Vol. 16(1), pp. 1-4, February 2024
DOI: 10.5897/AATCVS2022.0050
Article Number: 2BE08F771860
ISSN 1994-7461

http://www.academicjournals.org/AATCVS

ACADEMIC JOURNALS
expand your knowledge

African Annals of Thoracic and Cardiovascular Surgery

Full Length Research

The magnitude of systemic arterial oxygen saturation improvement achievable by a Blalock-Taussig-Thomas shunt: A systematic review

Mark N. Awori*, Jonathan A. Awori, Gilbert Langat and Kimberly Kipkoech

Department of Surgery, School of Medicine, University of Nairobi, P. O. Box 19676-00202, Nairobi, Kenya.

Received 30 September, 2023; Accepted 13 February, 2024

This study was carried out to determine the magnitude of systemic arterial oxygen saturation (SaO_2) improvement caused by a Blalock-Taussig-Thomas shunt (BTTS). PUBMED (PM) and Google Scholar (GS) were searched between 1st January, 1966 and 31st March, 2023. Search terms included: Blalock, Taussig, shunt, pulmonary artery and Tetralogy of Fallot. Only full-text papers that measured pre-BTTS and post-BTTS systemic arterial oxygen saturation were included. Of 153 records retrieved, 12 full-text articles (427 patients) were included in this review. The mean pre-BTTS and post-BTTS SaO_2 were 69.9 and 86.9%, respectively. Nine out of 12 studies representing 371 patients (86.8%) had a post-BTTS increase in SaO_2 of 20% or less. Available evidence suggests that a BTTS is unlikely to increase the SaO_2 by more than 20% in almost 90% of patients. This finding may have important implications for the continued use of BTTS to raise the SaO_2 in patients with severe cyanosis.

Key words: Blalock, Taussig, Thomas, arterial, oxygen, saturation.

INTRODUCTION

Since the first report of symptomatic improvement following the creation of a systemic-arterial-to-pulmonary arterial shunt (SAPAS) (Blalock and Taussig, 1945), SAPASs have become an accepted part of the surgical treatment of patients with cyanotic congenital heart disease. The rational for offering a patient a SAPAS is as follows: cyanosis indicates inadequate oxygenation of the blood; creation of a SAPAS will increase pulmonary blood flow and so increase oxygenation of the blood. Un-operated patients with cyanotic congenital heart disease and an arterial oxygen saturation (SaO_2) of less than 80% are unlikely to live to adulthood (Poterucha et al., 2016); the inference is that an SaO_2 of at least 80% is required for survival. The general aim of the SAPAS, therefore, is to the raise the SPO2 to about 80%. In the original description of a SAPAS, the left subclavian artery was anastomosed to the left pulmonary artery; the anastomosis of a subclavian artery to a branch pulmonary artery is known as a 'classic' Blalock-Taussig shunt (Blalock and Taussig, 1945). Later, the 'modified' Blalock-Taussig was introduced and became more popular. This procedure involves anastomosing one end of a synthetic tube graft to a subclavian artery and anastomosing the other end of the tube graft to a branch pulmonary artery (de Leval et al., 1981). More recently, the Blalock-Taussig shunt has come to be known as the

*Corresponding author. E-mail: mnawori@yahoo.com

Table 1. Search strategy.

Searches and terms
Blalock; Taussig; shunt; pulmonary; artery; growth (GS,PM)
Blalock; Taussig; shunt; tetralogy (GS)

GS = Google scholar, PM= PubMed.

