UPDATES ON SURGICAL MANAGEMENT OF COARCTATION OF AORTA: A SYSTEMATIC REVIEW

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Abstract

Background: Aortic coarctation (CoA) is a congenital deformity that frequently coexists with other cardiac disorders. The operation's results are currently satisfactory, but postoperative restenosis is still a concern. Patient results might be enhanced by early therapy changes and the identification of restenosis risk factors.

Objectives: This systematic review aims to study the recent updates regarding the surgical approach to CoA. Methods: PubMed, SCOPUS, Web of Science, and Science Direct were systematically searched for relevant literature. Rayyan QRCI was employed throughout this comprehensive process.

Results & interpretation: Our results included nine studies with a total of 708 patients, and 466 (56.9%) were males. Preoperative diagnostic accuracy was greatly improved when CTA (CT angiography) and TTE (transthoracic echocardiography) The reported surgical approaches such as resection with end-to-end anastomosis (EEA), extended resection with end-to-end anastomosis (EEEA), subclavian flap aortoplasty (SCAP), patch aortoplasty (PP), and Interposition graft (IPG) were all found safe and successful for CoA repair. Even when comparing these first two methods, no differences in mortality or re-coarctation were found. It was discovered that aortoplasty was a better defence against re-coarcitation. The degree of CoA was a highly significant predictor of poor surgical outcomes.

Keywords: Coarctation of Aorta (CoA); Updates; surgical management, Systematic review

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Introduction

A congenital cardiac defect known as coarctation of the aorta (CoA) is characterized by a restricted aortic segment with localized medial thickening, some medial infolding, and superimposed neointimal tissue. The localized constriction can take the form of a membranous curtain-like structure with a central or eccentric opening or a shelf-like structure with an eccentric opening. A large stretch of the aorta can be constricted, or the coarctation can be discrete; the former is more prevalent. Depending on whether the coarctation segment is proximal or distal to the ductus arteriosus, respectively, preductal (or infantile) type and postductal (or adult) type AC (put details or reference) have been labelled. However, a thorough examination of the anatomy leads one to believe that all Coarctation are juxtaductal [1].

Between 5% and 8% of all congenital heart abnormalities were reported to have AC. In elderly patients, there has been a slight male predominance, whereas in babies, it is negligible [2, 3].

Hypertension or a systolic murmur are the modes of presentation in children, adolescents, and adults. With signs of left ventricular hypertrophy (LVH) and collateral circulation, the aortic blockage is thought to have grown gradually. Mechanical blockage and renin-angiotensin-mediated humoral mechanisms have been proposed as potential mechanisms for the development of hypertension [3].

The coarctation is typically discovered as a result of a murmur or hypertension found during a regular examination. It is advised to palpate femoral pulses and assess blood pressure during routine examinations to prevent delays in diagnosis because the primary care physician does not frequently recognize the AC (I think write aortic coarctation). When the brachial and femoral artery pulses are palpated concurrently, the femoral pulses are diminished, delayed, or non-existent. It is necessary to measure the blood pressure in both arms and one leg; AC may be suspected if there is a pressure differential of more than 20 mm Hg in favour of the arms [4, 5].

Intervention is needed if there is severe hypertension or congestive heart failure. Alternatives include aortic blockage surgery and catheter interventional methods (stents and balloon angioplasty). Patients who are asymptomatic should choose to get the operation. Between the ages of 2 and 5 years, elective surgery or balloon therapy is advised if neither hypertension nor heart failure are evident. If the aortic blockage is resolved after the age of 5, waiting is not advised due to evidence of persistent hypertension [6]. This systematic review aims to study the recent updates regarding the surgical approach to CoA.

Methodology

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed in conducting this systematic review [7].

Study Design and Duration

September 2023 we started work on this systematic review.

Search strategy

To discover the pertinent literature, a thorough search was conducted across four main databases: PubMed, SCOPUS, Web of Science, and Science Direct. We limited our search to English and considered each database's specific needs. The following keywords were transformed into PubMed Mesh terms and used to locate the pertinent studies; "Coarctation of the aorta," "Surgery," "Repair," "Pericardial patch," "extended end-to-side anastomosis," "end-to-side anastomosis," "Interposition graft," and "Aortoplasty," The Boolean operators "OR" and "AND" matched the required keywords(Details?or reference). Publications with full English text, available free articles, and human trials were among the search results.

