty was confined to the very stenotic

bridging bronchus. In all but the first patient, the distal segment of stenosis was opened anteriorly. Patient 1 showed cartilage O rings in both main bronchi, but narrowing was insufficient to require enlargement. The slide technique could be modified to accomplish this were it necessary.

Patient 8 was operated on during bypass because of impaired ventricular function. The stenosis telescoped from a 3.5-cm segment with a diameter of 3 to 4 mm to a 4-cm segment of 2 to 3 mm in diameter, with an additional shelf of scar at the meeting point of the segments. This was believed to have resulted from prolonged intubation during prior operations. This 1-cm zone of maximal stenosis was resected, and slide tracheoplasty was performed on the remaining stenosis.

The thymic lobes are usually separated for tracheal exposure. With modest further mobilization, a thymic lobe was generally interposed between the tracheal suture line and the brachiocephalic artery to buttress the anastomosis and prevent potential erosion of the artery. Right sternohyoid muscle divided superiorly was used in patient 8, in whom previous cardiac operations made the thymus unavailable.

Resection and simple reconstruction was done with our conventional tracheal surgical techniques. In the patient with supracarinal stenosis and malacia (patient 9), complete sternotomy and transpericardial exposure of the carina provided excellent access. A

sufficiently wide opening for generous tracheal anastomosis was created at the junction of the relatively transverse main bronchi. The anastomosis was covered with a pedicled strip of pericardium.

Resection of a connecting bridge bronchus was described by Cantrell and Guild.¹ Larger ovoid apertures were made at the site of origin of the stenotic bridge and at its insertion into the distal bronchial branching (patient 11). Great care was taken to widen these openings so that bronchial kinking would be minimized after approximation of the apertures. Cardiopulmonary bypass was used in this patient with single-ventricle physiology because atrial septectomy was performed concomitantly. The preexisting tracheostomy was left in place.

All patients were approached anteriorly, 3 through a cervical incision only, 3 through a collar incision with partial upper sternotomy, and 5 through a collar incision with complete sternotomy.

Results

All patients survived and obtained a widely patent and stable airway. Although wholly normal tracheal cross-sectional area was not expected after slide tracheoplasty, the quadrupled enlargement was sufficient to relieve all symptoms. In all juvenile patients the repaired tracheal segment continued to grow. Growth has been observed in patients operated on at age 10 days, 3 months, 6 months, and 3½ years during, respectively, follow-up periods of 1 year and 6 months and over 8, 5, and 7 years. Growth was predictable from sequential bronchoscopic observation of unoperated stenosis (patient 10) and by means of imaging.²²

Two of 7 slide tracheoplasty patients and 1 resection patient had a single suture line granuloma that was removed by means of a single bronchoscopy and did not recur. Tracheal stomal granulation tissue occurred in the resected patient referred with a preexisting tracheostomy, multiple prior operations, and on a ventilator. He was troubled by postoperative atelectasis and needed repeated aspiration bronchoscopies for secretions. He has continuing medical problems, but his airway remains entirely adequate. The 2 patients who had left pulmonary artery reimplantation showed reduced arterial flow. One underwent dilation of the arterial anastomosis, with improvement in flow. One subcutaneous sternal closure suture was removed. One patient had left vocal cord paralysis postoperatively, which recovered spontaneously.

Discussion

Short-segment congenital tracheal stenosis is generally best treated with now safe and standardized methods of tracheal resection and reconstruction. Long-segment stenosis is effectively and safely treated with slide tracheoplasty, as shown here. The advantages of this method over various techniques of patch tracheoplasty lie in the immediate reconstruction of trachea with tracheal tissue, providing a stable cartilaginous wall with normal epithelial lining. When carefully executed, the operation has not led to loss

of viability from interference with tracheal blood supply or to failure of healing. Most of the lateral blood supply of the trachea is preserved. Excessive tension does not develop. Direct complications have been limited to a few one-time granulomas and a single transient injury to a recurrent laryngeal nerve. The conduct of the operation is simplified because cardiopulmonary bypass is usually not needed. Bypass is necessary only for accompanying cardiovascular procedures or borderline cardiac physiology. Routine postoperative endotracheal tube splinting is unnecessary, allowing prompt or early extubation except in patients with otherwise complicated anomalies. Tracheostomy was not performed.

Given the lesser tolerance of tension in juvenile tracheal anastomosis,⁹ slide tracheoplasty should, in our opinion, be considered for all but the shortest stenotic segments. In infants it is also likely that a slide procedure would lessen the obstructive possibility of early narrowing caused by edema in a circular suture line after resection. Slide tracheoplasty is gaining acceptance.^{16,23-30} Although most are reports of 1 or 2 patients, overall mortality, including this series, is 9% (Table 3).

Patch tracheoplasty met a previously urgent need but should now perhaps be largely reserved for unusual problems. Insertion into the tracheal wall of a devascularized mesenchymal patch of pericardium or cartilage without epithelial covering, subsequent need for prolonged postoperative airway splinting by means of intubation, proclivity to form troublesome granulations, and the possibility, although infrequent, of necrosis or collapse, would all seem to favor use of slide tracheoplasty or resection and reconstruction as preferred techniques for treating long and short congenital tracheal stenosis, respectively.

