The short- and long-term effect of Blalock-Taussig shunt size on the outcome after first palliative surgery for cyanotic heart diseases

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BACKGROUND AND OBJECTIVES: The Blalock-Taussig (BT) shunt is regarded a safe and effective means increasing pulmonary blood flow for cyanotic heart conditions. The evaluation of shunt size for postoperative hemodynamics and until second-stage palliation remains difficult. Our objective is to compare the effect of different shunt sizes on short- and long-term outcomes after a BT shunt surgery.

DESIGN AND SETTINGS: This is a retrospective review in a tertiary care hospital.

PATIENTS: The records of all patients with a modified BT shunt between January 2007 and January 2010 were reviewed.

METHODS: Patients were divided into 2 groups: Group A with a BT shunt of 3.5 mm and Group B with a BT shunt of 4 mm, and their body weight was less than 4 kg. Groups were compared for the short-term outcome, which includes: intensive care unit course, intensive care unit (ICU) and hospital stay, mortality during the same admission, and the size of branch pulmonary arteries (PAs) before second surgery.

RESULTS: A total of 29 (42%) patients were in Group A and 40 (58%) in Group B. There was no significant difference in the mean weight between both groups; P value .06. There was no significant difference between the 2 groups in regard to diastolic blood pressure and lactate levels by the end of the first 48 hours after surgery. Group A required longer duration of inotropes and more days of ventilation with P value .03 and .001, respectively. The mean (standard deviation) ICU and hospital stay were 10.0 (8.9) days and 17.0 (11.4) days, respectively, for Group A and 12 (8.9) days and 15 (12.9) days, respectively, for Group B with P value .7 and P value .6, respectively. Yet Group B had a better branch PA size and required lesser intervention for branch PAs in comparison to Group A.

CONCLUSION: These data suggest that a smaller shunt size may have a trend toward higher morbidity. A bigger shunt size does not necessairily lead to stealing phenomena and its consequnces, and can be performed with a low risk leading to a better growth of branch PAs.
may become too large. There is very little published work with a special reference to the size of the MBTS. 4

Our objective was to compare the effect of different shunt sizes on short- and long-term outcomes after a BT shunt surgery. We decided to review our experience aiming to find whether this would have a significant impact on the outcome of this group of patients.

METHODS

Patients
Institutional review board approval and waiver of consent were obtained. Then a nonrandomized retrospective review was performed on all patients who underwent BT shunt surgery at our Heart Center (HC) from January 01, 2007-January 01, 2010.

Patients who underwent a BT shunt surgery were identified for inclusion in the study through the HC Apollo Database.

Exclusion Criteria
We excluded patients who underwent a BT shunt surgery with the shunt size of 4 mm, whose body weight was more than or equal to 4 kg, and who underwent Norwood procedure.

Patients included in the study were divided into the following 2 groups based on the BT shunt size they had: Group A, with a BT shunt size of 3.5 mm and Group B, with a BT shunt size of 4 mm and their body weight was less than 4 kg; this was to eliminate the effect of having higher weight on the shunt size selection.

The 2 groups were compared for both short- and long-term outcomes. We pre-defined the short-term outcomes as follows: intensive care unit (ICU) course during the first 48 hours after surgery (analyzing mean blood pressure, diastolic blood pressure [DBP], lactic acid level, and duration of inotropic support), ICU and hospital stay, and mortality during the same hospital admission. The long-term outcomes were defined as follows: the size of branch PA and Z-score prior to the second-stage surgery and requirement for PAs augmentation with the second-stage surgery.

Patients were followed up till their next-stage surgery, which was on average about 4 to 5 months after their BT shunt surgery.

Data collection
Information on patient demographics, diagnosis, type(s) of procedure(s), hospital complications, and long-term outcomes were gathered from medical records and hospital electronic system.

All data were collected into a pre-designed data collection form specific for the study.

Statistical Analysis
Statistical analysis was performed using SPSS, version 12.0 (SPSS, Inc., Chicago, IL USA). Comparisons between groups were made using a 2-tailed Student t test and Fisher exact test as indicated. All statistics were reported as mean (standard deviation [SD]) unless otherwise indicated. A probability value of less than.05 was considered significant.

RESULTS

The total number of patients who underwent a BT shunt surgery and weighed less than 4 kg during the study period was 69. A total of 29 patients (42%) had a shunt of 3.5 mm (16 [55%] of them were males), and 40 patients (58%) had a shunt of 4 mm (20 [50%] of them were males). The cardiac diagnosis for both groups was comparable as shown in Table 1.