Selection criteria

We considered the following criteria for inclusion in this review:

- Study designs that investigated the updates on the surgical approaches to CoA.
- Studies conducted between 2022 and 2023.
- Surgeries conducted on children and neonates.
- Only human subjects.
- English language.
- Free accessible articles.

Data extraction

The search technique's output was double-checked using Rayyan (QCRI) [8]. By modifying the combined search results with a set of inclusion/exclusion criteria, the researchers evaluated the relevance of the titles and abstracts. Each paper that met the requirements for inclusion underwent a careful examination by the reviewers. The authors talked about methods for resolving disputes. The approved study was uploaded using a data extraction form already created. The authors extracted data about the study titles, authors, study year, city, participants, gender, the surgical approach, and main outcomes. A separate sheet was created for the risk of bias assessment.

Strategy for data synthesis

Utilizing information from pertinent research, summary tables were made to

offer a qualitative evaluation of the findings and study elements. The most effective method for using the data from the included study articles was selected after the data for the systematic review were retrieved.

Risk of bias assessment

The ROBINS-I risk of bias assessment technique for non-randomized trials of therapies was used to evaluate the caliber of the included studies [9]. The seven themes that were assessed were confounding, participant selection for the study, classification of interventions, deviations from intended interventions, missing data, assessment of outcomes, and choice of the reported result.

Results

Search results

A total of 359 study articles resulted from the systematic search, and 169 duplicates were deleted. Title and abstract screening were conducted on 190 studies, and 133 studies were excluded. 57 reports were sought for retrieval, and 9 articles were retrieved. Finally, 48 studies were screened for full-text assessment; 25 were excluded for wrong study outcomes, 13 for the wrong population type, and 1 article was a letter to the editors. Nine eligible study articles were included in this systematic review. A summary of the study selection process is presented in (Figure 1).

Characteristics of the included studies

Table (1) REF NO. presents the sociodemographic characteristics of the included study articles. Our results included nine studies with a total of 708 patients, and 466 (56.9%) were males. All of the included studies were retrospective in nature [10-18].

Table (2) REF NO. presents the clinical characteristics. Regarding the preoperative assessment, combined CT angiography (CTA) and transthoracic echocardiography (TTE) significantly increased the preoperative diagnostic accuracy [11]. The reported surgical approaches such as resection with end-to-end anastomosis (EEA), extended resection with end-to-end anastomosis (EEEA), subclavian flap aortoplasty (SCAP), patch aortoplasty (PP), and Interposition graft (IPG) were all found safe and successful for CoA repair. Even when comparing these modalities, no difference in mortality or re-coarctation was found [18]. The degree of aortic coarctation significantly predicted poor surgical outcomes [10, 14] (Table 1, Table 2).

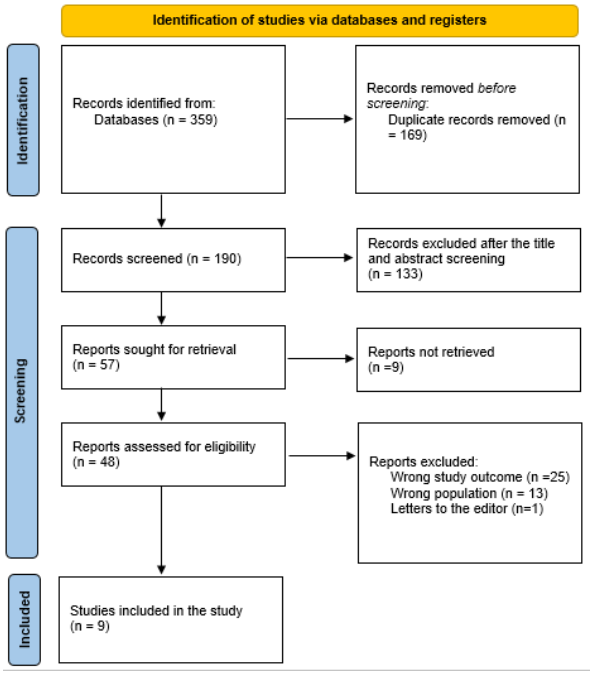

Figure 1. PRISMA flowchart summarizes the study selection process.

