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# Outcomes of truncus arteriosus repair with bovine jugular vein conduit

*Sığır jugüler ven kondüiti ile yapılan trunkus arteriyozus tamiri sonuçları*

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## ABSTRACT

***Background:*** In this study, we aimed to evaluate the outcomes of truncus arteriosus repair in patients undergoing Rastelli type truncus arteriosus.

***Methods:*** A total of 13 patients (7 males, 6 females; median age 37 days; range, 16 to 60 days) underwent repair of truncus arteriosus using Contegra conduits between January 2011 and March 2017. Preoperative diagnosis was truncus arteriosus type 1 (Edwards-Collett) in eight, type 2 in three, type 3 in one, and type 4 in one patient. Contegra conduits used for operations were 14 mm (n=5), 12 mm (n=7), and 16 mm (n=1).

***Results:*** Early death was seen in two patients (15.4%). The median intensive care and hospital stays were 10 (range, 6 to 14) and 20 (range, 14 to 41) days, respectively. The median follow-up was 36 (range, 2 to 66) months. In four patients (31%), the conduit sizes severely increased during follow-up and reached 23 mm in two patients and 20 mm in one patient, and 18 mm in the other patient. Three patients had moderate distal conduit stenosis. Moderate pulmonary insufficiency was detected in four patients and severe pulmonary insufficiency in one patient. Two patients had moderate truncal valve insufficiency and one patient had moderate residual ventricular septal defect. None of the patients needed reoperation.

***Conclusion:*** Contegra conduit is a good alternative for repair of truncus arteriosus in infants; however close follow-up is necessary, as distal conduit stenosis and conduit dilatation may develop.

***Keywords:*** Congenital heart disease; infant; truncus arteriosus; xenograft.

## ÖZ

***Amaç:*** Bu çalışmada Rastelli tipi trunkus arteriyozus olan hastalarda trunkus arteriyozus tamirinin sonuçları değerlendirildi.

***Çalışma planı:*** Ocak 2011 - Mart 2017 tarihleri arasında 13 hastaya (7 erkek, 6 kadın; medyan yaş 37 gün; dağılım, 16-60 gün) Contegra kondüiti kullanılarak trunkus arteriyozus tamiri yapıldı. Ameliyat öncesi tanı sekiz hastada trunkus arteriyozus tip 1 (Edwards-Collett), üç hastada tip 2, bir hastada tip 3 ve bir hastada tip 4 idi. Ameliyat için kullanılan Contegra kondüitleri 14 mm (n=5), 12 mm (n=7) ve 16 mm (n=1) idi.

***Bulgular:*** İki hastada (%15.4) erken ölüm görüldü. Medyan yoğun bakım ve hastanede kalış süreleri sırasıyla 10 (dağılım 6-14) ve 20 (dağılım 14-41) gün idi. Medyan takip süresi 36 (dağılım, 2-66) ay idi. Dört hastada (%31) takip sırasında kondüit boyutları ciddi şekilde artış gösterdi ve iki hastada 23 mm'ye, bir hastada 20 mm'ye ve diğer hastada 18 mm'ye ulaştı. Üç hastada orta derecede distal kondüit darlığı vardı. Dört hastada orta derecede pulmoner yetmezlik ve bir hastada ciddi pulmoner yetmezlik vardı. İki hastada orta derecede trunkal kapak yetmezliği ve bir hastada orta derecede rezidüel ventriküler septal defekt vardı. Hastaların hiçbirinde tekrar ameliyat gereksinimi olmadı.

***Sonuç:*** Contegra kondüiti bebeklerde trunkus arteriyozus tamiri için iyi bir alternatiftir; ancak, distal kondüit darlığı ve kondüit dilatasyonu gelişebileceği için yakın izlem gereklidir.

***Anahtar sözcükler:*** Doğuştan kalp hastalığı; bebek; trunkus arteriyozus; ksenogreft.

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Truncus arteriosus (TA) is a rare anomaly, which constitutes 1 to 3% of all congenital heart defects.[1,2] McGoon et al.[3] reported the first successful surgical repair of TA using an aortic homograft in 1967. Surgery is associated with good long-term results, although the rate of reoperation is still high.[2] Continuity between the right ventricle (RV) and pulmonary artery (PA) can be done with a conduit or direct anastomosis as described by Barbero-Marcial et al.[4]

Bovine jugular vein conduit (Medtronic Contegra; Medtronic, Minneapolis, MN) is a RV-to-PA conduit used for right ventricle outflow tract (RVOT) reconstruction. Its performance in small infants is promising.[2] Aortic and pulmonary homografts, polytetrafluoroethylene (PTFE) or Dacron tube grafts can be also used for the same purpose. All kinds of conduits have some disadvantages such as degeneration or lack of growth potential through time.[5] Contegra results vary in reports, although long-term complication is usually conduit stenosis which is mostly seen in smaller diameter conduits.[6,7] Dilatation of the Contegra conduit is rare. In this study, we aimed to analyze the outcomes of TA repair using the Contegra conduit for the RVOT reconstruction.