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Table 1. The cardiac diagnosis and BT shunt size for both groups.

| Diagnosis  | Group A (3.5 mm) | Group B (4 mm) |
|-----------|-----------------|---------------|
| PA, VSD   | 12/29           | 15/40         |
| PA, IVS   | 2/2             | 2/2           |
| PA, TOF   | 2/5             | 4/5           |
| TOF       | 2/5             | 4/5           |
| TGA, PA/PS| 8/7             | 7/7           |
| Others    | 5/7             | 7/7           |

PA: Pulmonary atresia; IVS: intact ventricular septum; TOF: tetralogy of fallot; TGA: transposition of great arteries; PS: pulmonary stenosis.

Table 2. Demographic data and surgical approach for both groups.

| Parameter          | Group A | Group B | P  |
|--------------------|---------|---------|----|
| Male               | 16      | 20      | .8 |
| Sternotomy         | 21      | 28      | .9 |
| Right BT shunt     | 24      | 30      | .5 |
| Revision of BT shunt | 1      | 2       | .9 |
The demographic data and surgical approach for both groups are shown in Table 2 with no significant difference between both groups.

The 2 groups were compared for the mean arterial pressure (MAP), DBP, and lactic acid levels during the first 48 hours after their BT shunt surgery, as shown in Table 3. Although there was a trend of significant difference between both groups for the MAP, yet there was no significant difference over their follow-up course in the mean values for DBP and lactate levels.

Group A patients required a longer duration of inotropic support and more days on mechanical ventilation when compared with Group B, with P values of .03 and .001, respectively. There was no statistical significant difference in the ICU and hospital stay as shown in Table 4. Additionally, the mortality rate was 10% (3/29 patients) in Group A and 5% in Group B (2/40 patients) with a P value of .4, which was not statistically significant.

As regards the long-term outcome, we compared the difference in the mean (SD) size of right pulmonary artery (RPA) before the BT shunt surgery with that of pre-second stage surgery in the same group; for Group A, the values were 3.4 (1.9) and 4 (1.3), respectively, with a statistically non-significant P value of .1; however, for Group B, the values were 4.1 (1) and 5.8 (1.9), respectively, with a statistically significant P value of .0001. On comparing both groups prior to the second-stage surgery, the mean (SD) of RPA size for Group A was 4 (1.3) mm and that for Group B was 5.8 (1.9) mm, with a P value of .0001 (Table 5).

A total of 26 patients survived till the second-stage surgery of which 6 patients (23%) required PAs augmentation, whereas 35 patients survived in Group B and only 4 (11%) of them required PAs augmentation, with a P value of .02.

**DISCUSSION**

The evaluation of shunt size for favorable short- and long-term outcomes at every time point until the second-stage palliation remains difficult. In our center, most surgeons would ligate the patent ductus arteriosus (PDA) and use either an MBTS of 3.5 mm or that of 4 mm in a neonate, according to the surgeon’s preference together with the patient’s body weight and anatomy. We decided to compare the patients with matching cardiac diagnosis who underwent MBTS and divided them into 2 groups based on the MBTS size they got; first, with an MBTS shunt size of 3.5 mm and second, with an MBTS shunt size of 4 mm. The postoperative hemodynamic status in patients with large shunts was overall better, mirrored by shorter duration of inotropic support, and fewer days on mechanical ventilation. Our findings matched what was found by Joachim and colleagues,4 who concluded that in Norwood patients, postoperative hemodynamic status in patients with large shunts was better. It was reported by Sanjeeva and colleagues3 that using a shunt of 3.5 mm has helped to a great extent in decreasing the possibility of over-shunting, and the postoperative course of patients with shunts of 3.5 mm may be smoother than those with larger shunts because over-shunting may be reduced; however, in our series this was not obvious as there

**Table 3. Short-term outcome for both groups. Difference between both groups for MAP, DBP, and lactate values during first 48 h after BT shunt surgery.**

