

# Pulmonary Artery Banding in the Current Era: Is It Safe and Useful Yet?

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## **Abstract:**

**Background:** The main goal of this study was to assess the results of the pulmonary Artery (PA) banding in patients with congenital heart defects (CHD) and pulmonary Hypertension (PH).

**Methods:** We analyzed data from 305 patients who had operation between April 2005 and April 2010 in Rajae Heart Center, Tehran, Iran. All patients were approached through a Left thoracotomy and 20% of patients underwent PA banding based on Tru-sler's rule (Group1), 55% of them underwent PA banding based on PA pressure measurement

(Group 2), and the rest of them (25%) based on surgeon experience (group 3). The follow-up period was 39±20 month and 75 % of patients (230 cases) had definitive repair of mean interval 23±10 month.

**Results:** The rate of anatomically and functionally effectiveness of PA banding in all groups were high (97% and 92% respectively). There were no significant differences in anatomically and functionally efficacy rate between all groups ( $p= 0.77$ ,  $p=0.728$  respectively). There was PA bifurcation stenosis in 6 cases (2%), and pulmonary valve injury in 1 case ( 0.3%). There were 11 patients (3.6%) intubated two days or more in intensive care unit (ICU). The mortality rate in PA banding was 2% and in definitive repair was 3%.

**Conclusion:** With low mortality (2%) and morbidity and high efficacy rate of PA banding in our series, we believe that PA banding still plays a role in management of patients with CHD, particularly for infants with medical problems such as sepsis, low body weight, intracranial hemorrhage and associated non cardiac anomalies. We believe that PA banding can be done safely with low morbidity and mortality.

**Key words:** Pulmonary artery banding, congenital heart disease, pulmonary hypertension

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Muller & Dammann [1] introduced pulmonary artery banding (PA banding) in clinical practice in 1951.

They advocated this operation for patients with single ventricle or large ventricular septal defect (VSD).

Since then, this operation has been used as a palliative procedure for small infants with complex congenital heart defects.

Then, they were followed by definitive repair of an older age. Currently, early primary repair is the treatment of first choice for congenital cardiac defects [2, 3, 4 & 5].

The main goal of this study was to assess the result of PA banding in patients with congenital heart defects and to realize if PA banding still play an important role in the treatment of congenital heart disease or not?

### **Patients & Methods:**

In this retrospective study, all patients who underwent PA banding between April 2005 and April 2010 in Rajaei Heart center were evaluated.

Data including ; Age, Diagnosis, Weight, Sex, Primary type of procedure for PA banding, early and late complications, rate of anatomically and functionally effectiveness of PA banding, Peak systolic and mean systolic gradient after PA banding during operation and in post operation echo in intensive care unit (ICU).

Early and late mortality rate, cause of death, complications after PA banding in final corrections and follow-up period were extracted and analyzed.

After surgery all patients underwent echocardiographic assessment.

Anatomically effectiveness was defined as a 50% reducing in diameter of pulmonary artery (PA) and functionally effectiveness was defined as PA pressure less than 50% systolic pressure.

### **Surgical procedure:**

All patients were approached through a left lateral thoracotomy and a 4mm wide polyester tape was used for all patients.

Some of surgeons used Trusler's rule for achieving optimal PA banding (Trusler's rule group or group 1) [6]. According to Trusler's rule, band was marked to a length of 20mm, plus the number of millimeters corresponding to the child's weight in Kilograms, to indicate the ultimate tightness of the band. If the banding was done for a complex cardiac

anomaly with bidirectional shunting, the length was 24 mm plus the child's weight.

For achieving optimal PA banding, some surgeons judged by the pressure difference across the band during the operation. They did it based on measurements of the pulmonary artery pressure distal to the band.

In this group (PA pressure measurement or group 2), the PA pressure was reduced to less than 50% of systolic pressure.[5] The test of patients underwent PA banding based on surgeon experience.

They didn't use the Trusler's rule, or PA pressure measurement (experience group or group 3).

In all of the patients arterial oxygen saturation was considered and most of them had the arterial oxygen saturation more than 80% to 85% with FIO<sub>2</sub> of 50%. When the ideal diameter is obtained, the band was fixed to pulmonary artery trunk adventitia to prevent migration of the band.

Data were analyzed with T-test and Chi-square test and the P-value less than 0.05 was considered statistically significant.

### **Results:**

In this retrospective study, the data of 305 patients who underwent PA banding in Shahid Rajaei Heart Center between April 2005 to April 2010 was collected.

The mean age was 7.12± 5.2 month and the mean weight was 5.59±1.6 Kg.

163 patients were male (53%) and 142 patients were female (47%).

The preoperative demographic data of patients are depicted in table 1, and also table 1 shows the primary diagnosis of patients.

175 patients had large ventricular septal defect (VSD) or multiple VSD (57.4%) and 26 patients had complete atrio-ventricular septal defect (CAVCD) (8.5%).