## PATIENTS AND METHODS

A total of 13 patients (7 males, 6 females; median age 37 days; range, 16 to 60 days) underwent total repair of TA between January 2011 and March 2017 by a single surgeon in two institutions. The mean body surface area (BSA) was 0.22 kg/m$^2$. An Edwards-Collett classification for TA was used. Eight patients were TA type 1 (Edwards-Collett), three patients were type 2, one patient was type 3, and one patient was type 4. There was a subtruncal large ventricular septal defect (VSD) in all cases. One of the patients had severe truncal valve insufficiency preoperatively. The study protocol was approved by the Acıbadem Mehmet Ali Aydınlar University Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki. A written informed consent was obtained from each parent.

Operations were performed with median sternotomy and cardiopulmonary bypass (CPB) under moderate hypothermia. Aortic and bicaval cannulation was used. Pulmonary arteries were separated from the truncus. The remaining defect in TA was closed with an autologous pericardial patch, while VSD was closed with interrupted sutures with Teflon pledgets via right ventriculotomy using a Dacron patch. A small fenestration of 2 to 3 mm in size in atrial septum was performed in three patients to prevent RV dysfunction. In one patient with severe truncal valve insufficiency, additional truncal valve repair with hypoplastic leaflet resection (Figure 1, 2) and subaortic ridge resection was also done. Another patient (type 4) had two major aortopulmonary collateral arteries (MAPCAs) arising from the descending aorta separately, and these MAPCAs were reached and unifocalized during the operation. The continuity between the RV and PA was established using 14 mm (n=5), 12 mm (n=7) and 16 mm (n=1) Contegra conduits. The patients were weaned from CPB with low doses of dopamine and milrinone infusions. Median CPB and cross-clamp times were 133 (range, 99 to 211) min and 93 (range, 69 to 117) min, respectively.

### Statistical analysis

Statistical analysis was performed using the IBM SPSS version 19.0 for Windows (IBM Corp., Armonk, NY, USA). Data were presented in mean ± standard deviation (SD) or median (range). A $p$ value of $<0.05$ was considered statistically significant.

## RESULTS

There were two early deaths and both patients needed extracorporeal membrane oxygenation (ECMO) support during the intensive care unit stay due to sudden cardiac arrest in the postoperative period. One of these patients was weaned from the ECMO support, although both died from left ventricular dysfunction and severe bleeding and multiorgan failure. The early mortality rate was 15.4%. Eleven patients underwent delayed sternal closure. The median intensive care unit stay was 10 (range, 6 to 14) days. Six patients had transient peritoneal dialysis during early postoperative period. Left diaphragma paralysis occurred in one patient which required re-intubation. Left diaphragma plication was performed on postoperative Day 29. Temporary hemiparesis was seen in a patient who was transferred to another hospital for rehabilitation. The median hospital stay was 20 (range, 14 to 41) days.

Transthoracic M-mode, two-dimensional, color-flow, and Doppler echocardiograms (ECHO) were obtained in all patients before discharge. Early postoperative ECHO revealed normal conduit size and normal truncal valve function; however, one of the patients had mild right PA stenosis. The median follow-up was 36 (range, 2 to 66) months. There was mild pulmonary insufficiency (PI) in two patients, moderate in four patients, and free pulmonary insufficiency in one patient at the final follow-up. The conduit sizes severely increased during follow-up in four patients and reached 23 mm in two patients,


**Figure 1.** Truncal valve repair with the resection of the hypoplastic leaflet.
IVC: Inferior vena cava; PA: Pulmonary artery; SVC: Superior vena cava.

