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Is sternotomy superior to thoracotomy for modified Blalock–Taussig shunt?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was: is sternotomy approach superior to a thoracotomy approach for a modified Blalock–Taussig shunt procedure? More than 58 papers were found using the search as described below, of which 11 papers represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. Three of seven papers compared the sternotomy and thoracotomy approaches. The operative approach was a significant predictor of shunt failure. The criterion used to define early shunt failure was either the complete occlusion during hospitalization or the need to return to the operating room for a second shunt. The studies that compared the thoracotomy and sternotomy approaches observed increased shunt failure rates in the thoracotomy group. The sternotomy approach was associated with advantages like less pulmonary artery distortion, ease of technical performance, cosmetic advantage of a single sternotomy incision, ease of ligation of patent ductus, less phrenic nerve injury, less collateral formation in chest wall adhesions and less thoracotomy induced scoliosis. However, other papers studied either the sternotomy approach only or the thoracotomy approach and drew conclusions regarding risk factors for operative morbidity and mortality. We conclude that the sternotomy approach is beneficial to neonates and infants undergoing modified Blalock–Taussig shunt when compared with the conventional thoracotomy approach.

Keywords: Modified Blalock–Taussig shunt • Sternotomy • Thoracotomy

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in *ICVTS* [1].

THREE-PART QUESTION

In [patients undergoing modified Blalock–Taussig shunt] does [sternotomy or thoracotomy] [make any difference to the clinical outcomes]?

CLINICAL SCENARIO

A 2-month old male child requires an elective modified Blalock–Taussig shunt (BTS) for tetralogy of Fallot with diminutive pulmonary arteries. There is a history of recurrent cyanotic spells. The question is: should we perform the shunt through a sternotomy or a thoracotomy? Which approach is best suitable to gain faster access, ensure patient safety, technically easy with least anastomotic distortion and ease of take down at the future correction?

SEARCH STRATEGY

Medline 1950 to July 2013 using the PubMed and Google Scholar database. The search was limited to English language articles and the reference lists of each publication were searched.

SEARCH OUTCOME

Fifty-eight papers were found using the reported search. From these, 11 papers provided the best evidence to answer the question (Tables 1 and 2).

RESULTS

Most papers showed evidence that the sternotomy approach is superior to the thoracotomy approach for modified BTS.

Reddy *et al.* [2] while reviewing the records of 20 infants undergoing modified BTS via the sternotomy approach stated that avoidance of lung compression is a major advantage compared with the thoracotomy approach. Through the sternotomy approach, modified BTS is technically easier to perform, cosmetically

Table 1: Best evidence papers

Author, date, journal and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Reddy *et al*. (2000), Asian Cardiovasc Thorac Ann, India [2] Retrospective case review (level 4)	Case records of 20 infants who underwent modified BTS by a sternotomy approach from July 2007 to 2009	Mean hospital stay Mean O_2 saturation at discharge Postoperative mortality Shunt failure	10.4 ± 4.3 days 89% (81–93%) 1 (5%) 0%	The study was small and did not compare with the thoracotomy approach Studied only the sternotomy approach
McKenzie *et al*. (2013) J Am Coll Surg, USA [3] Retrospective case review (level 4)	Clinical records of 730 infants who underwent BTSs from June 1995 to December 2011	Median length of hospital stay Patients bridged to complete repair or second stage of single-ventricular palliation after a median duration of 6.5 months	16 days (0–347) 536 (73%)	Multivariable regression analysis of this large study showed that the sternotomy approach is one of the risk factors for in-hospital mortality ($P < 0.05$)
Shauq *et al*. (2010), Heart Lung Circ, UK [4] Retrospective case review (level 4)	Clinical records of 45 modified BTSs in 41 patients between January 2002 and October 2004	Postoperative O_2 saturation Duration of ventilation Inotropic requirement intensive care unit (ICU) stay	Same in both groups 183 h—sternotomy 53 h—thoracotomy 33.3%—sternotomy 4.2%—thoracotomy 9.14 days—sternotomy 3.3 days—thoracotomy	Median sternotomy carry a higher morbidity than thoracotomy However, it was a small study with short follow-up
Dirks *et al*. (2013), Eur J Cardiothorac Surg, Switzerland [5] Retrospective case review (level 4)	Case records of 32 infants who underwent isolated MBT shunt from 2004 to 2013	Shunt thrombosis Successful take down at a median age of 5.5 months Hospital mortality	3 (9%) 28 infants 3 (9%)	Studied only the sternotomy approach Study analysed the risk factors for shunt intervention and mortality like univentricular hearts ($P < 0.001$) and bigger shunt size ($P = 0.054$)
Ahmad *et al*. (2008), Heart Lung Circ, Pakistan [6] Retrospective case review (level 4)	Patient charts of 22 neonates who had undergone modified BTS from 1999 to 2005	Mean duration of mechanical ventilation Rate of shunt failure/occlusion Hospital mortality	3.9 ± 4.5 days 9% 3 (9%)	Studied only the thoracotomy approach Study analysed the modified BTS risk factors associated with age, PA diameter and baseline cardiac anatomy pulmonary atresia, intact ventricular septum
Odim *et al*. (1995), Circulation, USA [7] Retrospective case review (level 4)	Clinical records of 104 children who underwent primary modified BTSs at Children's Hospital, Boston from January 1988 to December 1992	Shunt failure rate Hospital mortality	10 (20%)—Thoracotomy 4 (8%)—Sternotomy 3 (6%)—Thoracotomy 6 (12%)—Sternotomy	Study compared both the thoracotomy and sternotomy approaches Observed that shunt failure is more commonly seen in thoracotomy group No obvious disadvantage seen during sternal re-entry
Akhulaifi *et al*. (2000), Ann Thorac Surg, France [8] Retrospective case review (level 4)	75 neonates underwent modified BTS between March 1993 and December 1998	30-day mortality Predictors of early mortality	3 (4%) <2 kg BW ($P = 0.039$) Preoperative mechanical ventilation ($P = 0.008$)	Concluded that the approach is not a predictor of mortality, whereas preoperative mechanical ventilation, low body weight is a predictor

