

Patent Ductus Arteriosus

Adam C. Adler

A 12-week-old female, born at 32 weeks' gestation, is being evaluated for poor weight gain and "fussiness" with feeds. BP: 60/17 mmHg; HR: 146/min; RR: 45/min increasing to 60/min with feeds; SpO₂: 100% on room air. Weight: 2.6 kg. CXR: prominent pulmonary vascular markings.

What Is the Function of the Ductus Arteriosus?

The ductus arteriosus (DA) is a vascular connection between the aorta and the pulmonary arterial circulation. During fetal life, prior to lung expansion, high pulmonary venous resistance (PVR) forces blood to bypass the lungs via the ductus arteriosus. It is usually located proximal to the take-off of the left subclavian artery; however, this location may vary in a small percentage of the population.

How Is a PDA Diagnosed?

The history of prematurity, feeding intolerance, and wide pulse pressure all point in the direction of a patent ductus arteriosus (PDA). PDAs may be identified as a murmur in an asymptomatic patient or may present as heart failure. Most commonly, echocardiography is performed to visualize the PDA and exclude other structural heart disease lesions.

What Are the Important Diagnoses to Consider?

Other forms of structural heart disease that should be excluded include atrial septal defect (ASD), aortopulmonary window, and aortic insufficiency.

What Are the Signs/Symptoms of a PDA?

Patients often present with a murmur that can be heard across the entire precordium although best auscultated in the upper left sternal border and infra-clavicular regions. As pulmonary pressures fall in the first few days to weeks of life, aortic pressure exceeds pulmonary pressures in both systole and diastole, producing a continuous flow murmur, often referred to as a "machine-like" murmur.

Patients may also have widened pulse pressure due to diastolic run-off, bounding pulses, tachypnea, pulmonary edema, and/or a history of poor feeding.

Findings associated with other diseases of prematurity, i.e., necrotizing enterocolitis (NEC), intraventricular haemorrhage (IVH), bronchopulmonary dysplasia (BPD), should be considered.

What Is the Incidence of PDA?

The incidence of an isolated PDA is approximately 1 in 2,500–5,000 cases and is more common in females than males. The incidence of PDA is highest in premature infants.

What Is the Most Likely Age for Presentation?

The age at presentation is variable. Symptoms usually appear as the PVR decreases in the first weeks of life.

Describe the Anatomic Location of the Ductus Arteriosus

The DA most often originates from the aorta, immediately distal to the left subclavian artery take-off, and attaches to the left pulmonary artery. The location of the ductus arteriosus may vary, complicating surgical identification at times.

What Is the Pathophysiology of a PDA?

Most often, a PDA results in a left-to-right cardiac shunt. As the PVR decreases in the first few days to months of life, the volume shunted from left to right may increase significantly. The volume of blood shunted is generally proportional to the length and diameter of the PDA as well as the balance of systemic vascular resistance (SVR) and PVR.

What Are the Major Hemodynamic Consequences of a PDA?

Large PDAs result in large left-to-right cardiac shunts and pulmonary overcirculation. These children can have dyspnea with feedings, poor weight gain, and pulmonary vascular enlargement from increased flow. Additionally, diastolic run-off (L→R flow through the PDA in diastole) reduces the coronary perfusion pressure which can result in myocardial ischemia, especially in the presence of anemia or reduced SVR. Reduced systemic blood flow as a result of pulmonary overcirculation may result in decreased renal and splanchnic perfusion with resulting necrotizing enterocolitis.

What Factors Contribute to Spontaneous Closure of the DA?

Postnatally, drop in PVR with lung aeration and expansion, reduction in placental prostaglandins, rising arterial PaO₂, and release of vasoactive substrates (thromboxane, bradykinin, etc.) all promote closure of the DA.

Review the Available Medical Therapies for PDA Closure

The most commonly used medical therapies include indomethacin and other NSAID medications. Infants born preterm are more likely to have PDA lesions that require surgical closure after failure of medical therapy when compared to full term infants.

What Is the Treatment to Maintain the DA in Patients with Ductal Dependent Lesions?

These patients are maintained on intravenous prostaglandins to promote ductal patency until the primary

lesions may be surgically corrected or a more stable form of pulmonary blood flow established in the form of a conduit (BT shunt).

What Are the Major Risks of IV Prostaglandins?

Intravenous prostaglandins should be started and maintained as a slow continuous infusion. Care must be taken to avoid bolus doses, which may result in hypotension or seizure activity. Due to the long half-life of prostaglandin, the infusion is often stopped before transport to the operating room for definitive treatment to avoid accidental bolus dosing.

What Are the Main Indications for Closure of a PDA?

Patients with moderate or large PDAs associated with symptoms of L→R shunting, left-sided volume overload and those with mild to moderate pulmonary hypertension should be considered for elective closure. Patients with a previous history of infective endocarditis should also be considered for elective closure.

What Are the Main Reasons to Avoid Closing the Ductus?

Patients with mild signs (small audible murmur) or those with incidentally found PDA (“silent PDA”) are often managed by observation alone.

Patients with severe and irreversible pulmonary hypertension should also not undergo closure as the ductus is often required to allow right to left shunting during episodes of elevated pulmonary vascular resistance.

