Patent Foramen Ovale: Symptoms,
Detection, and Treatment

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Abstract

A Patent Foramen Ovale (PFO) is a connection between the right and left atria that persists after birth. The Foramen Ovale found in fetal anatomy normally grows together after birth but can remain open for life, resulting in a PFO. Though PFOs are usually considered nonthreatening, they can be associated with cerebral ischemic events, such as stroke and migraine. A patient can undergo multiple ultrasound exams to identify the PFO. The most common and useful procedures are transthoracic echocardiograms, transesophageal echocardiograms, and transcranial Doppler studies all coupled with injection of bubble contrast. When a PFO is detected, the patient can receive preventative antiplatelet therapy or surgical placement of a closure device.
Patent Foramen Ovale

A Foramen Ovale is a connection between the right and left atria found in fetal anatomy. The atrial connection typically closes soon after birth, but it can remain open resulting in a Patent Foramen Ovale (PFO). This is not to say that a PFO is a great anatomical variation. The presence of a PFO in a newborn/adult indicates that the interatrial septum did not completely grow together. An estimated 20-34% of the population has a PFO, depending on age, and although a PFO is a discrepancy from typical anatomy, it most often does not pose a threat or concern for the patient (Calvert, Rana, Kydd, & Shapiro, 2011, p.148).

Circulation in the Body

Newborn/Adult Circulation

A PFO can potentially cause problems, but one must analyze the circulation of blood to understand the possible effects. Blood cycles through the body by the pumping of the heart and filtration through the vasculature of the lungs. The blood from the body empties into the right atrium from the Superior Vena Cava (SVC) and Inferior Vena Cava (IVC). The blood then passes through the tricuspid valve into the right ventricle. The heart

Fig. 1 Developed Blood Circulation
pumps the blood to the lungs through the pulmonary arteries. There is an exchange of gases across the alveoli and the capillaries found in the lungs. Carbon Dioxide and waste is removed from the blood, into the lungs, and out of the body through exhalation. Oxygen is taken into the lungs, across the alveoli and capillaries and into the blood through inhalation. The pulmonary veins empty the oxygenated blood into the left atrium. The blood passes into the left ventricle by way of the bicuspid valve, and the heart pumps the blood to the rest of the body by way of the aorta. This cycle of blood is necessary to maintain oxygen levels in the body, filter out carbon dioxide and other waste products, and to prevent the mixing of oxygenated blood with deoxygenated blood. (See Fig. 1)

**Fetal Circulation**

Fetal blood circulation is different because the fetus does not require functional lungs. The fetus’ utero location prevents it from having the ability of supplying its own oxygen through breathing. The fetus must rely on its mother’s breathing to supply oxygen to its growing body. The mother and fetus are connected through the placenta and umbilical cord. The umbilical cord supplies oxygenated blood to the
fetus by joining with the IVC. The IVC and SVC still direct blood into the right atrium. However, the blood from the SVC is deoxygenated, and the blood from the IVC is a combination of deoxygenated and oxygenated blood. As the blood empties into the right atrium, it is no longer separated based on the presence of oxygen. The blood continues to circulate through the heart and body similar to newborn/adult circulation, but the blood passes through the PFO because it does not need to travel through the lungs. The fetus is unaffected, and oxygen is still delivered to and used in the entire body. (See Fig. 2)

**Symptoms and Conditions Associated with PFO**

Complications may occur from a PFO because of the crossing of fetal blood flow with a newborn/adult body. If the PFO does not close shortly after birth, it usually results in a movable flap between atria. The PFO can open up when the pressure in the right atrium exceeds that of the left atrium. The blood from the right atrium is then able to enter directly into the left atrium, bypassing filtration of the lungs and new oxygen. The blood is now following fetal-like circulation in a body that needs newborn/adult circulation. Deoxygenated blood cycling back into the body can carry, “bloodborne materials, such as thrombi, air, or vasoactive substances . . . with the potential to cause a cerebrovascular event” (Calvert et al., 2011, p. 148). These waste materials have the potential to produce negative conditions in a patient. PFOs have been associated with many adverse symptoms, such as stroke, migraine, decompression illness, and arterial embolism (p. 148). Two commonly associated symptoms under much dispute because of research results conflicting with possibility of occurrence are stroke and migraine.