Continued

Table 1: (*Continued*)

Author, date, journal and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Williams *et al.* (2007), Ann Thorac Surg, USA [9] Retrospective case review (level 4)	2016 BTS (both classic and modified) performed by 28 surgeons on 1880 patients from 35 centres from November 1944 to March 2006	Overall operative mortality Increased preparation of single-ventricle physiology	14% (227 of 1574)	Median sternotomy is the preferred approach and modified BTS has become standard method for systemic artery to PA shunt
Mohammadi *et al.* (2008), Eur J Cardiothorac Surg, Canada [10] Retrospective case study (level 4)	226 patients underwent modified BTS between January 1988 and April 2005		Group S Group T	In the multivariate analysis, younger age ($P = 0.03$) and group T (thoracotomy) ($P = 0.03$) were independent risk factors of interim mortality Patients with a thoracotomy approach have higher interim mortality Sternotomy (S) approach avoids pulmonary artery distortion and improves in-hospital and interim outcomes
		Number	($n = 46$) ($n = 180$)	
		Age (median)	13 days 22 days	
		Neonates	13 44	
		Weight (median)	3.5 4.1	
		Preoperative intubation (%)	8.7% 9.4%	
		PA distortion	8.7% 12.7%	
		Early reoperations	4 8	
		Interim reoperation	None 7	
		O_2 saturation at discharge (% ± Standard deviation)	85.2 ± 4.8 84.0 ± 5.6	
Abu-Senna *et al.* (2005), J Egypt Soc Cardiothorac Surg, Egypt [11] Retrospective analysis (level 4)	Case study of 75 patients who underwent modified BTS through the sternotomy approach between January 2002 and December 2004	Shunt failure Excessive shunt flow Re-exploration Early mortality	3/75 (4%) 2/75 (2.6%) 3/75 (4%) 2/75 (2.6%)	Sternotomy is technically easier Sternotomy approach is associated with fewer shunt failure, lesser PA distortion, good exposure
Çetin *et al.* (2005), Türk Göğüs Kalp Damar Cerrahisi Dergisi, Turkey [12] Retrospective case review (level 4)	Analysing 10 neonates who underwent modified BTS between January 2001 and September 2003 by the partial sternotomy approach	Surgical reintervention Operative mortality	1% 0%	The author concluded that MBT shunt through sternotomy is a simple and practical technique Noticed uniform growth of pulmonary arteries

preferable and perhaps haemodynamically superior. The hospital mortality rate was 5%.

McKenzie *et al.* [3] analysed the risk factors in patients undergoing modified BTS. Of 730 BTSs, 473 (65%) were performed through the sternotomy approach. The hospital mortality was 15% for BTS in univentricular lesions when compared with 3% in two ventricle circulation patients. They concluded that sternotomy approach, use of cardiopulmonary bypass, innominate artery-pulmonary artery (PA) shunt and diagnosis of Ebstein's were risk factors for in-hospital mortality ($P < 0.05$).

According to Shauq *et al.* [4], patients undergoing BTS via median sternotomy needed prolonged mechanical ventilation, more inotropes and longer intensive care unit stay. The conclusion of this study was higher morbidity in the sternotomy group; authors suggested the need for a large study and longer follow-up.

Dirks *et al.* [5] reviewed 32 patients who had an isolated modified BTS performed via the sternotomy approach and concluded that lower body weight and bigger shunt/kg body weight (BW) were significant risk factors for mortality and reintervention.

