นิพนธ์ต้นฉบับ

# Post-operative complications in pediatric cardiac surgery*

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*Cardiac surgery was performed on 212 pediatric patients during the period July 1989 to June 1991 at Chulalongkorn Hospital; 42 patients underwent palliative surgery and 170 corrective surgery. The causes of death were: low cardiac output (12 cases), congestive heart failure (4 cases), pulmonary edema (2 cases), hemopericardium (1 case), intravascular hemolysis with renal failure (1 case), brain edema (1 case), hyperkalemia (1 case), pneumonia with bleeding from tracheostomy site (1 case) and ventricular fibrillation (1 case). Post-operative complications can be reduced if operations are done cautiously and prudent post-operative precautions with proper stepwise management are carried out.*

*Key words : Post-operative complications, Pediatric cardiac surgery.*

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Post-operative complications are unexpected events related to surgery.[1] Sometimes complications are severe enough to cause mortality. The purpose of this paper is to report the early post-operative complications that occurred in the first month after pediatric cardiac surgery at Chulalongkorn Hospital.

## Materials and Results

From July 1989 to June 1991, 237 patients admitted to the Department of Pediatrics, Chulalongkorn Hospital underwent cardiac surgery. The records of only 212 of these patients were available for this study. Twenty-four patients (11.3%) died after surgery. These patients are divides into three groups: congenital acyanotic heart diseases, congenital cyanotic heart diseases and acquired heart diseases.

### 1. Congenital acyanotic heart diseases

*1.1 Ventricular septal defect (VSD)*

This group consisted of pure VSD (24 cases) and VSD associated with other lesions included; pulmonary stenosis (4 cases), dysplastic pulmonary valve (1 cases), aortic insufficiency (2 cases), atrial septal defect (ASD) (1 case) and patient ductus arteriosus (1 case). The overall number of patients in this group were 33 cases; 16 patients had post-operative complications (47%) and five died (14.7%) (Table 1).

**Table 1.** Post-operative complications in 16 cases of VSD.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 5 yrs | VSD, PS | Closure VSD, pulmonary valvulotomy | PPS, residual PG across PV | Survived |
| 2 | 6 yrs | VSD | Closure VSD | Hemopericardium | Expired |
| 3 | 7 yrs | Multiple VSD, PDA | Closure VSD, Ligate PDA | Residual left to right shunt | Survived |
| 4 | 12 yrs | VSD, ASD PH | Closure ASD and VSD, Tricuspid annulo. | PPS | Survived |
| 5 | 3 yrs | VSD (cushion) | Closure VSD | Residual left to right shunt | Survived |
| 6 | 6 yrs | VSD, MI, TI Post PA banding | Closure VSD, debanding PA, MV and TV annulo. | RBBB, Hemothorax | Survived |
| 7 | 13 yrs | VSD, PH | Closure VSD | Intravascular hemolysis, renal failure | Expired |
| 8 | 5 yrs | VSD | Closure VSD | Wound infection | Survived |
| 9 | 1 yr | VSD | Closure VSD | Low CO, Pneumonia | Expired |
| 10 | 1 yr | VSD | Closure VSD | Low CO | Expired |
| 11 | 3.5 yrs | VSD | Closure VSD | Pneumonia | Survived |
| 12 | 13 yrs | VSD (cushion) | Closure VSD | RBBB | Survived |
| 13 | 6 yrs | VSD, AI | Closure VSD, repair aortic valve | Convulsion | Expired |

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 14 | 4 yrs | VSD (cushion) | Closure VSD | Residual left to right shunt, PPS | Survived |
| 15 | 9 yrs | VSD | Closure VSD | PPS | Survived |
| 16 | 11 yrs | VSD, Dysplastic PV | Closure VSD, PVR | Osteomyelitis of the sternum | Survived |

Abbreviations: PS = Pulmonary stenosis; PPS = Post-pericardiotomy syndrome; PG = Pressure gradient; PV = Pulmonary valve; PDA = Patent ductus arteriosus; ASD = Atrial septal defect; PH = Pulmonary hypertension; MI = Mitral insufficiency; TI = Tricuspid insufficiency; PA = Pulmonary artery; MV = Mitral valve; TV = Tricuspid valve; RBBB = Right bundle branch block; CO = Cardiac output; AI = Aortic insufficiency; PVR = Pulmonary valve replacement; annulo. = annuloplasty.