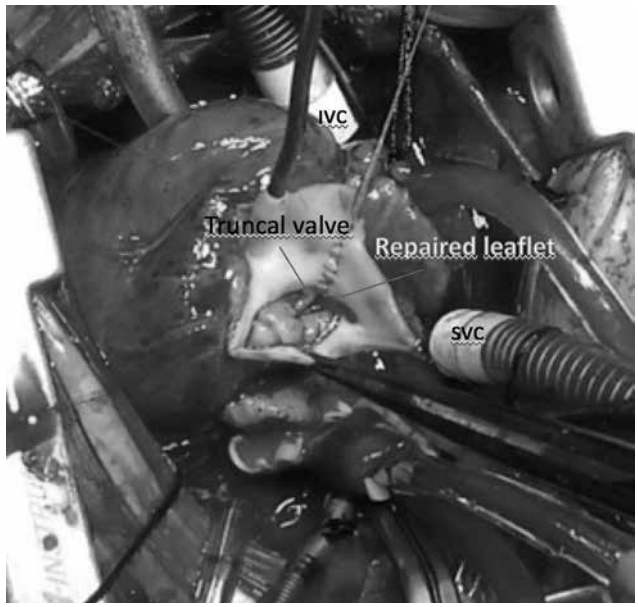


**Figure 2.** Truncal valve repair with the resection of the hypoplastic leaflet.
IVC: Inferior vena cava; PA: Pulmonary artery; SVC: Superior vena cava.

18 and 20 mm in the other two patients, respectively. Early ECHO revealed no significant difference in the PA pressure and conduit gradients between the patients with conduit dilatation and others. The patient with mild right pulmonary stenosis (55 mmHg) and conduit dilatation (23 mm) underwent right PA balloon angioplasty 10 months after the operation (Figure 3). In three patients, moderate (50 mmHg gradient) distal conduit stenosis was observed. One of these patients underwent balloon angioplasty for distal anostomosis of the conduit one year after the operation, and a 10 mm PA bifurcation stent (Abbott Vascular Omnilink Elite vascular balloon-expandable stent) was used 14 months later. The rate of reintervention was 15% at 36 months. The mean conduit gradient was 22.7 mmHg (range, 10 mmHg to 55 mmHg). In one patient, moderate residual VSD was seen during follow-up. Two patients had moderate truncal valve insufficiency. No reoperation was performed yet. All four patients who had conduit dilatation and pulmonary insufficiency remained with good ventricular function.

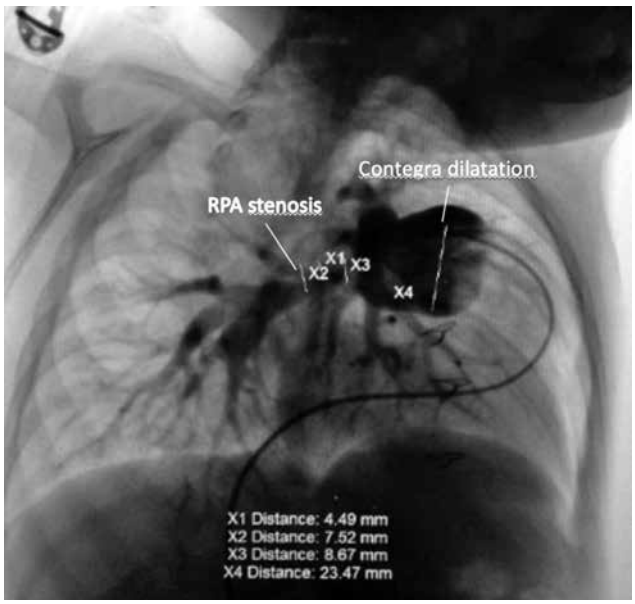


**Figure 3.** Angiography of the patient with right pulmonary artery stenosis and Contegra dilatation (23 mm).
RPA: Right pulmonary artery stenosis.

## DISCUSSION

Current management of TA is early total repair with RV-to-PA conduits. In recent years, early mortality has decreased to 5 to 10% in some centers.[8] The most common problems in the mid-term after repair of TA are the need for reinterventions of RVOT, which is almost inevitable, due to patient growth and conduit degeneration. The bovine jugular venous valved conduit (Contegra) is considered as one of the most optimal alternative for RVOT reconstructions. Contegra conduit does not cause pressure to adjacent vital structures. Its soft nature, easy pliability, and

good hemostatic properties make it an attractive choice for neonates.[6]

In this study, we used Contegra conduits in all consecutive patients during TA repair. Although early results are satisfactory, distal anastomotic stenosis, conduit dilatation and pulmonary valve insufficiency are concerns in the mid-term. In our study, we did not observe any conduit body-related stenosis or calcification. During follow-up, the rate of reintervention was 15%. Although this rate was not high, there were conduit dilatation in four patients (31%), distal conduit stenosis in three patients (23%), moderate pulmonary insufficiency in four patients (31%), and severe pulmonary insufficiency in one patient (7.7%).