Ahmad *et al.* [6] retrospectively analysed 22 neonates undergoing modified BTS through a posterolateral thoracotomy and found that age, pulmonary artery diameter and the underlying cardiac anatomy were determining factors for outcomes. Four of 22 (18%) neonates had shunt occlusion or failure.

Odim *et al.* [7] decided to test the hypothesis that sternotomy approach yields less mortality and morbidity than the traditional thoracotomy approach and compared 52 shunts performed through thoracotomy and 52 shunts performed through sternotomy approach. They proved that thoracotomy patients have significantly higher shunt failures and hospital deaths compared with the sternotomy approach. They also concluded that the sternotomy route is technically less challenging with less anastomotic distortion, cosmetic advantages of a single incision and equal flow distribution into both pulmonary arteries. They also observed that patients with a previous thoracotomy may develop multiple aortopulmonary collaterals across the chest wall adhesions that may complicate future Fontan operations. The theoretical disadvantage of a future sternal re-entry was not apparent in this study.

Table 2: Secondary analysis of published literature comparing sternotomy vs thoracotomy for modified BTS

Parameters	Shauq *et al.* [4]		Odim *et al.* [7]		Alkhulaifi *et al.* [8]		Mohammadi *et al.* [10]	
Group	Gp S	Gp T	Gp S	Gp T	Gp S	Gp T	Gp S	Gp T
Number of patients (*n*)	21	21	52	52	33	42	46	180
Duration of ventilation (h)	183	53	–	–	96	88	112	30
Inotropic requirements	33.3%	4.2%	–	–	–	–	–	–
ICU stay (days)	9.14	3.3	–	–	–	–	6	2
Hospital stay (days)	14	5	–	–	12.5	11.2	–	–
Shunt failures	–	–	4 (7.7%)	10 (19%)	2 (6%)	5 (11%)	4 (8.6%)	15 (8.3%)
In-hospital mortality	–	–	6 (11%)	3 (5.7%)	1 (3%)	2 (4%)	7 (15.2%)	6 (3.33%)
Phrenic nerve injury	–	–	1	1	–	–	–	–
PA distortion on subsequent surgery	–	–	10%	16%	–	–	8.7%	12.7%
Recurrent laryngeal nerve injury	–	–	1	1	–	–	–	–
Horner's syndrome	–	–	0	2	–	–	–	–
Resternotomy complications	–	–	5 (9%)	–	0	–	–	–
O_2 saturation at discharge	–	–	–	–	88.6 ± 4.2	84.8 ± 3.8	85.2 ± 4.8	84.0 ± 5.6
Late mortality	–	–	–	–	–	–	0%	8.33%
Reoperations	–	–	–	–	–	–	4 (8%)	15 (8%)

Not all parameters were reported in all papers.
Gp S: sternotomy; Gp T: thoracotomy.

Alkhulaifi *et al.* [8] studied 75 neonates who underwent modified BTS retrospectively and identified that the median sternotomy approach offers additional advantages like construction of anastomosis at the side of superior vena cava onto the right PA, thus allowing repair of PA at the time of bidirectional (BD) Glenn. This study concluded that the median sternotomy approach and small shunt size (3–5 mm) have been useful to improve the safety of modified BTS.

Williams *et al.* [9] conducted a retrospective review of all patients undergoing BTS at The Johns Hopkins Medical Institute over 6 decades. They observed that median sternotomy is the preferred approach in all patients. A comparison of first and second halves of the series revealed decreasing operative mortality (16 vs 9%).

Mohammadi *et al.* [10] reviewed 226 children to identify risk factors associated with in-hospital and interim mortality in children with a systemic to pulmonary shunt. Univariate analysis revealed younger age ($P = 0.03$) and lower body weight ($P = 0.04$) as risk factors for early shunt-related complications. Surgical approach was not a risk factor for early shunt thrombosis or stenosis. PA distortion ($P = 0.12$) and increased risk of interim mortality (7%) were more commonly seen in the thoracotomy group. Modified BTS through sternotomy approach had better pulmonary artery blood flows and lesser pulmonary artery distortion.

Abu-Senna *et al.* [11] studied retrospectively 75 patients who had median sternotomy for BTS. They observed 4% shunt failure rate, 2% excessive shunt flow and early mortality. Finally, they concluded that the sternotomy route is technically easier and associated with few shunt failures.

Cetin *et al.* [12] performed modified BTS in 10 neonates by using partial median sternotomy (from jugulum to third intercostal space). Only 1 patient underwent surgical reintervention and there was no operative mortality. Of 10 patients, 5 underwent a subsequent BD Glenn procedure after a period of 1.5 years. The authors concluded that partial median sternotomy is technically easier and simple procedure with uniform enlargement of both pulmonary arteries, and subsequent BD Glenn or Fontan is easier by leaving the right PA intact with less adhesions due to limited sternotomy.