Residual left to right shunt persisted in cases no. 3 and 5. Case no. 3 had three muscular VSDs. Only two VSDs could be closed during surgery, the location of the other defect made it too difficult to be closed.

Hemothorax developed after surgery in case no. 6 from tearing of the superior vena cava (SVC) caused by venipuncture with Cavafix. Follow-up EKG showed RBBB.

Case no. 2 developed hypotension from hemopericardium. Reoperation was necessary to stop bleeding. The patient had signs of low cardiac output and finally expired.

Case no. 7 died from intravascular hemolysis and renal failure. Intravascular hemolysis might have been due to prolonged cardiopulmonary bypass or trauma to red blood cells due to the use of a Dacron patch.

Cases no. 9 and 10, both less than one year of age, succumbed from low cardiac output.

Case no. 13 developed convulsion and became unconscious after surgery. CT scan showed diffuse brain edema which might have been due to an air embolism. The patient eventually died.

### *1.2 Atrial septal defect (ASD)*

This group comprised 23 cases of secundum ASD, two cases of primum ASD, one case of both primum and secundum ASDs, one case of secundum ASD associated with PS and four cases of PDA. The total number of patients in this group was 31. There were seven cases with post-operative complications (22.5%) including one death (3%) (Table 2).

In case no. 1, EKG after cardiac surgery showed RBBB. The etiology of RBBB in this case was unknown.

Case no. 3 developed right pneumothorax, the cause of which was uncertain.

Case no. 4 presented with signs of pneumonia and heart failure from the large PDA. The patient developed pulmonary edema during operation and expired. Cause of death might have been fluid overload because she received 100 ml of fluid during the operation (body weight 3 kilopgrams).

Case no. 5 had a large hematoma at the Cavafix site and developed hypotension associated with hemothorax and hemopericardium. Prolonged shock was most likely due to a large amount of concealed bleeding at the Cavafix site, with right femoral vein puncture.

### *1.3 Patent ductus arteriosus (PDA)*

There were 49 cases in this group. Twenty-four cases (49%) had post-operative complications. Twenty-two cases developed significant and severe hypertension by criteria of the Report of the Second Task Force on Blood Pressure Control in Children.[2] Fourteen of the 22 cases received diruretics or vasodilators to control blood pressure. In the majority of cases, blood pressure dropped to the normal range within three days. The other eight cases did not receive any drugs and blood pressure decreased spontaneously within one week. The cause of post-operative hypertension in PDA patients was not studied.

In the other two cases, one developed transient phrenic nerve palsy which returned to normal one week later; this complication might have been due to traction during operation.[1] The other patient developed pneumonia. There was no mortality in this group.

### *1.4 Pulmonary stenosis (PS)*

There were 10 cases in this group. Only moderated and severe cases were operated upon; four cases (40%) had post-operative complications and three died (30%) (Table 3).

**Table 2.** Post-operative complications in ASD group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 6 yrs | ASD secundum | Closure ASD | RBBB | Survived |
| 2 | 8 yrs | ASD secundum | Closure ASD | Arrhythmia (Low RA rhythm with nodal escape beat) | Survived |
| 3 | 11 yrs | ASD secundum PI, TI, PH | Closure ASD | Pneumothorax | Survived |
| 4 | 21 days | ASDsecundum PDA | D&S PDA | Pulmonary edema | Expired |
| 5 | 7 yrs | ASD secundum PS | Closure ASD Pulmonary valvulotomy | Retroperitonial hematoma, hemothorax, hemopericardium and pneumonia | Survived |
| 6 | 8 yrs | ASD secundum Cleft MV, MI TI, PH | Closure ASD Repair MV | Residual MI | Survived |
| 7 | 14 yrs | ASD secundum | Closure ASD | RLL atelectasis | Survived |

Abbreviations are the same as in Table 1, plus: PI = Pulmonary insufficiency; RA = Right atrium; D&S PDA = Division and suture PDA; RLL = Right lower lobe.

**Table 3.** Post-operative complications in PS group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 9/12 yrs | Infundibular, valvular PS | Infundibulectomy, pulm. valvulotomy | Low CO | Expired |
| 2 | 3.5 yrs | Infundibular, valvular PS | Infundibulectomy RVOFT enlarge, tricusp. annulo. | RBBB + LAH | Survived |
| 3 | 6/12 yrs | Severe PS, small RV | B-H, Waterston shunt | CHF, Pneumonia | Expired |
| 4 | 3 yrs | Severe PS | Pulm. valvulotomy, tricusp. annulo. | Pulm. edema | Expired |

Abbreviations are the same as in Table 2, plus: RVOFT enlarge = Right ventricular outflow tract enlargement; tricusp. annulo. = tricuspid annuloplasty; LAH = Left anterior hemiblock; B-H = Blalock-Hanlon operation.