Discussion

If untreated, long-term complications, including congestive heart failure, endocarditis, aortic rupture, or cerebrovascular haemorrhage, limit the mean survival for CoA patients to mid-adulthood [19]. The degree of stenosis and the existence of accompanying abnormalities have a significant impact on life expectancy [19-21]. In this review, we found that combined CTA and TTE significantly increased preoperative diagnostic accuracy [11].

Given its ready accessibility, safety, and ability to provide haemodynamic parameters such as the CoA-gradient using Doppler, TTE is the preferred imaging modality for suspected CoA [19]. TTE can also evaluate cardiac anomalies and associated cardiac and valvular function [22]. However, because of a weak acoustic window and operator reliance, proper imaging of the CoA site may be challenging.7 TTE is only marginally useful for assessing collateral circulation and extra cardiac structures [19, 22]. Using high spatial resolution data from CT scans of both intracardiac and extra cardiac components, important vascular architecture can be reconstructed in two and three dimensions [19]. Given its improved visualisation capabilities, particularly in the detection of extra cardiac vascular anomalies, along with its quick acquisition times and high spatial resolution, CTA is now regarded as a more trustworthy method than TTE for the diagnosis of aortic disorders. The overall radiation burden needed for a CTA has greatly decreased as a result of recent developments in current scanning technology, making this procedure very safe for new-borns and young children [23].

The reported surgical approaches, such as EEA, EEEA, SCAP, PP, and IPG were all found safe and successful for CoA repair in this study [10-18]. Even when comparing these modalities, no difference in mortality or re-coarctation was found [18]. Similarly, Dani et al. found that all treatment options for coarctation have their own complications to deal with; however, surgery has been found to be a better alternative for dealing with complications than angioplasty is for dealing with aneurysm and recoarctation prevention [24]. Ashraf et al. also reported that in the mid- to long-term follow-up, surgical repair of coarctation was strongly correlated with a decreased incidence of reCoA, fewer repeat operations owing to re-CoA, and a smaller residual transcoarctation gradient.

The possibility of a coarctation forming again in the treated area is one of the main problems in treating a coarctation. It is a serious condition that necessitates additional treatment and is also known as recoarctation. According to our findings, angioplasty is significantly more effective than other procedures at preventing the development of a recoarctation, which is consistent with recent research and literature [26, 27]. There will inevitably be some form of stricture because healing tissue will replace the normally elastic tissue when the channel is closed again after surgery. This is why there is a higher rate of recoarctation after surgery.

Patients have a shorter life expectancy and a higher risk of morbidity despite great long-term survival after CoA-repair [27, 28]. Despite prompt and sufficient healing, long-term issues can still develop, necessitating ongoing monitoring. It is advised to regularly image the heart and aorta as well as evaluate blood pressure annually (four limbs) [30, 31].

We also found that the degree of aortic coarctation significantly predicted poor surgical outcomes [10, 14]. The degree of restriction following ductal closure, the level of collateral circulation development, and the existence of concomitant cardiac lesions all play major roles in the pathophysiology of

Table 1. REF NO. presents the sociodemographic characteristics of the included study articles.

Study	Study design	Country	Participants	Mean age (years)	Males (%)
Xiao et al., 2022 [10]	Retrospective cohort	China	27	16.3 ± 7.1	15(55.6)
Gong et al., 2023 [11]	Retrospective cohort	China	197	4.1	129 (65.5%)
Al-Dairy, 2023 [12]	Retrospective cohort	Syria	228	NM	158 (69.3)
Polyviou et al., 2022 [13]	Retrospective cohort	UK	89	0.32 y	48 (54)
Hysko et al., 2023 [14]	Retrospective cohort	Germany	26	11.4 ± 4.4 d	20 (76.9)
Zhao et al., 2023 [15]	Retrospective cohort	China	51	5.33	30 (58.8)
Grieshaber et al., 2022 [16]	Retrospective cohort	Germany	26	20 d	12 (46.2)
Xiao et al., 2023 [17]	Retrospective cohort	China	30	2.1 ± 0.9	18 (60)
Çelik, 2023 [18]	Retrospective cohort	Turkey	34	12.5 d	18 (52.9)

Table 2. Clinical characteristics and outcomes of the included studies.