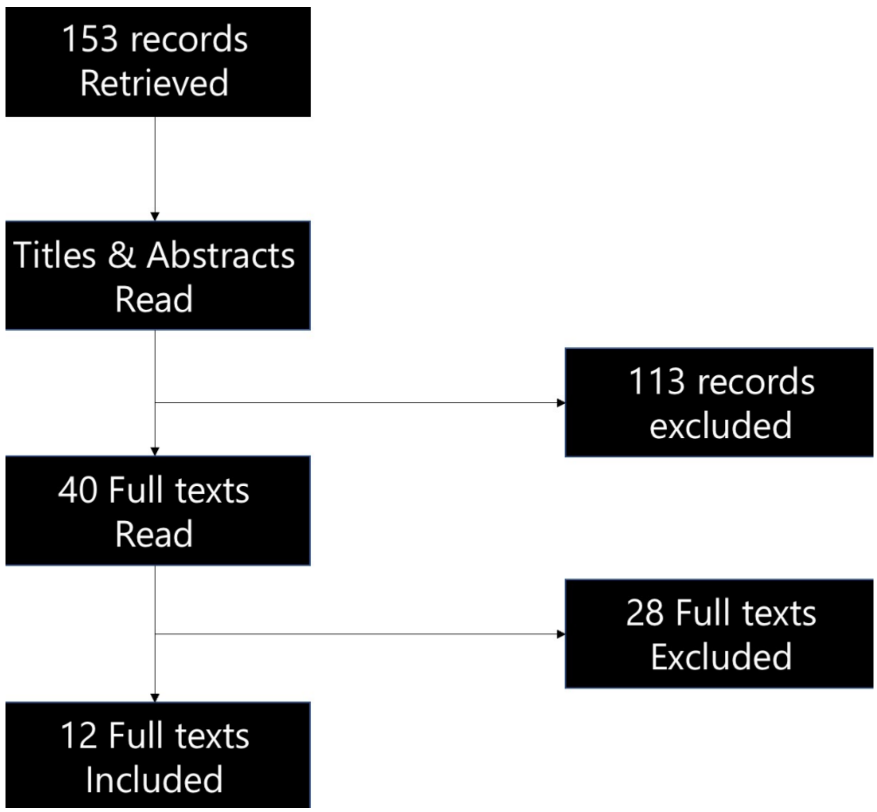

Figure 1. Search flow diagram.

Blalock-Taussig-Thomas shunt (BTTS) (Blake and Yancy, 2022). The basic surgical technique, the principles of peri-operative care, and the operative outcome have essentially remained the same for almost 40 years (Bove et al., 1984). The magnitude of the SaO_2 mean increase post BTTS varies between reports; 33% (Bove at al., 1984) and 0% (Sheth and Loomba, 2022). If it were known before hand, that a BTTS would be unlikely to raise the SaO_2 to 80% in a particular patient, surgery may not be offered to that patient. The aim of the present review was to determine the magnitude of SaO_2 increase that can be expected post-BTTS; this information may improve surgical decision making.

MATERIALS AND METHODS

PUBMED (PM) and Google Scholar (GS) were searched between 1st January 1966 and 31st March 2023. The search particulars are shown in Table 1. The “all in title” function was utilised for GS searches and the “title/abstract” function was used for PM searches. The operator “AND” was used for all searches. Titles and abstracts were read; full-text articles were examined if the abstract suggested that there was a possibility that pre-BTTS and post BTTS SaO_2 were examined. Only full-text articles that examined pre-BTTS and post-BTTS SaO_2 were included. The search flow is as shown in Figure 1.

RESULTS AND DISCUSSION

The present search yielded 153 records: 40 full-texts were examined after accounting for duplicate records; 28 of these were rejected. Thirteen full-text articles representing 427 patients were included in this review; the key details of these papers are shown in Table 2 and Figure 2.

Table 2. Full-texts included.