Case no. 1 developed low cardiac output until epiration.

In case no. 2, the EKG after surgery showed RBBB + LAH, which might have been due to injury during operation.

Case no. 3 developed congestive heart failure and pneumonia from the large shunt and expired.

Case no. 4 was in good condition until the third day after surgery. He developed dyspnea, cough, hypotension with frothy sputum from the endotracheal tube and died.

**2. Congenital cyanotic heart diseases**

***2.1 Tetralogy of Fallot (TOF)***

This group comprised two subgroups: the

subgroup that underwent total correction (23 cases) and the subgroup that had systemic-to-pulmonary artery shunt surgery (18 cases).

In the subgroup that had total correction (Table 4), there were three deaths (13%). EKG showed RBBB in 13 of the 14 cases obtained (92.8%).

**Table 4.** Post-operative complications in TOF group who underwent total correction.

| Cose no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 9 yrs | TOF | Total correction | Pleural effusion | Survived |
| 2 | 3.5 yrs | TOF | Total correction | Pleural effusion | Survived |
| 3 | 13 yrs | TOF | Total correction | PPS | Survived |
| 4 | 11 yrs | TOF | Total correction | Low CO | Survived |
| 5 | 9 yrs | TOF | Total correction | Rt. Pneumothorax | Survived |
| 6 | 14 yrs | TOF, post Rt. B-T | Total correction | Low CO | Expired |
| 7 | 7 yrs | TOF | Total correction | Complete AV block | Survived |
| 8 | 4 yrs | TOF | Total correction | Low CO | Expired |
| 9 | 12 yrs | TOF, Post Rt. B-T | Total correction | RUL atelectasis | Survived |
| 10 | 8 yrs | TOF | Total correction | Low CO | Expired |
| 11 | 14 yrs | TOF | Total correction | Pleural effusion | Survived |
| 12 | 10 yrs | TOF | Total correction | Pleural effusion Wound infection | Survived |
| 13 | 5 yrs | TOF | Total correction | PPS | Survived |

Abbreviations are the same as in Table 3, plus: Rt. = Right; B-T = Blalock-Taussig shunt; RUL = Right upper lobe.

Pleural effusion was detected after surgery in cases no. 1, 2, 11 and 12. It may be found in severe TOF with small main pulmonary artery and small left ventricle after total corrective surgery.

Case no. 4, 6, 8 and 10 developed low cardiac output after surgery because of a small left ventricle. Case no. 4 survived, but cases no. 6, 8 and 10 died.

Complete atrioventricular block was detected after surgery in case no. 7 so he underwent a permanent pacemaker implantation.

In the subgroup of TOF that had systemic-to-pulmonary artery shunt operation (18 cases), there were 15 cases of TOF and three cases of VSD with pulmonary atresia. Every case underwent a modified Blalock-Taussig shunt. There were four cases with post-operative complications: two cases with pleural effusion, one with wound infection and another one with shunt obstruction. There was no mortality in this subgroup.

*2.2 Complete transposition of the great arteries (TGA)*

There were six cases in this group; Three cases (50%) died after surgery (Table 5).

Case no. 3 developed low cardiac output and metabolic acidosis, which persisted until he died.

Case no. 5 developed heart failure after surgery. An echocardiogram showed left ventricular dysfunction. She died in the second week after operation. The cause of left ventricular dysfunction may have been due to the small size of the VSD and restricted pulmonary artery from banding.

Case no. 6 developed cardiopulmonary arrest after surgery. Serum electrolytes showed potassium 9.2 mEq/L. The patient died on the second post-operative day.

**Table 5.** Post-operative complications in complete TGA group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 30 days | TGA, VSD, PDA | Ligate PDA, PA banding, atrial septectomy | None | Survived |
| 2 | 9 yrs | TGA, VSD, PS PDA, Post B-H | Rastelli op. | Pleural effusion | Survived |
| 3 | 24 days | TGA, VSD, PDA | Ligate PDA, PA banding, atrial septectomy | Low CO | Expired |
| 4 | 5 yrs | Simple TGA Post B-H | Mustard op. | Pleural effusion, pneumonia | Survived |
| 5 | 1 yr | TGA, VSD, PDA TA | Ligate PDA, PA banding, atrial septectomy | LV dysfunction | Expired |
| 6 | 4 yrs | TGA, VSD, PS Post B-H | Rastelli op. | Cardiac arrest, hyperkalemia | Expired |

Abbreviations are the same as in Table 4, plus: op. = operation; TA = Tricuspid atresia; LV = Left ventricle.