Study	Surgical approach	Main outcomes	ROBIN-I
Xiao et al., 2022 [10]	Surgical correction	In neonates with uncomplicated CoA, the degree of aortic coarctation significantly predicts poor surgical outcomes.	Moderate
Gong et al., 2023 [11]	EEA, ESA, EEEA, EESA, PAP, PP, GORETEX patch or aortic release	The combined use of CTA and transthoracic echocardiography (TTE), which provides a more thorough assessment for clinical care and surgical decision-making, may increase the preoperative diagnostic accuracy of CoA and concomitant cardiovascular anomalies, respectively. TTE was useful for clinical management and post-operative monitoring.	Moderate
Al-Dairy, 2023 [12]	EEA, EEEA, SCAP, PP, and IPG	With minimal morbidity and mortality, surgical correction of CoA is still viable for treating aortic coarctation in patients of various ages. They found no discernible difference in the development of coarctation across various surgical procedures.	High
Polyviou et al., 2022 [13]	A lateral thoracotomy or more extensive repair of the aortic arch on bypass by way of a median sternotomy	After a prenatal diagnosis of this lesion, the cohort confirms good postoperative survival after repair of CoA, with mortality restricted to 5% and no deaths occurring beyond the first two years of life. The 20% of affected infants with a genetic and/or extracardiac problem confirms the significance of thorough prenatal examination by foetal medicine professionals.	Moderate
Hysko et al., 2023 [14]	Balloon angioplasty and stent placement	Regardless of treatment method or degree of cardiac dysfunction at hospital admission, primary catheter intervention and surgical repair result in restoration of biventricular systolic function and improvement of LV diastolic function in newborns with critical, isolated CoA. Therefore, percutaneous transcatheter intervention (balloon angioplasty stent) is a viable option for initial surgical repair, especially for newborn children with substantially reduced systolic LV function or even decompensated heart failure/cardiac shock.	Moderate
Zhao et al., 2023 [15]	EEEA, ESA, PAP, and SAR	The CoA operation had a successful overall result. Closer monitoring of these patients is necessary, particularly within the first year after surgery, because smaller preoperative z-scores of the ascending aorta and transverse aortic arch, as well as an arm-leg systolic pressure gradient of less than 12.5 mmHg at discharge, enhance the risk of reCoA.	Moderate
Grieshaber et al., 2022 [16]	Stent angioplasty	The intricacy of the subsequent surgical repair is exacerbated as a result of neonatal stent angioplasty for CoA. However, this stepwise strategy enables a bridge from subsequent surgical repair to high-risk newborns with reduced perioperative risk and good midterm outcomes.	High
Xiao et al., 2023 [17]	Surgical correction: cardiopulmonary bypass	In neonates with complex CoA, CT angiography can offer a thorough and precise preoperative examination of the aortic dimensions. In newborns with complex CoA, the degree of CoA is a separate risk factor for a protracted postoperative hospitalisation in a cardiac critical care unit.	Moderate
Çelik, 2023 [18]	Sternotomy and descending aorta-ascending aorta ESA	In neonatal aortic coarctation repair, there was no difference in mortality or recoarctation development between the sternotomy and descending aorta-ascending aorta end-to-side anastomosis approaches and the thoracotomy repair method.	Moderate

aortic coarctation [32]. In terms of mortality, recoarctation, and complications such as aneurysm, paraplegia, chylothorax, nerve injury, left arm dysfunction, and bleeding, the benefits and drawbacks of the various procedures should be examined. No one procedure seems to be clearly superior at the moment. Since the discovery of prostaglandins, the mortality rate following coarctation repair has decreased dramatically and is no longer significantly different between the various techniques. In addition, technique-related complications are also uncommon and comparable, with the exception of aneurysms after patch aortoplasty and arm pain after subclavian flap aortoplasty. Furthermore, because of various criteria, age groups, and follow-up times [32-34], no conclusive data on the incidence of recoarctation with each approach are available, which frequently makes the choice of the suitable technique up to the institution.

Conclusion

Combined CTA and TTE significantly increased preoperative diagnostic accuracy. All of the documented surgical techniques, including EEA, EEEA, SCAP, PP, and IPG, were determined to be safe and efficient for CoA repair. There was no difference in mortality or re-coarctation identified even when comparing these techniques. Aortoplast was found to be a superior approach against re-coarcitation. Poor surgical results were significantly predicted by the degree of CoA.