**Stroke**

Stroke is associated with PFOs because of the possibility that a clot will pass through the PFO, reach the brain, and trigger a stroke. Although strokes are often coupled with PFO as a
general opinion, “without pathological evidence, definitive proof of the linkage is hard to come by . . . [and,] for the vast majority of patients, absolute evidence is lacking [in regards to PFOs and stroke]” (Gersony & Gersony, 2010, p. 1377). To test this hypothesis, Petty et al. (2006) conducted research on 1072 patients receiving echocardiograms because of past cerebrovascular ischemic events. After adjusting for other risk factors, no statistically significant correlation was found between PFO and stroke. Also, in 40% of patients suffering from stroke, the cause is unknown (Calver et al., 2011, p. 150). Such findings discourage the strong correlation of PFOs with stroke.

**Migraine**

Research has also been completed to determine if an association between PFOs and migraine headaches exists. Garg et al. (2010) performed a study investigating migraine occurrence in patients with a PFO compared to those without a PFO. The results showed no discrepancy between the patients with or without a PFO and symptomatic migraines. The same conclusion was attained in a study conducted by Woods et al. (2010). These results should discouraged many patients from getting tested for a PFO because of migraine symptoms. Patients still have the choice of getting tested for a PFO, but patients should be aware of the present controversy relating to PFOs and association symptoms.

**Detection of a PFO**

If a patient is experiencing possible PFO associated symptoms, his or her physician can order tests to identify if a PFO does exist. The choice imaging modality for detection of PFOs is Ultrasonography. Ultrasound imaging is ideal for studies of the heart specifically because of its ability to demonstrate the functional activity of heart in real time, and no radiation exposure to the patient. Therefore, Echocardiography is utilized to analyze the heart.
Use of Contrast in Echocardiograms

When looking for a PFO, an echocardiogram has to be modified by adding agitated saline contrast into the patient’s blood stream. This is also known as a bubble study. The technologist starts an intravenous line (IV) on the patient. A three-way hub is used to connect two syringes to the IV port. One syringe contains a saline solution, and the other syringe contains air. The agitation of the contrast is accomplished by pushing the solution back and forth between the two syringes until no bubbles are visible.

Then the solution is injected into the patient’s IV. (Stewart, 2003, p. 344) These bubbles are visible during the ultrasound, and the technologist can monitor the flow of blood through the heart by watching for the presence of bubbles in the different cardiac chambers. During a regular cycle of the heart, the contrast should enter the right atrium, right ventricle, left atrium, and end in the left ventricle. If bubbles are seen in the left atrium before they are seen throughout the entire heart, the patient has a PFO. (See Fig. 3) In some cases, no PFO is seen on a regular cycle. The patient then has to perform a Valsalva maneuver by trying to exhale while keeping his or her airway closed. This can force the PFO to open. If the patient has trouble making a proper Valsalva maneuver, the technologist can also have the patient cough. A Valsalva maneuver is necessary to prevent any PFOs from being overlooked.

**Fig. 3** PFO visible on transthoacic echocardiogram

Transthoracic and Transesophageal Echocardiography

There are two methods for conducting an echocardiogram and bubble study. The first is a Transthoracic Echocardiogram. The ultrasound probe is kept on the outside of the patient’s body during the scan. This method is useful unless the patient is very large, and the amount of tissue between the probe and heart prevents adequate sensitivity. The second method is a Transesophageal Echocardiogram. The probe is directed into the patient’s esophagus and lowered down to the level of the heart. Since the esophagus runs directly posterior to the heart, this method is ideal for closer cardiac examination. (See Fig 4)

According to research by Maffè et al. (2010) and Souteyrand et al. (2006), Transesophageal echocardiograms are considered the preferred method because of higher sensitivity compared to transthoracic echocardiograms. The disadvantage is the need for conscious sedation. González-Alujas et al. (2010) states, “[Transesophageal echocardiography] with moderate sedation tends to give false negatives and underestimates the severity of the shunt” (p.138). The conscious sedation makes it difficult for the patient to generate a satisfactory Valsalva maneuver, and this can lead to inadequate information. All three of the studies previously mentioned did agree that transthoracic echocardiography is adequately sensitive diagnostically and can be used in place of transesophageal echocardiograms as the preferred clinical method.


Fig. 4 PFO seen on transesophageal echocardiogram
**Transcranial Doppler**

An additional method of searching for a PFO with ultrasound technology is the Transcranial Doppler study (TCD). This method of ultrasound measures the velocity of blood in the cranial blood vessels. The exam still requires the administration of bubble contrast, but instead of searching for bubbles, the technologist watches the wave patterns on the Doppler reader. If there is a hit or irregular pattern, the patient has a PFO. (See Fig. 5)

![Fig. 5 PFO pattern seen on Transcranial Doppler at 15 seconds](image)


Fig. 5) Maffè et al. (2010) explains that TCD studies are very useful in detection of a PFO, but they lack anatomical information (p. 62). TCD tests can be used but should be coupled with a transthoracic echocardiogram for satisfactory results.