### *2.3 Tricuspid atresia (TA)*

There were five cases in this group: one had corrective surgery (Fontan operation) and the other four palliative surgery. The patient who had the Fontan operation expired (Table 6).

### *2.4 Double outlet right ventricle (DORV)*

There were four cases in this group, two had corrective surgery and the other two had palliative surgery. One of the two cases who had corrective surgery died (Table 7).

**Table 6.** Tricuspid atresia group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 3 yrs | TA, PA, Post B-H & Rt. B-T | Modified Lt. B-T | None | Survived |
| 2 | 3.75 yrs | TA, ASD, VSD PS | B-H, B-T | None | Survived |
| 3 | 1 yr | TA, VSD | B-H, PA banding | None | Survived |
| 4 | 6 yrs | TA, TGA, PS, Post B-H | Fontan op. | Low CO, metabolic acidosis | Expired |
| 5 | 2 yrs | TA, TGA, PS, Post B-H, Central shunt | Modified Lt. B-T | Wound infection | Survived |

Abbreviations are the same as in Tables 3 and 4, plus: Lt. = left.

**Table 7.** Double outlet right ventricle group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 2 yrs | DORV, ASD PS | Closure VSD & ASD infundibulectomy | RBBB | Survived |
| 2 | 13 yrs | DORV, PS | Rastelli op. | Paraplegia, Pneumonia | Expired |
| 3 | 7/12 yrs | DORV | PA banding | Lt. lower lobe atelectasis | Survived |
| 4 | 4/12 yrs | DORV | PA banding | None | Survived |

Case no. 2 developed paraplegia after surgery.- The cause may have been due to spinal cord ischemia during cardiopulmonary bypass. She developed pneumonia later and died from bleeding at the tracheostomy site.

### *2.5 Persistent truncus arteriosus*

There was only one case, aged seven years,- classified as truncus arteriosus type I.[3] The patient was in good condition after total corrective surgery until the third day after operation. Four hours after removal of the endotracheal tube, he developed dyspnea, hypotension and metabolic acidosis, which persisted until he died. The cause of death may have been due to right heart failure from severe pulmonary hypertension.

### *2.6 Total anomalous pulmonary venous return (TAPVR)*

There was only one case, aged one year, who had TAPVR (supracardiac type) and PDA. A week after total correction and PDA ligation, she developed fever; an echocardiogram showed pericardial-effusion compatible with post-pericardiotomy syndrome. The patient responded well to acetyl salicylic acid.

### *2.7 Left-sided obstruction*

There were five cases in this group (Table 8).-

**Table 8.** Left-sided obstruction group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 7 yrs | Interrupted aortic arch, PDA | Lt. subclavian to DAO bypass graft, ligate PDA | None | Survived |
| 2 | 10 days | Hypo. LV, COAT, PDA | Distal PA banding | Arrhythmia, renal failure | Survived |
| 3 | 20 days | Hypo. LV | Distal PA banding | Cardiac arrest | Expired |
| 4 | 4 yrs | COAT | Coarctectomy | Postcoarctectomy syndrome | Survived |
| 5 | 2 yrs | Cong. MS, VSD PDA, Interrupted aortic arch | Mitral annulo. and commis., repair interrupted aortic arch, closure VSD, D&S PDA | Low CO | Expired |

Abbreviations are the same as in Table 5, plus: DAO = Descending aorta; Hypo. LV = Hypoplastic left ventricle; Cong. MS = Congenital mitral stenosis; commis. = commissurotomy; D&S PDA = Division and suture PDA.

Case no. 2 developed frequent premature ventricular contractions (PVC) and renal failure after surgery. The PVC may have been due to myocardial ischemia from the underlying disease. The patient was discharged from hospital in spite of the PVCs.

Case no. 3 developed cardiac arrest and expired during operation. The cause of death was due to poor coronary perfusion from the underlying disease.

Case no. 5 developed low cardiac output and expired later. Death might have been due to left heart failure.

### *2.8 Complex heart diseases*

There were 11 cases in this group: one case had corrective surgery and 10 had palliative surgery. Three patients (27.3%) died after operation (Table 9).