Others cardiac anomalies were transposition of great arteries (TGA) with VSD (10.2%), Double outlet right ventricle (DORV) (4.3%), VSD with coarctation of aorta or interrupted aortic arch (3.9%), single ventricular (SV) (1.6%).

62 patients (20%) underwent PA banding with Trusler's rule (group 1) and 169 patients (55%) underwent PA banding based on measurement of the PA pressure distal the band during the operation (group 2) and the rest of

Table 1: The preoperative demographic and diagnosis data of patients.

Age Month))	Mean =7.12 ±5.2	Range :1 -48
Weight (Kg)	Mean = 5 .59 ± 1 .6	Range :3-15
Sex	Male = 163 (53 %)	Female = 142 (47 %)
Diagnosis: DoRV	13 (4 .3 %)	
TGA With VSD	31 (10 .2 %)	
CAVSD	26 (8 .5 %)	
SV	5 (1 .6 %)	
Large VSD or Multiple VSD	175 (57 .4 %)	
VSD with CoA or VSD with interrupted aortic arch	12 ( 57 .4 %)	
Others	3 ( 1 %)	

DoRV: Double Outlet right ventricle  
 TGA: Transposition of great arteries  
 VSD: Ventricular septal defects  
 CAVSD: Complete atrioventricular septal defect  
 SV: Single ventricle  
 CoA: Coarctation of aorta

patients (72 cases , 25%) underwent PA banding based on surgeon experience (group 3). (Figure 1)

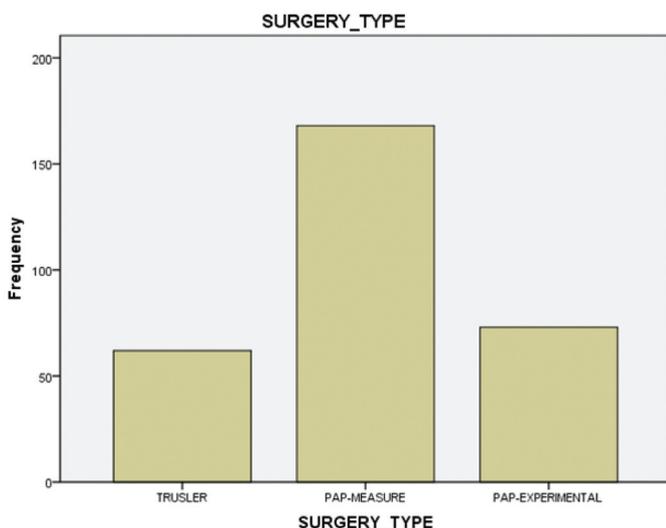


Figure 1 :Histogram of various techniques of PA banding in patients

In post op echocardiography 97% of the PA banding were anatomically and 92% of them were functionally effective. The mean peak gradient (PG) across PA banding was 56±18 mmHg. There were no significant differences in anatomically effectiveness rate between different types of PA banding (group 1, 2 & 3) (p = 0.77%) and functionally effectiveness rate between all groups (p = 0.728).

There were 51 cases of post operative atelectasia (16%) and 6 cases of the sepsis and 11 cases of the prolong intubation (intubation period 2 days and/or more) (3.6%). No case of bleeding and PA injury during operation were found. The post operation data and character of patients are shown in table 2. The follow-up period was 39±20 month. The in -hospital mortality was 2% (6 cases) and 3 cases died due to sepsis and another died due to heart failure. No cases of mortality were found in follow-up period.

230 patients (75.4%) had definitive repair of a mean interval 23±10 month. The mean age at definitive repair was 30.48±11 month and the mean weight was 11±2.6 kg.

Table 2: The postoperative data and characters of patients

PG across PA band	Mean = 55 .92	Range:10 -140
Functionally efficacy of PA banding	92 %	
Anatomically efficacy of PA banding	97 %	
ICU stay (days )	Mean = 3.6	Range :2 - 43
Athelectasia	51 (16 %)	
Sepsis	6 (2 %)	
Prolong intubation ( 2 days or more )	11 (3.6 %)	
PA bifurcation stenosis	6 ( 2% )	
Pulmonary valve injury	1 ( 0.3 % )	

PA: Pulmonary artery

PG: Peak gradient

2% of patients had PA bifurcation stenosis (6 cases) and one patient (0.3%) had pulmonary valve injured. In hospital mortality rate in definitive repair was 3% (7 cases).

In definitive repair, only 20% of patients underwent pulmonary artery repairing with pericardial patch after PA de banding and the rest of patients (80%) underwent just PA de banding without any repair of pulmonary artery.

There was residual pulmonary stenosis (PS) in 2% of patients after definitive repairing with mean gradient of 30 mmHg. There was no significant difference in residual PS after PA de banding and repairing, with pericardial patch and without pericardial patch.