| Parameters      | Group A (N=29) Mean (SD) | Group B (N=40) Mean (SD) | P       |
|-----------------|--------------------------|--------------------------|---------|
| MAP (Adm.)      | 46 (6)                   | 40 (10)                  | .005    |
| MAP (6 h)       | 42 (7)                   | 40 (3)                   | .1      |
| MAP (12 h)      | 41 (8)                   | 40 (4)                   | .4      |
| MAP (24 h)      | 42 (9)                   | 50 (5)                   | .0001   |
| MAP (48 h)      | 43 (9)                   | 50 (4)                   | .0001   |
| DBP (Adm.)      | 30 (5)                   | 30 (8)                   | 1       |
| DBP (6 h)       | 30 (6)                   | 30 (2)                   | 1       |
| DBP (12 h)      | 30 (6)                   | 30 (4)                   | 1       |
| DBP (24 h)      | 32 (4)                   | 30 (4)                   | .04     |
| DBP (48 h)      | 34 (7)                   | 35 (5)                   | .4      |
| Lactate (Adm.)  | 3.2 (2.4)                | 2.0 (0.8)                | .004    |
| Lactate (6 h)   | 3.0 (2.1)                | 3.0 (1.3)                | 1       |
| Lactate (12 h)  | 2.6 (1.8)                | 3.0 (1.4)                | .3      |
| Lactate (24 h)  | 1.8 (1.1)                | 2.6 (2.3)                | .08     |
| Lactate (48 h)  | 1.6 (0.9)                | 1.9 (0.6)                | .1      |

Adm: Admission; MAP: mean arterial pressure; DBP: diastolic blood pressure.

**Table 4. Short-term outcome for both groups.**

| Parameter                     | Group A Mean (SD) | Group B Mean (SD) | P       |
|-------------------------------|-------------------|-------------------|---------|
| Mean (SD) duration of inotropes (d) | 3.0 (1.2)         | 2.0 (2.2)         | .03     |
| Mean (SD) ventilation (d)     | 6.7 (3.7)         | 3.0 (3.8)         | .001    |
| Mean (SD) ICU stay (d)        | 10.0 (8.9)        | 7.0 (6)           | .7      |
| Mean (SD) hospital stay (d)   | 17.0 (11.4)       | 11.0 (6.3)        | .6      |

ICU: Intensive care unit; SD: standard deviation.

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were no significant differences between the 2 groups for serial measurement of DBP and lactic acid levels that were used as parameters to assess over-shunting during the first 48 hours after surgery. Additionally, our series did not show any significant difference neither in ICU and hospital stay, nor in mortality between both groups. The trend of the mortality was higher in the smaller shunt (10% versus 5% in the group with larger shunt) even though both groups were comparable for primary cardiac lesions and surgical approaches. The hospital mortality rate reported in some studies was observed as follows: 8% of patients in the group using larger shunts and 32% in the group preferring smaller shunts, while the overall hospital mortality for BT shunt in another series was reported as 10.9%. In another study by Bove and colleagues, no PA distortion was observed in the 32 patients who had angiographic follow-up. Another study by Anjan and colleagues concluded that in the absence of antegrade pulmonary blood flow, an MBTS to the main PA may promote a more uniform branch PA growth.

In our series, there was an increase in the pulmonary artery size on both sides after the shunt surgery (yet we only analyzed the RPA due to incomplete data for the LPA) together with an increase in the mean RPA size that correlates with using a bigger shunt size with a statistically significant difference. It was reported that even perfect shunts might result in unbalanced development of the central pulmonary vessels, with a preferential growth of the ipsilateral or contralateral PA. On the contrary, the BT shunt surgery can be performed with a low risk, offers excellent palliation, and is associated with an excellent PA growth, and this goes in line with our findings.

However, the mean PA pressure was higher in the bigger shunt group, which may be explained by more pulmonary blood flow going through the bigger shunt, but interestingly enough this difference did not significantly affect the second-stage surgery.

Limitations of the study: We are fully aware that this is a retrospective, nonrandomized study, and that the 2 groups of patients are not completely homogeneous in terms of age and weight. And as the sample size is small, this might over-reflect the analysis.

In conclusion, data suggest that smaller shunt size may have a trend toward higher morbidity. Bigger shunt size does not necessarily lead to stealing phenomena and its consequences and can be performed with a low risk leading to better growth of branch PAs.

| Parameter                  | Group A | Group B | P     |
|----------------------------|---------|---------|-------|
| Mean (SD) BSA (m2)         | 0.3 (0.1) | 0.3 (0.1) | .5 |
| Mean (SD) RPA size (mm)    | 4.0 (1.3) | 5.8 (1.9) | .001 |
| RPA Z-score                | -1.2    | -1.4    | .8   |
| Mean (SD) LPA size (mm)    | 5.7 (1.9) | 5.6 (2.3) | .9   |
| LPA Z-score                | -0.5    | -0.7    | .6   |
| Mean (SD) MPAP (mm Hg)     | 17.0 (3.2) | 21.0 (5.7) | .001 |

BSA: Body surface area; RPA: right pulmonary artery; LPA: left pulmonary artery; MPAP: mean pulmonary artery pressure.
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