Author	n	Age at BTTS: months	SaO_2 (pre-op/post-op)	SaO_2 difference	Most common/mean shunt size (mm)	Type of CHD
Guo et al. (2023)	9	15.8 (mn)	70/90	20	6	TET
Sheth and Loomba (2022)	38	0.5 (md)	89/88	0	4	MCHD
Lenoir et al. (2021)	64	1 (mn)	76/91	15	4	MCHD
Zhou et al. (2020)	90	6 (md)	73/88	15	4	MCHD
Lenoir et al. (2020)	70	1 (mn)	70/90	13	4	MCHD
Bigdelian et al. (2018)	8	3 (mn)	74.9/89.3	14.4	3.5	MCHD
Quandt et al. (2017)	28	2 (md)	75/90	15	3.5	MCHD
Awori et al. (2017)	22	20 (md)	68/89	21	5	MCHD
Ishikawa et al. (2001)	12	12*	60/75	15	Classic	MCHD
Gladman et al. (1997)	52	24 (md)	71/86	15	5	TET
Ullom et al. (1987)	16	2.4 (mn)	55/84	29	5	MCHD
Bove et al. (1984)	18	0.5 (md)	50/83	33	5	MCHD

BTTS = Blalock-Taussig-Thomas Shunt; MCHD = multiple types of congenital heart disease; TET = Tetralogy of Fallot; * = all patients under 12 months old; md= median; mn=mean.

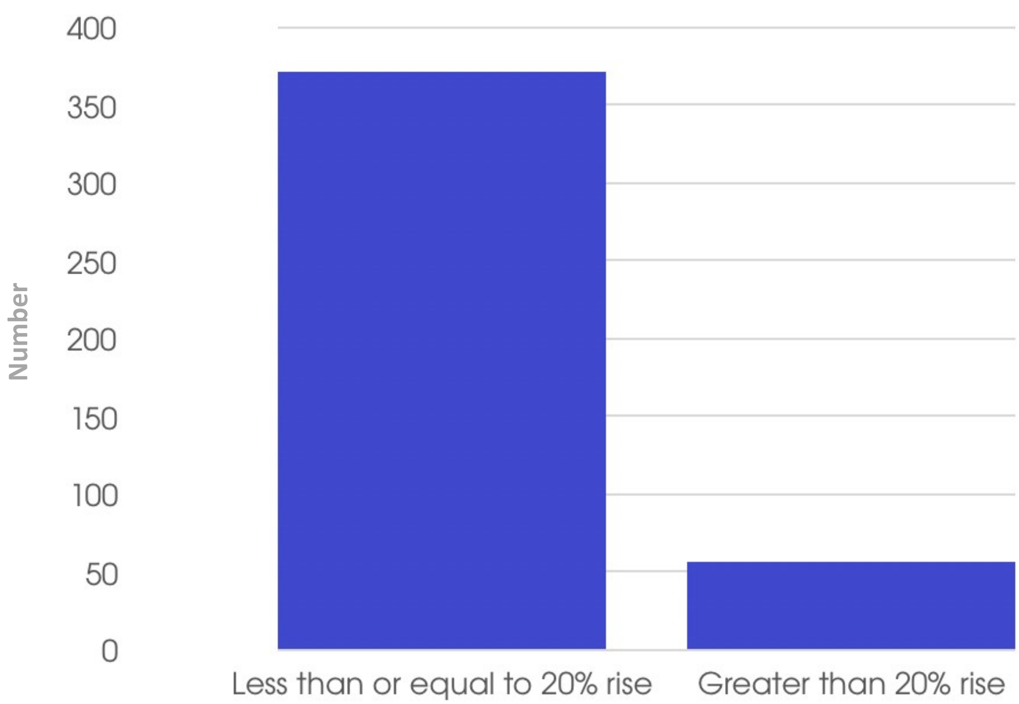

Figure 2. Number of patients vs magnitude of SaO_2 increase post-BTTS.