### **Discussion:**

We know that primary repair is expected to replace staged operation [2, 3, 4 & 5]. The complication of banding includes distal migration of band and erosion of band into the PA lumen [2, 3]. We had bifurcation stenosis in 2% of our patients and we didn't have any erosion of band into the PA lumen and we didn't have bleeding and rupture of

PA in our series.

In our study the mortality rate of PA banding was 2% (6 cases) ,but mortality rate in other studies is reported between 10% to 38%[2, 3, 4 & 5].The reported mortality rate decreased from approximately 30% before 1980 to approximately 10% [7,8,9].

In the series reported by Hiroo Takayama et al, mortality rate was 13.8% [2].

In our study, multivariate analysis demonstrated that no isolated variable including Sex, Weight and diagnosis was a significant risk factor. But in some reports, child's weight was detected as a significant risk factor for early death [3].

In some reports PA banding has been used in neonate with isolated congenitally corrected transposition of the great arteries (ccTGA) [1]. In the series reported by Metton et al, early prophylactic PA banding was performed safely for preparing and improving of the left ventricle function.[10] Then the patients underwent double switch operation.

PA banding has still important role in the treatment of

functionally single ventricle [3, 4 & 11]. In this patients PA banding is as an initial step followed by bidirectional cava pulmonary shunts. About PA banding in definitive repair, we believe that in most patients the removal of band without repairing PA could be enough and the rate of residual PS in our series was low (2%).

### **Conclusion:**

In the current era operative indication have been extended to complex and high risk patients and many neonates and infants are now treated by primary repair. But in our study we had low mortality (2%) and morbidity rate after PA banding, and rate of efficacy was high (92% to 97%).

We believe that PA banding still plays a role in management of patient with congenital heart disease, particularly for infants with a single ventricle and infant with medical problems such as intracranial hemorrhage, low body weight, sepsis and associated noncardiac anomalies.

We believe that PA banding can be done safely with low complications and mortality.

### **References:**

1. Muller Jr WH, Dammann JE. Treatment of certain congenital malformations of the heart by the certain of pulmonic stenosis to reduce pulmonary hypertension and excessive pulmonary blood flow :a preliminary report .*Surge Gynecol Obstet* 1952 ; 95: 213 -219.
2. Yoshimura N , Yamaguchi M ,Oka S , Yoshida M , Murakami H. Pulmonary artery banding still has an important role in the treatment of the congenital heart disease. *Ann Thorac Surg* 2005 ;79 :1463.
3. Takayama H ,Sekiguchi A, Chikada M, Noma M , Ishizawa A , Takamoto S. Mortality of pulmonary artery banding in the current era: recent mortality of PA banding . *Ann Thorac Surg* 2002 ; 74: 1219-1224 .
4. Günter T , Mazzitelli D , Haehnel cJ ,Holper K , Sebening F , Meisner H. Long Term results after repair of complete atrioventricular defect: analysis of risk factors. *Ann Thorac Surg* 1998; 65: 754-759.
5. Kouchouks NT , Blackstone EH ,Doty DB , Hanley FL , Karp RB .Tricuspid atresia and management of single ventricle physiology. In Kirklin , Barratt –Boyes , editors. *Cardiac Surgery* 3rd edition. Philadelphia: Churchill Livingstone; 2003. p. 1114 -1166.
6. Trusler's GA, Mustard WT .A method of banding the pulmonary artery for large isolated ventricular septal defect with and without transposition of great arteries .*Ann Thorac Surg* 1972 ; 13: 351 -355 .
7. Kron IL ,Nolan SP, Flanagan TL ,Gutgessell HP ,Muller Jr WH .Pulmonary artery banding revisited . *Ann Surge* 1989; 209: 642 -647.
8. Horowitz MD, Culpepper WS, 3rd, Williams LC, 3 rd, Sundgaard –Riise K, Ochsner JL .Pulmonary artery banding: analysis of a 25 –year experience. *Ann Thorac Surg* 1989 ; 48 : 444 -450 .
9. Le Blanc JC , Ashmor PG ,Pineda E , Sander GC ,Patterson MW ,Tipple M. Pulmonary artery banding: results and current indications in pediatric cardiac surgery. *Ann Thorac Surg* 1987 ; 44 : 628 -632 .
10. Metton O , Gaudin R , OU P ,Gerelli S , Mussa S , Sidi D , Vouhe P ,Raisky O . Early prophylactic pulmonary artery banding in isolated congenitally corrected transposition of the great arteries . *Euro J Cardiothorac Surg* 2010 ; Dec ; 38 (6) :728- 34 .
11. Kajihara N , Asou T , Takeda Y , Kosaka Y , Onakatomi Y ,Nagafuchi H, Yasui S. *Ann Thorac Surg* 2010 ; 89 : 174 -179.