Truncal valve insufficiency, interrupted aortic arch, and coronary artery anomalies are the main risk factors for mortality in total repair of TA. In our study, one patient had truncal valve insufficiency before the operation and truncal valve repair was done. In a report, 16 of 72 patients (22%) undergoing TA repair had concomitant truncal valve repair, and the presence of anatomic factors such as anomalous coronary artery pattern, the number of truncal valve cusps, and presence of truncal valve dysplasia were found closely associated with the need for truncal valve surgery.[9] The mean age of repair was reported as 76±45 days in Karaci et al.'s study[10] involving 19 patients, one with interrupted aortic arch. Early mortality was 21.1%. As a result of mean follow-up of 21.9±20.8 months, freedom from reintervention rates were found to be 100%, 69%, and 23% for one, three, and five years, respectively. Common cause of reoperations after repair of the TA in the late postoperative period is right heart problems, conduit degeneration, and PA stenosis.[11,12] In a study, 30 patients in a total of 57 patients (36%) who underwent TA repair required reoperations and 11 patients (13%) required catheter interventions during follow-up for mean 10.9±6.7 years.[12] In our study, two patients needed catheter interventions. Reoperation was not planned for any of the patients with conduit dilatation and pulmonary insufficiency, as the patients were asymptomatic and they had good ventricular functions.

Although homografts are mostly preferred as conduits, heterografts are often used, as the homografts are difficult to obtain. Thirty-five consecutive neonates who underwent truncus repair with 27 homografts and eight Contegras from 1987 to 2007 were studied in another report.[13] During a median follow-up of 68 months (range, 1 to 180 months), 42 reinterventions (of which 17 reoperations) were performed in 21 patients. The rate of reintervention was 2.6 per early survivor per 10 years. The RVOT obstruction constituted the main indication and branch PAs were often being involved (n=25). Clinical reports with short-term to mid-term follow-up described acceptable results and a low calcification rate with Contegra conduit, compared to other conduits.[14,15] In a multi-center study, the results of 107 patients who underwent TA repair with a homograft or a Contegra conduit were examined. The rates of freedom from conduit stenosis at three years were better for Contegra (96 to 69%).[16] It was also reported that the Contegra conduit responded better to catheter interventions, when stenosis developed. Neukamm et al.[17] described that necessity for reoperations within the first two years was significantly lower for Contegra grafts than for non-blood group compatible cryopreserved homografts, two of 78 (2.6%) and eight of 20 (40.0%), respectively. However, there are also studies reporting that distal anastomotic stenosis after the Contegra use is more frequent, and that some conduits may lead to pulmonary insufficiency associated with significant conduit dilatation.[18] Conduit dilatation is commonly due to distal anostomotic stenosis or increased pressure in the RV.[6,19] High pulmonary pressure is also thought to be a reason. In a report among 170 Contegra implantations, four grafts implanted in high pulmonary pressure situations developed aneurysm formation needing replacement.[20] In our study, we used Contegra conduits for other different kinds of congenital pathologies; however, we did not observe any dilatation. Mechanisms involved for Contegra dilatation are not completely understood, although geometric distortion along with immunological rejection has been suggested. It was also shown that histological examination of the explanted conduits revealed complex collagenization throughout the conduit and foreign body reaction.[19] Pannus formation over the top of the commissures and on the conduit wall with extensive mineralization was also suggested to be seen.[18] Conduit insufficiency is more common in the heterotopic position of the conduit in anomalies such as TA or pulmonary atresia.[15]

Early failure of surgical RVOT reconstructions is particularly seen in small infants. Patient-prosthesis mismatch has been cited as a reason for early failure and, therefore, there has been a demand for small pediatric allografts (<12 mm).[16]

In conclusion, our study results suggest that Contegra conduit may be used for right ventricular outflow tract reconstruction in small infants with truncus arteriosus. Early surgical results are

satisfactory. However, close follow-up is necessary for the probability of development of distal conduit stenosis and conduit dilatation. Catheter interventions are usually feasible, when stenosis develops. Long-term results are necessary for the impact of conduit dilatation on event-free survival.

**Declaration of conflicting interests**

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