There is evidence that BTTSs do improve the quality of life (Harris et al., 1964). However, when compared with the natural history, BTTSs may not increase longevity (Reid et al., 1973; Samánek, 1992). In current practice, the main indication for a BTTS is to increase a patient's SaO_2 prior to surgical correction, or as the first step on the Fontan pathway. The present review found that although BTTSs did raise the SaO_2, the magnitude of the increase was not more than 20% in almost 90% of patients; in fact, the mean of the mean increase of the studies included was 17.1%. The highest mean increase in SaO_2 found in this review was 33%; this study represented 4.2% of all patients included in this review (Bove et al., 1984). Only 3 out of 12 studies had a mean SaO_2 rise of greater than 20%; this represented 13.1% of all the patients included in this review. The aim of performing a BTTS prior to total correction, or as a step on the Fontan pathway, is to ensure sufficient oxygenation of the blood to promote adequate growth of the patient and to minimise the chance of mortality before definitive surgery. In this regard, no target post-BTTS SaO_2 has been identified as reliably achieving these aims. However, patients with un-operated single ventricle arrangements, who have survived into the 5th decade of life, can give us an idea of what this target SaO_2 should be. These unoperated long-term survivors generally have a SaO_2 above 80% and are said to have a 'balanced circulation' (Poterucha et al., 2016). A balanced circulation is said to exist when the ratio of pulmonary to systemic blood flow is between 0.8 and 1. When this condition is met, the SaO_2 generally lies between 75 and 80% (Anders, 2021). This implies that the minimum post-BTTS SaO_2 that would promote adequate somatic growth and minimize mortality, prior to definitive surgery, is likely to be 80%. This being the case, and armed with the knowledge that it is unlikely that a BTTS would increase the SaO_2 by more than 20%, it seems that a reasonable SaO_2 threshold for performing a BTTS would be 60%. It is unlikely that patients presenting with a pre-BTTS of less than 60% would benefit, from a survival perspective, from a BTTS. Awori et al. (2023) have already demonstrated that patients with a single ventricle physiology, who present with a pre-BTTS SaO_2 of less than 75%, do not benefit from a BTTS. The findings of the current study suggest that patients with a two-ventricle arrangement who present with a pre-BTTS SaO_2 of less than 60% are unlikely to benefit from a BTTS.

Conclusion

Available evidence suggests that a BTTS shunt is unlikely to raise the SaO_2 by more than 20%. As it is likely that a SaO_2 above 80% is required for a patient to benefit from a BTTS, we suggest that the lower threshold for performing a BTTS, in a patient with a two-ventricle arrangement and who requires a BTTS before surgical correction, appears to be about 60%.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Anders M (2021). Single ventricle physiology- Functionally univentricular heart, parallel circulation. Available at https://dontforgetthebubbles.com/picu-single-ventricle-physiology/ accessed 23rd August 2023.

Awori M, Awori J, Ibrahim MH, Kipkoech K (2023). Use of a composite survival graph to optimise the surgical strategy for Tricuspid atresia. African Annals of Thoracic and Cardiovascular Surgery 15(2):10-18.

Awori M, Ali M, Khan N (2017). Systemic Arterial-to-Pulmonary Artery Shunt Utilization. Annals of African Surgery 14(2). 10.4314/aas.v14i2.9.

Bigdelian H, Ghaderian M, Sedighi M (2018). Surgical repair of Tetralogy of Fallot following primary palliation: Right ventricular outflow track stenting versus modified Blalock-Taussig shunt. Indian Heart Journal 70(Suppl 3):S394-S398.

Blake K, Yancy CW (2022). Change the Name of the Blalock-Taussig Shunt to Blalock-Thomas-Taussig Shunt. JAMA Surgery 157(4):287-288.

Blalock A, Taussig HB (1945). The surgical treatment of malformations of the heart in which there is pulmonary stenosis or pulmonary atresia. JAMA 128:189-202.

Bove EL, Sondheimer HM, Kavey RE, Byrum CJ, Blackman MS, Parker FB Jr. (1984). Subclavian-pulmonary artery shunts with polytetrafluorethylene interposition grafts. The Annals of Thoracic Surgery 37(1):88-91.

de Leval MR, McKay R, Jones M, Stark J, Macartney FJ (1981). Modified Blalock-Taussig shunt. Use of subclavian artery orifice as flow regulator in prosthetic systemic-pulmonary artery shunts. The Journal of Thoracic and Cardiovascular Surgery 81(1):112-119.