References

1. Abbruzzese, P. A., & Aidala, E. (2007). Aortic coarctation: an overview. Journal of Cardiovascular Medicine, 8(2), 123-128.
2. Matsui, H., Mellander, M., Roughton, M., Jicinska, H., & Gardiner, H. M. (2008). Morphological and physiological predictors of fetal aortic coarctation. Circulation, 118(18), 1793-1801.
3. Brouwer, R. M., Erasmus, M. E., Ebels, T., & Eijgelaar, A. (1994). Influence of age on survival, late hypertension, and recoarctation in elective aortic coarctation repair: including long-term results after elective aortic coarctation repair with a follow-up from 25 to 44 years. The Journal of thoracic and cardiovascular surgery, 108(3), 525-531.
4. Tanous, D., Benson, L. N., & Horlick, E. M. (2009). Coarctation of the aorta: evaluation and management. Current opinion in cardiology, 24(6), 509-515.
5. Dijkema, E. J., Leiner, T., & Grotenhuis, H. B. (2017). Diagnosis, imaging and clinical management of aortic coarctation. Heart, 103(15), 1148-1155.
6. Tanous, D., Benson, L. N., & Horlick, E. M. (2009). Coarctation of the aorta: evaluation and management. Current opinion in cardiology, 24(6), 509-515.
7. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International journal of surgery, 88, 105906.
8. Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. Systematic reviews, 5, 1-10.
9. Jüni, P., Loke, Y., Pigott, T., Ramsay, C., Regidor, D., Rothstein, H., ... & Shea, B. (2016). Risk of bias in non-randomized studies of interventions (ROBINS-I): detailed guidance. Br Med J.
10. Xiao, H. J., Zhan, A. L., Huang, Q. W., Huang, R. G., & Lin, W. H. (2022). Computed tomography angiography assessment of the degree of simple coarctation of the aorta and its relationship with surgical outcome: A retrospective analysis. Frontiers in Pediatrics, 10, 1017455.
11. Gong, T., Zhang, F., Feng, L., Zhu, X., Deng, D., Ran, T., ... & Ji, X. (2023). Diagnosis and surgical outcomes of coarctation of the aorta in pediatric patients: a retrospective study. Frontiers in Cardiovascular Medicine, 10.
12. Al-Dairy, A. (2023). Long-term outcomes of surgical repair of isolated coarctation of the aorta in different age groups. BMC surgery, 23(1), 1-4.
13. Polyviou, S., Charakida, M., Miller, O. I., Vigneswaran, T. V., Zidere, V., Day, T. G., ... & Simpson, J. M. (2022). Outcome and Impact of Associated Left-

Sided Cardiac Lesions in Coarctation of the Aorta Diagnosed During Fetal Life. The American Journal of Cardiology, 166, 114-121.