**Table 9.** Complex heart diseases group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 3 yrs | Dextrocardia SA, SV, PS, TGA | Modified Lt. B-T | None | Survived |
| 2 | 4/12 yrs | SA, VSD, PA TGA | Modified B-T | CHF | Expired |
| 3 | 2/12 yrs | MA, DORV, TGA, VSD, PS | B-H | None | Surived |
| 4 | 17 days | Hypo. LV and MV, DORV, PDA, ASD, PS | Waterston | Low CO | Expired |
| 5 | 9 yrs | AV canal, DORV PS, MI | Lt. B-T | None | Survived |
| 6 | 2/12 yrs | MA, SV, TGA | B-H and PA banding | None | Survived |
| 7 | 6/12 yrs | SV, TA, PS | B-H, Waterston | Pneumonia | Survived |
| 8 | 6/12 yrs | Dextroposition SV, TA, ASD TGA, PS | Fontan op. | Low CO | Expired |
| 9 | 4/12 yrs | SV, TA, PA, PDA | Modified Lt. B-T | None | Survived |
| 10 | 4 yrs | SV | PA banding | None | Survived |
| 11 | 11 days | SV, TGA, ASD PA, PDA | Rt. B-T | Wound infection | Survived |

Abbreviations are the same as in Table 8, plus: MA = Mitral atresia; SV = Single ventricle; SA = Single atrium.

## 3. Acquired heart disease

### *3.1 Rheumatic heart disease (RHD)*

There were nine cases in this group. They had abnormality of mitral and/or aortic valves. There were three cases who had post-operative complications.

The first case, RHD with MS and mitral insufficiency (MI), underwent and open mitral commissurotomy and annuloplasty. An echocardiogram after surgery showed residual MI and MS.

The second case, RHD with MI, tricuspid insufficiency (TI) and atrial fibrillation, underwent mitral and tricuspid annuloplasty. He developed left lower bobe atelectasis and left pleural effusion after surgery.

The other case, RHD with MI, TI and atrial fibrillation, underwent mitral and tricuspid annuloplasty. Three days after operation, she complained of abdominal and leg pains. The femoral pulses could not be palpate on either side. The aortogram showed embolism at the infrarenal level of the aorta. Embolectomy was performed with excellent results.

### *3.2 Miscellaneous*

There were five cases in this group and one died (Table 10).

**Table 10.** Miscellaneous group.

| Case no. | Age | Diagnosis | Operation | Postop. comp. | Result |
|---|---|---|---|---|---|
| 1 | 1 yr | Cong. complete AV block | Pacemaker implantation | None | Survived |
| 2 | 6/12 yrs | AV canal, PDA Peri. effusion | Peri. window | None | Survived |
| 3 | 9 yrs | MI | MVR | None | Survived |
| 4 | 2 days | Intracardiac tumor | Excision tumor | Low CO | Expired |
| 5 | 13 yrs | IE of MV, MI | Repair MV | None | Survived |

Abbreviations are the same as in Table 9, plus: Peri. = Pericardial; MVR = Mitral valve replacement; IE = Infective endocarditis.

Case no. 4 had an intracardiac tumor at the outflow tract of the left ventricle. EKG showed an ischemic pattern. She developed low cardiac output, hypothermia and metabolic acidosis after excision of the tumor and expired later.

## Discussion

Post-operative complications found often in this study included:

### 1. Right bundle branch block (RBBB)

RBBB is the result of delayed activation of the right ventricle. A characteristic QRS pattern defines RBBB: 1. QRS prolonged for age; 2. An RSR′ or rR′ pattern in leads V3R and V1, with the late positive deflection indicative of delayed right ventricle activation; 3. A broad S wave in leads 1 and V6.[4]

For patients who had undergone ventriculotomy, 84-100% would have RBBB pattern in the electrocardiograms.[5,6] Compared with this study, 13 out of 14 (92.8%) cases developed RBBB after undergoing total correction for TOF. One developed complete atrioventricular block. RBBB was caused by a large incision right ventriculotomy for right ventricular outflow tract enlargement.[6-10] Among the patients who had follow-up EKG, there was one who developed RBBB and left anterior hemiblock (the criteria for diagnosis being the same as RBBB plus frontal plane QRS axis leftward −30 degrees) after infundibulectomy and right ventricular outflow tract enlargement. RBBB and left anterior hemiblock occurred in about 7% of patients undergoing ventricular septal defect closure.[5,11] It is necessary to follow up these patients closely because of the possible development of complete atrioventricular block.[12,13] More precise understanding of location of the cardiac conduction system has made this complication a rare occurrence.