**Risks of Testing for PFO**

Patients receiving tests in regards to a PFO should be aware of the associated risks with the tests. The fact that bubbles of varying size are forced into the bloodstream can potentially cause a cerebrovascular event to arise, although the occurrence is very rare. Romero et al. (2009) conducted research on patients undergoing bubble studies and suffering from stroke. The incidence rate of cerebrovascular events was low with five episodes occurring out of 3314 bubble studies (p. 2344). The exact risk in a particular patient is unknown but probably is influenced by other co-existing factor, particularly a history of stroke. More research is needed.
to adequately analyze such cerebrovascular events, but patients should be informed about possible risks before undergoing a bubble study.

**Treatment of a PFO**

**Preventative Antiplatelet Therapy**

If a patient undergoes testing and does have a PFO, there are two main treatment options offered. The first method is thrombus (clot) prophylaxis through antiplatelet therapy. When treating a PFO patient with these kinds of medications, the goal is to prevent thrombi from forming as opposed to closing the PFO. According to Salem, O’Gara, Madias, & Pauker (2008), “For patients with cryptogenic ischemic stroke and a patent foramen ovale, . . . APA [antiplatelet agent] therapy is [recommended]” (p. 593S). The two most commonly prescribed medications are Warfarin (an anticoagulant) and Aspirin (an antiplatelet). Clotting or thrombi can occur throughout the body and directly across the PFO patients. (See Fig. 6) Thrombi reaching the brain are considered one of the major triggers of possible PFO symptoms, such as stroke. Medication treatment is the least expensive option, but a patient should be informed about the risk of increased bleeding as a side effect before choosing antiplatelet therapy as his or her treatment (Messé et al., 2004, p. 1047).

**Surgical Closure of a PFO**

The second form of treatment for a PFO is closure of the connection by placement of a surgical device. The procedure can be performed in a catheterization laboratory, or the PFO can...
be closed during cardiac surgery as an incidental finding.

If a patient has the PFO closed in a catheterization laboratory, the procedure can be completed in one day with no sedation (Calvert et al., 2011, p. 156). A catheter is inserted into the femoral vein, directed into the heart through the IVC, and across the PFO. A balloon is inflated in the PFO to measure size, and the properly sized device is selected. Then, the closure device is directed across the PFO surrounded by a protective sheath. The closure device resembles two disks connected with a short cylinder made of expandable mesh. (See Fig 7) Once the sheath is in the correct location, the disk in the left atrium is opened or deployed by pushing it outside of the sheath. The right atrial disk is deployed by completely removing the sheath, and the additional equipment is removed from the body (Calvert et al., 2011, p. 156-7). (See Fig. 8)

In the case of a PFO being an incidental finding during surgery, “the surgeon must balance the additional risks from changes in the surgical plan necessary to close a defect with the potential long-term complications, such as paradoxical embolic stroke, if left intact” (Krasuski et al., 2009, p. 296).

When a patient is in surgery because of a cerebovascular event such as a stroke or heart attack, it...
is very common for the surgeon to find a PFO and decide to close it. To determine the occurrence of PFOs as incidental finding during preplanned surgery and any effect on life expectancy, Krasuski et al. (2009) analyze 13,092 patients scheduled to have cardiothoracic surgery. The results showed 28% of the patients had a PFO closed during these preplanned surgeries. It is important to note the surgeons did not repair all incidental PFOs. Instead, the surgeon took into consideration the age of the patient, the type of surgery, and history of stroke. PFO closure had no effect on mortality rate (p. 290). However, PFO closure is discouraged as a treatment option for migraine symptoms. A patient could still receive such treatments for migraines, but closure device treatments are commonly reserved for stroke patients (Gersony and Gersony, 2010, p. 1378). It is the decision of the patient and his or her physician which treatment method is the best option.

**Conclusion**

PFOs are common occurrences and can affect the lives of many people. Although a PFO most often will go undetected, there is always a chance it can have a negative impact on a patient’s life. There is a great deal of research available to the public, and it can be difficult to know what is fact and what is opinion. Often, patients and physicians make the mistake of over simplifying results and labeling PFOs as the obvious and only cause of the associated symptoms. The consistent evidence to support this statement does not exist, and patients should be aware of these findings. Patients may still choose to have a PFO investigated, but he or she needs to be aware of the controversy surrounding PFOs and possible associated symptoms. With the proper knowledge, a PFO can be properly monitored, and the patient’s standard of living can be improved.
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