14. Hysko, K., Hohmann, D., Bobylev, D., Horke, A., Bertram, H., Happel, C. M., & Hansmann, G. (2023). Recovery of Biventricular Function After Catheter Intervention or Surgery for Neonatal Coarctation of the Aorta. JACC: Advances, 2(3), 100326.
15. Zhao, Z., Pan, Z., Wu, C., Tian, J., Qin, J., Zhang, Y., & Jin, X. (2023). Risk factors for recurrence after surgical repair of coarctation of the aorta in children: a single-center experience based on 51 children. Frontiers in Cardiovascular Medicine, 10, 1144755.
16. Grieshaber, P., Merbecks, M., Jaschinski, C., Fonseca, E., Arnold, R., Karck, M., ... & Loukanov, T. (2022). Surgical Treatment Following Stent Angioplasty for High-Risk Neonates With Critical Coarctation of the Aorta. World Journal for Pediatric and Congenital Heart Surgery, 13(4), 426-435.
17. Xiao, H. J., Zhan, A. L., Huang, R. G., Lin, W. H., & Huang, Q. W. (2023). Using Revolution™ CT Angiography to Assess Complex Coarctation of the Aorta in Infants and Its Association with a Prolonged Postoperative Cardiac ICU Stay. Brazilian Journal of Cardiovascular Surgery, 38, e20220402.
18. Çelik, M. (2023). Comparison of Thoracotomy and Sternotomy Repair in Neonatal Aortic Coarctation Surgery: A Single Center Experience.
19. Nie, P., Wang, X., Cheng, Z., Duan, Y., Ji, X., Chen, J., & Zhang, H. (2012). The value of low-dose prospective ECG-gated dual-source CT angiography in the diagnosis of coarctation of the aorta in infants and children. Clinical radiology, 67(8), 738-745.
20. E Vergales, J., J Gangemi, J., S Rhueban, K., & Scott Lim, D. (2013). Coarctation of the aorta-the current state of surgical and transcatheter therapies. Current cardiology reviews, 9(3), 211-219.
21. Cardoso, G., Abecasis, M., Anjos, R., Marques, M., Koukoulis, G., Aguiar, C., & Neves, J. P. (2014). Aortic coarctation repair in the adult. Journal of Cardiac Surgery: Including Mechanical and Biological Support for the Heart and Lungs, 29(4), 512-518.
22. Karaosmanoglu, A. D., Khawaja, R. D. A., Onur, M. R., & Kalra, M. K. (2015). CT and MRI of aortic coarctation: pre-and postsurgical findings. American Journal of Roentgenology, 204(3), W224-W233.
23. Budoff, M. J., Shittu, A., & Roy, S. (2013). Use of cardiovascular computed tomography in the diagnosis and management of coarctation of the aorta. The Journal of Thoracic and Cardiovascular Surgery, 146(1), 229-232.
24. Dani, A., Thakkar, H., Desai, D., Dani, J. S., & Dani, S. I. (2023). Surgery versus Balloon angioplasty for treating coarctation of aorta: A meta-analysis. medRxiv, 2023-04.
25. ASHRAF, A. E., HASSAN, M. M., MOSTAFA, R. H., & MOHAMED, A. (2022). Outcome of Surgical Repair of Coarctation in the Neonate: Meta-Analysis. The Medical Journal of Cairo University, 90(6), 1163-1177.
26. Shaddy, R. E., Boucek, M. M., Sturtevant, J. E., Ruttenberg, H. D., Jaffe, R. B., Tani, L. Y., ... & Orsmond, G. S. (1993). Comparison of angioplasty and surgery for unoperated coarctation of the aorta. Circulation, 87(3), 793-799.
27. Fiore, A. C., Fischer, L. K., Schwartz, T., Jureidini, S., Balfour, I., Carpenter, D., ... & Johnson, R. G. (2005). Comparison of angioplasty and surgery for neonatal aortic coarctation. The Annals of thoracic surgery, 80(5), 1659-1665.
28. Canniffe, C., Ou, P., Walsh, K., Bonnet, D., & Celermajer, D. (2013). Hypertension after repair of aortic coarctation—a systematic review. International journal of cardiology, 167(6), 2456-2461.
29. Heck, P. B., Von Ohain, J. P., Kaemmerer, H., Ewert, P., & Hager, A. (2017). Survival and cardiovascular events after coarctation-repair in long-term follow-up (COAFU): Predictive value of clinical variables. International journal of cardiology, 228, 347-351.
30. Brown, M. L., Burkhart, H. M., Connolly, H. M., Dearani, J. A., Cetta, F., Li, Z., ... & Schaff, H. V. (2013). Coarctation of the aorta: lifelong surveillance is mandatory following surgical repair. Journal of the American College of Cardiology, 62(11), 1020-1025.
31. Choudhary, P., Canniffe, C., Jackson, D. J., Tanous, D., Walsh, K., & Celermajer, D. S. (2015). Late outcomes in adults with coarctation of the aorta. Heart, 101(15), 1190-1195.
32. Castaneda, A. R., Jonas, R. A., Mayer, J. E., & Hanley, F. L. (1994). Cardiac surgery of the neonate and infant. In Cardiac surgery of the neonate and infant (pp. 506-506).
33. Ziemer, G., Jonas, R. A., Perry, S. B., Freed, M. D., & Castaneda, A. R. (1986). Surgery for coarctation of the aorta in the neonate. Circulation, 74(3 Pt 2), I25-31.
34. Cobanoglu, A., Thyagarajan, G. K., & Dobbs, J. L. (1998). Surgery for coarctation of the aorta in infants younger than 3 months: end-to-end repair versus subclavian flap angioplasty: is either operation better?. European journal of cardio-thoracic surgery, 14(1), 19-26.