Finally, resection of a very short bridge bronchus (patient 11) deserves attention for treatment of that specific anatomic situation.¹

References

1. Cantrell JR, Guild HC. Congenital stenosis of the trachea. *Am J Surg*. 1964;108:297-305.
2. Wells TR, Gwinn JL, Landing BH, Stanley P. Reconsideration of the anatomy of sling left pulmonary artery: the association of one form with bridging bronchus and imperforate anus. Anatomic and diagnostic aspects. *J Pediatr Surg*. 1988;23:892-8.
3. Sade RM, Rosenthal A, Fellows K, Castaneda AR. Pulmonary artery sling. *J Thorac Cardiovasc Surg*. 1975;69:333-46.
4. DeLorimier AA, Harrison MR, Hardy K, Howell LJ, Adzick NS. Tracheobronchial obstruction in infants and children: experience with 45 cases. *Ann Surg*. 1990;212:277-89.
5. Maeda M, Zannini P. Management of obstructive tracheal disease in children. *J Pediatr Surg*. 1984;19:414-6.
6. Carcassonne M, Dor V, Aubert J, Kreitman P. Tracheal resection with primary anastomosis in children. *J Pediatr Surg*. 1973;8:1-8.
7. Maeda M, Grillo HC. Tracheal growth following anastomosis in puppies. *J Thorac Cardiovasc Surg*. 1972;64:3094-13.
8. Couraud L, Moreau JM, Velly JF. The growth of circumferential scars of the major airways from infancy to adulthood. *Eur J Cardiothorac Surg*. 1990;4:521-6.

9. Maeda M, Grillo HC. Effect of tension on tracheal growth after resection and anastomosis in puppies. *J Thorac Cardiovasc Surg.* 1973; 65:658-68.
10. Kimura K, Mukohara N, Tsugawa C, et al. Tracheoplasty for congenital stenosis of the entire trachea. *J Pediatr Surg.* 1982;17:869-71.
11. Tsugawa C, Kimura K, Muraji T, Nishijima E, Matsumoto Y, Murata H. Congenital stenosis involving a long segment of the trachea: Further experience in reconstructive surgery. *J Pediatr Surg.* 1988; 23:471-5.
12. Idriss FS, DeLeon SY, Ilbawi MN, Gerson CR, Tucker GF, Holinger L. Tracheoplasty with pericardial patch for extensive tracheal stenosis in infants and children. *J Thorac Cardiovasc Surg.* 1984;88:527-36.
13. Bando K, Turrentine MW, Sun K, et al. Anterior pericardial tracheoplasty for congenital tracheal stenosis: intermediate to long-term outcomes. *Ann Thorac Surg.* 1996;62:981-9.
14. Jaquiss RDB, Lusk PR, Spray TL, Huddleston CB. Repair of long-segment tracheal stenosis in infancy. *J Thorac Cardiovasc Surg.* 1995; 110:1504-12.
15. Dunham ME, Holinger LD, Backer CL, Mavroudis C. Management of severe congenital tracheal stenosis. *Ann Otol Rhinol Laryngol.* 1994; 103:351-6.
16. Cotter CS, Jones DT, Nuss RC, Jonas R. Management of distal tracheal stenosis. *Arch Otolaryngol Head Neck Surg.* 1999;125:325-8.
17. Backer CL, Mavroudis C, Dunham CE, Holinger LD. Reoperation after pericardial patch tracheoplasty. *J Pediatr Surg.* 1997;32:1108-12.
18. Tsang V, Murday A, Gilbe C, Goldstraw P. Slide tracheoplasty for congenital funnel-shaped tracheal stenosis. *Ann Thorac Surg.* 1989; 48:632-5.
19. Grillo HC. Slide tracheoplasty for long-segment congenital stenosis. *Ann Thorac Surg.* 1994;58:613-21.
20. Macchiarini P, Sulmet E, de Montpreville V, Mazmanian G-M, Chapelier A, Darteville P. Tracheal growth after slide tracheoplasty. *J Thorac Cardiovasc.* 1997;113:558-66.
21. Kutlu CA, Goldstraw P. Slide tracheoplasty for congenital funnel shaped tracheal stenosis (a 9-year follow-up of the first case). *Eur J Cardiothorac Surg.* 1999;16:98-9.
22. Manson D, Filler R, Gordon R. Tracheal growth in congenital tracheal stenosis. *Pediatr Radiol.* 1996;26:427-30.
23. Dayan SH, Dunham ME, Backer CL, Mavroudis C, Holinger LD. Slide tracheoplasty in the management of congenital tracheal stenosis. *Ann Otol Rhinol Laryngol.* 1997;106:914-9.
24. Cunningham MJ, Eavey RD, Vlahakes G, Grillo HC. Slide tracheoplasty for long-segment tracheal stenosis. *Arch Otolaryngol Head Neck Surg.* 1998;124:98-103.
25. Houël R, Serraf A, Macchiarini P, Bruniaux J, Planché C. Tracheoplasty in congenital tracheal stenosis. *Int J Pediatr Otorhinolaryngol.* 1998;44: 31-8.
26. Lang FJ, Hurni M, Monnier P. Long segment congenital tracheal stenosis: treatment by slide-tracheoplasty. *J Pediatr Surg.* 1999;34:1216-22.
27. Matúte JA, Romero MA, Garcia-Casillas JC, et al. Surgical approach to funnel-shaped congenital tracheal stenosis. *J Pediatr Surg.* 2001; 36:320-3.
28. Muraji T, Satoh S, Tsugawa C, et al. Slide tracheoplasty: a case report of successful concomitant reconstruction of extensive congenital tracheal stenosis and pulmonary artery sling. *J Pediatr Surg.* 1998;33:1658-9.
29. Lipshutz GS, Jennings RW, Lopoo JB, Farmer D, Harrison MR, Albanese CT. Slide tracheoplasty for congenital tracheal stenosis: a case report. *J Pediatr Surg.* 2000;35:259-61.
30. Garabedian EA, LeBret E, Corré A, Roger G, Pineau E, Bourel P, et al. Tracheal resection associated with slide tracheoplasty for long-segment congenital tracheal stenosis involving the carina. *J Thorac Cardiovasc Surg.* 2001;121:393-5.