### 2. Post-pericardiotomy syndrome (PPS)

In this study, only six out of 126 (4.8%) cases who had the pericardium opened developed this syndrome. This complication can occur in up to 27-30% of post-operative patients.[14,15] The reason why fewer cases were diagnosed in our series may be due to under-diagnosis; those patients with mild symptoms and signs might have gone undetected. Those who had this syndrome usually developed fever and chest pain at the end of the first week. Physical examination showed pericardial friction rub. Laboratory findings showed enlarged cardiac silhouette and pleural effusion on the chest roentgenogram; EKG would show elevation of S-T segment and echocardiogram demonstrated pericardial effusion.[16] All cases in this study responded well to acetyl salicylic acid.

### 3. Low cardiac output

Low cardiac output is a condition is which the heart cannot adequately pump the blood supplying the various organs. Patients develop poor skin perfusion, decreased blood pressure and urine output of less than 0.5 ml/kg/hr.[17]

This complication is often found in: 1. patients with left to right shunt, particularly VSD with pulmonary hypertension, who had operative mortality higher than VSD without pulmonary hypertension,[18] 2. severe TOF cases with small left ventricles who underwent total correction; and 3. small infants who could not tolerate the operation and anesthesia well.

Cardiopulmonary bypass and almost all anesthetic drugs suppress myocardial contractility.[19] Ventriculotomy also reduces myocardial contraction causing poor cardiac contraction.

The condition of the patients before surgery is another factor that affects post-operative complications. Chronic volume overload may increase mortality. Low cardiac output is the most common cause of death in our series; it is a complication that is very difficult to treat. However appropriate use of inotropic drugs with or without vasodilators may often be very beneficial.

**4. Hypertension**

This complication is found in post-operative division and suture of PDA. The cause is unknown. Hypertension may be caused by increased volume by compensation shunting to the lungs. Pre-operatively the patients do not develop hypertension because the lungs are large reservoirs; after PDA ligation, blood volume remains increased, therefore blood pressure increases.[20,21] Another possible explanation is that the patients with PDA developed vasoconstriction of systemic arterioles (increased peripheral resistance). They may not develop hypertension pre-operatively because of the large reserviors (the lungs); after PDA ligation, "latent hypertension" emerges.[22]

In this study, hypertension usually did not last longer than one week (3 days in most cases). Luckily this compliation is normally not severe and easily controlled with diuretics and/or vasodilators.

**5. Infection**

Sternal wound infection was found in five of all the patients (2.36%) which is nearly equal to that in 2.7% of patients who underwent heart surgery, as reported by others.[23] One of the causes of wound contamination is carelessness in sterile technique. In addition, tissue hypoxia in patients with cyanotic heart disease causes poor wound healing. Strict aseptic technique would certainly lower the occurrence of this complication.

Ten of the patients (4.72%) developed atelectasis and/or pneumonia after surgery. This post-operative complication is due to pain secondary to a midline sternotomy or thoracotomy incision, causing the patient to reduce lung expansion and to cough, leading to atelectasis and pneumonia.

**6. Arrhythmia**

Arrhythmias can be caused by injury to the SA node during cannulation for bypass[17], from myocardial ischemia or electrolyte imbalance, e.g. hyperkalemia, hypokalemia. Careful cannulation during operation and close monitoring of the serum electrolytes would decrease the risk of this complication.

**7. Miscellaneous**

There was one case (RHD) with MI, TI and atrial fibrillation who developed embolism at the infrarenal level of the aorta after open mitral and tricuspid annuloplasty. The cause of the embolism was not known but this kind of complication may occur in open heart surgery.[24]

One case, VSD with AI, developed convulsion after closing VSD and repairing the aortic valve. The cause of convulsion was not known.

Some of the post-operative complications mentioned above are common and are difficult to prevent. But some iatrogenic complications are undoubtedly preventable: for example, extreme caution during placement of either an intravenous or an intraarterial catheter would certainly prevent bleeding and contamination.

Good post-operative care is very important. The medical staff team consisting of thoracic surgeons, anesthesiologists, pediatric cardiologists and intensive care nurses must observe every patient in the post-operative period very closely so that preventable complications could be prevented or treated early in order to avoid severe complications that could cause mortality. Hopefully in the future, with improved surgical techniques and better post-operative care; we would be able to operate successfully and save more lives of those children especially infants suffering from heart diseases.

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