A critical review of the above papers and Tables 1 and 2 clearly demonstrate that a BTS via a sternotomy is technically easier to perform, provides even distribution of blood flow to both PAs due to an anastomosis closer to the PA bifurcation, there is no need for lung compression in a child whose respiratory status is already compromised, provides ease of take down at reoperation and is associated with less incidence of aortopulmonary collateral formation. In patients with ventricular septal defect, pulmonary atresia and aortopulmonary collaterals, a sternotomy approach avoids the chest wall collaterals and simplifies the operation. A patent ductus arteriosus can be easily ligated via the sternotomy approach to prevent overshunting. The ability to institute cardiopulmonary bypass is another advantage of the sternotomy. Additionally, literature documents a troublesome incidence of phrenic nerve palsy requiring diaphragmatic placation in up to 23.8% patients undergoing BTS via thoracotomy [13] and an incidence thoracotomy induced scoliosis in up to 31% patients [14]. This is avoided by the sternotomy approach that is also cosmetically superior.

CLINICAL BOTTOM LINE

Median sternotomy approach for modified BTS is preferable to the thoracotomy approach with fewer shunt failures. The theoretical disadvantage of injury to heart or great vessels during re-entry was not observed in any series of patients who went on to definitive repair.

Conflict of interest: none declared.

REFERENCES

[1] Dunning J, Prendergast B, Mackway-Jones K. Towards evidence-based medicine in cardiothoracic surgery: best BETS. Interact CardioVasc Thorac Surg 2003;2:405–9.

[2] Kandakure PR, Dharmapuram AK, Ramadoss N, Babu V, Rao IM, Murthy KS. Option?. Asian Cardiovasc Thorac Ann 2010;18:368–72.
[3] McKenzie ED, Khan MS, Samayoa AX, Vener DS, Ishak YM, Santos AB *et al*. The Blalock-Taussig shunt revisited: a contemporary experience. J Am Coll Surg 2013;216:699–704.
[4] Shauq A, Agarwal V, Karunaratne A, Gladman G, Pozzi M, Kaarne M *et al*. Surgical approaches to the Blalock shunt: does the approach matter?. Heart Lung Circ 2010;19:460–4.
[5] Dirks V, Prêtre R, Knirsch W, Valsangiacomo Buechel ER, Seifert B, Schweiger M *et al*. Modified Blalock Taussig shunt: a not-so-simple palliative procedure. Eur J Cardiothorac Surg 2013;44:1096–102.
[6] Ahmad U, Fatimi SH, Naqvi I, Atiq M, Moizuddin SS, Sheikh KB *et al*. Modified Blalock-Taussig shunt: immediate and short-term follow-up results in neonates. Heart Lung Circ 2008;17:54–8.
[7] Odim J, Portzky M, Zurakowski D, Wernovsky G, Burke RP, Mayer JE Jr *et al*. Sternotomy approach for the modified Blalock-Taussig shunt. Circulation 1995;92:II256–61.
[8] Alkhulaifi AM, Lacour-Gayet F, Serraf A, Belli E, Planché C. Systemic pulmonary shunts in neonates: early clinical outcome and choice of surgical approach. Ann Thorac Surg 2000;69:1499–504.
[9] Williams JA, Bansal AK, Kim BJ, Nwakanma LU, Patel ND, Seth AK *et al*. Two thousand Blalock-Taussig shunts: a six-decade experience. Ann Thorac Surg 2007;84:2070–5.
[10] Mohammadi S, Benhameid O, Campbell A, Potts J, Joza J, Al-Habib H *et al*. Could we still improve early and interim outcome after prosthetic systemic-pulmonary shunt? A risk factors analysis. Eur J Cardiothorac Surg 2008;34:545–49.
[11] Abu-Senna WG, Lotfy W. Sternotomy approach for the modified Blalock-Taussig shunt: advantages and disadvantages. J Egypt Soc Cardiothorac Surg 2005;13:64–8.
[12] Çetin G, Özkara A, Tireli E, Haydin S, Korkut K. Neonatal Blalock Taussig shunt in complex cyanotic heart pathologies. *Türk Göğüs Kalp Damar Cerrahisi Dergisi* 2005, Cilt 13 (Sayı 1), Sayfa(lar) 71–3.
[13] Akay TH, Ozkan S, Gultekin B, Uguz E, Varan B, Sezgin A *et al*. Diaphragmatic paralysis after cardiac surgery in children: incidence, prognosis and surgical management. Pediatr Surg Int 2006;22: 341–6.
[14] Bal S, Elshershari H, Celiker R, Celiker A. Thoracic sequels after thoracotomies in children with congenital cardiac disease. Cardiol Young 2003;13: 264–7.