Gladman G, McCrindle BW, Williams WG, Freedom RM, Benson LN (1997). The modified Blalock-Taussig shunt: clinical impact and morbidity in Fallot's tetralogy in the current era. The Journal of Thoracic and Cardiovascular Surgery 114(1):25-30.

Guo H, Wu Z, Zhao T, Yang J, Hu S, Huang C, Yang Y, Xie L (2023). Right ventricular outflow tract stenting promotes pulmonary artery development in tetralogy of fallot. Frontiers in Surgery 10:1056772.

Harris AM, Segel N, Bishop JM (1964). Blalock-Taussig anastomosis for Tetralogy of Fallot. A ten-to-fifteen year follow-up. British Heart Journal 26(2):266-267.

Ishikawa S, Takahashi T, Sato Y, Suzuki M, Murakami J, Hasegewa Y, Mohara J, Oshima K, Ohtaki A, Morishita Y (2001). Growth of the pulmonary arteries after systemic-pulmonary shunt. Annals of thoracic and cardiovascular surgery: official journal of the Association of Thoracic and Cardiovascular Surgeons of Asia 7(6):337-340.

Lenoir M, Fouilloux V, Desnous B, Rahmani B, El Gueddari N, Ovaert C, Aries E, El Louali F, Aldebert P, Metras D, Macé L (2020). Pulmonary atresia with ventricular septal defect and tetralogy of Fallot: transannular path augmentation versus systemic to pulmonary artery shunt for first-stage palliation. Cardiology in the Young 30(11):1679-1687.

Lenoir M, Desnous B, Rahmani B, El Gueddari B, Aries E, El Louali F, Aldebert P, Ovaert C, Metras D, Macé L, Fouilloux V (2021). Anterograde blood flow associated with modified Blalock-Taussig shunt does not modify pulmonary artery growth compared with modified Blalock-Taussig shunt alone. Archives of Cardiovascular Diseases 114(4):268-276.

Poterucha JT, Anavekar NS, Egbe AC, Julsrud PR, Connolly HM, Ammash NM, Warnes CA (2016). Survival and outcomes of patients with unoperated single ventricle. Heart (British Cardiac Society) 102(3):216-222.

Quandt D, Ramchandani B, Stickley J, Mehta C, Bhole V, Barron DJ, Stumper O (2017). Stenting of the Right Ventricular Outflow Tract Promotes Better Pulmonary Arterial Growth Compared with Modified Blalock-Taussig Shunt Palliation in Tetralogy of Fallot-Type Lesions. JACC Cardiovascular Interventions 10(17):1774-1784.

Reid JM, Coleman EN, Barclay RS, Stevenson JG, (1973). Blalock-Taussig anastomosis in 126 patients with Fallot's tetralogy. Thorax 28(3):269-272.

Samánek M (1992). Children with congenital heart disease: probability of natural survival. Pediatric Cardiology 13(3):152-158.

Sheth SP, Loomba RS (2022). Haemodynamic and clinical variables after surgical systemic to pulmonary artery shunt placement versus arterial ductal stenting. Cardiology in the young Cardiology in the Young 33(10):2060-2065.

Ullom RL, Sade RM, Crawford FA Jr, Ross BA, Spinale F (1987). The Blalock-Taussig shunt in infants: standard versus modified. The Annals of Thoracic Surgery 44(5):539-543.

Zhou T, Wang Y, Liu J, Wang Y, Wang Y, Chen S, Zhou C, Dong N (2020). Pulmonary artery growth after Modified Blalock-Taussig shunt: A single center experience. Asian Journal of Surgery 43(2):428-437.