Describe the Three Main Invasive Approaches for Closure of PDAs

Common approaches for closure of PDAs include surgical closure or occlusion via catheter-based interventions.

Endovascularly, a catheter can be placed in the femoral or umbilical vessels and directed toward the DA. Endovascular coils can be deployed in the DA causing thrombosis and closure (Figure 59.1). Risks of the procedure include size limitation based on the catheter size and venous vessel size and large ducts >4 mm. Additionally, coils have been reported to

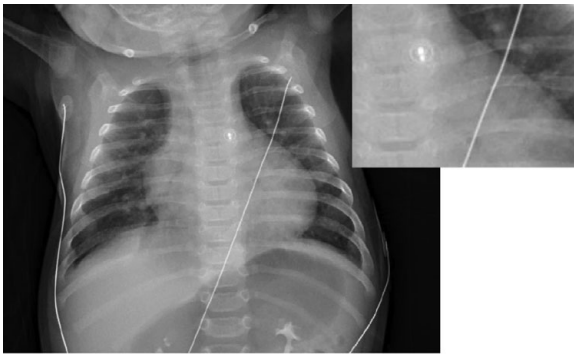


Figure 59.1 Portable chest X-ray of a four-month-old male after PDA Amplatzer device closure.

embolize or project out of the DA, causing occlusion of surrounding structures such as the left pulmonary artery. Antibiotic prophylaxis should be administered in these cases prior to device deployment.

Surgical techniques include open division and ligation of the duct or video assisted thoracoscopic (VATS) PDA ligation.

For either surgical technique, the patient assumes the right lateral decubitus position. The duct is visualized by open surgical technique or by video assist.

Compare the Advantages/Disadvantages to Open Surgical Technique vs. VATS

Open surgical technique may be performed at the bedside which may be beneficial in neonates who are hemodynamically unstable, of extremely low birth weight, or require nonconventional methods of ventilation. Open techniques allow for direct visualization and division and ligation of the duct which reduces risk of ductal recanalization. Open techniques may be beneficial for patients with aberrant anatomy and/or esophageal disorders which may require more extensive dissection of the PDA from surrounding esophageal and aortic structures.

The ability for immediate hemorrhage control using the open technique is obviously present when compared to the VATS technique.

VATS technique allows for a less invasive chest wall incision and potentially reduced pain postoperatively. In this technique, the surgeon places a vascular clip on the duct causing occlusion. However, it may be possible to only partially clip the DA resulting in an incomplete closure.

What Are the Major Anesthetic Considerations for Surgical PDA Ligation Procedures?

Aside from the general anesthetic considerations in premature infants and patients requiring remote site anesthesia, there are a few specific considerations for PDA closures.

With the proximity to the great vessels and potential for brisk bleeds, cross-matched blood should be at the bedside, cross-checked with a warmer immediately available for transfusion.

Arterial access, while beneficial for monitoring and sampling, is not necessarily required for this procedure and is largely institution dependent.

Ideally, a monitoring device should be applied to each extremity in the form of a non-invasive blood pressure (NIBP) cuff, arterial line, or pulse oximeter. As highlighted below, a major risk during PDA ligation is accidental ligation or damage to surrounding vessels including the aorta and branch pulmonary arteries. After ligation, loss of blood pressure or saturation on the lower extremity may signify aortic rather than DA occlusion. The surgeon will often apply a temporary clip or ligature to the DA while monitoring the lower extremity pressure or oximeter to identify changes prior to definitive ligation. Additionally, new gradients between upper and lower extremity measured pressures may indicate the formation of an aortic coarctation and should be addressed.

After the ligation of the DA, the diastolic blood pressure should be compared to the preligation value to assess for diastolic pressure increase as well as reduction in pulse pressure, a sign of successful PDA closure.

Is Endocarditis Prophylaxis Required for Patients with PDAs Or Those with Device Closure History?

Isolated PDAs are not an indication for endocarditis prophylaxis. However, antibiotics should be considered in the first six months following device closure.

What Becomes of the Ductus Arteriosus in Postnatal Life?

Shortly after birth (usually within 10–15 hours), due to the combination of decreased PVR, higher pO_2 , and cessation of circulating maternal prostaglandins, the

smooth muscle within the ductus arteriosus begins to contract, which causes its *functional* (reversible) closure. It achieves *anatomic* (irreversible) closure by two to three weeks of life. The ductus arteriosus then becomes the ligamentum arteriosum, the fibrous connection between the aorta and pulmonary artery.

POSTOPERATIVE CONSIDERATIONS

What Are the Most Common Complications Associated with Surgical PDA Closure?

- Major bleeding can complicate this delicate surgery.

- Esophageal damage or accidental ligation.
- Injury or ligation of the recurrent laryngeal nerve.
- Accidental ligation of other vessels including the aorta or branch pulmonary artery.
- Chylothorax from damage to lymphatic networks crossing the pleural of peri-aortic regions.
- Residual ductal patency.
- Pneumothorax.

Suggested Reading

Francis E, Singhi AK, Lakshmivenkateshaiah S, et al. Transcatheter occlusion of patent ductus arteriosus in pre-term

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