



Brain-eating amoeba: When swimming is dangerous

Water activities enjoyed by millions of people around the world carry the risk of primary amoebic meningoencephalitis—a rare but deadly central nervous system infection.

By Amanda Perkins, DNP, RN

One of the most common free-living amoebas, *Naegleria fowleri*, also known as the brain-eating amoeba, is responsible for the development of primary amoebic meningoencephalitis (PAM).^{1,2} Although this central nervous system infection is rare, it's also fatal, with over 97% of those infected dying.¹ Once infected, death occurs rapidly,

often within 1 week.² PAM was first identified in 1965 in Southern Australia and has since been noted in other countries, including the US.² It's estimated that there are approximately eight cases of PAM diagnosed in the US each year.³

This article will increase your knowledge and understanding of PAM by

discussing *N. fowleri*, risk factors, associated signs and symptoms, treatment, and prevention.

What's *n. Fowleri*?

N. fowleri is a free-living protozoan parasite that's found in warm fresh water, often in the sediment/soil.^{4,5} It can also be found in poorly chlorinated pools and tap water.^{4,5} *N. fowleri* has three life stages: cyst, trophozoite, and flagellate.^{1,5} The only infective stage is trophozoite, which is also the reproductive and growing stage.^{1,5} The trophozoite can change to flagellate when conditions don't support growth and then revert back when conditions improve.⁵

N. fowleri can grow in temperatures up to 120.2° F (45° C).⁵ Environmental stress can cause the trophozoite to form a cyst, which can withstand environmental extremes such as temperatures above freezing up to 149° F (65° C).⁵ In the cyst stage, *N. fowleri* can survive at temperatures as low as 39.2° F (4° C) for up to 6 months.⁶ At these temperatures, the cyst may be able to survive in the winter and start growing in the summer.

N. fowleri infects individuals who've been swimming, often while stirring up sediment.¹ When contaminated water is inhaled into the nose, the amoeba travels from the nose to the brain, destroying the brain tissue.¹ *N. fowleri* enters the nasal cavity, penetrating the olfactory neuroepithelium, migrating through the olfactory nerve, and crossing the cribriform plate (the portion of the ethmoid bone that forms the roof of the nasal cavity) until reaching the olfactory bulbs.^{1,2} Once in the brain, the amoeba grows and causes inflammation and hemorrhage.²

Within 1 hour of exposure, the amoeba is present within the mucus of the nasal cavity, at 6 hours an acute inflammatory reaction starts, at 12 hours the amoeba penetrates the olfactory neuroepithelium, at 30 hours trophozoites are found in the cribriform plate, at 48 to 72 hours the

amoeba reaches the olfactory bulb, and at 102 hours a severe inflammatory response occurs.² Within 5 to 7 days, extensive lytic necrosis and hemorrhaging occur.²

Risk factors

PAM is most often seen in individuals who've recently been swimming in contaminated water sources, but it may be caused by other activities.² PAM is associated with the following:⁴

- swimming in fresh water, lakes, or pools
- swimming in poorly chlorinated pools
- bathing in hot spring spas
- performing nasal irrigation.

In the US, young men are more likely to develop PAM.⁶ This may be due to the likelihood of increased risky behaviors in water in this group. Children and young adults may also have an increased risk of infection because their cribriform plate is more porous.³ Improper nasal irrigation is another risk factor; immunocompromised individuals should consult with a health-care provider before using nasal irrigation.⁷

Signs and symptoms

The development of symptoms in patients with PAM occurs between day 1 and 9, with death often occurring between day 1 and 18 of symptom development.¹ The average time of death is day 5.¹ The signs and symptoms of PAM are similar to those seen with other types of meningitis and may include a bifrontal headache, neck stiffness, vomiting, seizures, abnormal breathing patterns, papilledema (optic disc swelling), altered level of consciousness, shock, hypertension, and coma.^{2,4}

The symptoms of PAM progress in two stages.¹ In stage one, patients often develop a severe headache, fever, nausea, and vomiting.^{1,2} In stage two, patients often develop a stiff neck, seizures, altered level of consciousness, hallucinations, and coma (see *PAM stages*).^{1,2} Additional signs and symptoms include anorexia, irritability, photophobia, diplopia, and lethargy.²



Interventions to prevent increased ICP¹¹

The following nursing interventions may be used to help prevent increased ICP:

- maintain head of bed at 30 degrees
- avoid flexion of the neck and hips
- minimize suctioning
- keep the environment quiet
- space care activities
- administer medications as needed to control vomiting, cough, and constipation.

cheat
sheet

Diagnosis

Approximately 75% of PAM cases are diagnosed at autopsy.¹ The symptom overlap of bacterial meningitis and PAM may lead to the delay in diagnosis.¹ This delay can be fatal and may be decreased by obtaining a thorough health history.² Death typically occurs between day 3 and 7, highlighting the need for rapid diagnosis and treatment.²

An important part of diagnosis is to determine if the patient has had recent contact with fresh water or has been performing nasal irrigation.² In the US, most cases of PAM have occurred in Southern states; however, regardless of the location, the health history should include questions about activities that increase the risk of PAM. The patient should also be asked about rhinitis, allergies, and other upper respiratory tract diseases.²

One diagnostic tool is cerebral spinal fluid (CSF) analysis. Microscopic examination of the CSF will show multiple trophozoites, which are protozoa in the active, feeding, and multiplying stage.² Once the CSF sample is obtained, light microscopy is used to confirm that the amoeba is present (see *N. fowleri trophozoite stage in light microscope*).⁴ The CSF of patients with PAM may appear gray to yellow-white in color or may be red-tinged due to the presence of erythrocytes.² Analysis of the CSF will show glucose in low-to-normal concentrations and elevated protein levels, as well as elevated pressures.⁵

Patients with PAM will have increased intracranial pressure (ICP), so obtaining a

CSF sample increases the risk of brain herniation.⁴ In patients with increased ICP, caution should be used when collecting a CSF sample.⁸ The risks associated with lumbar puncture can be decreased if the increased ICP is identified and treated quickly.⁸

In some facilities, a computed tomography (CT) scan may be completed before lumbar puncture to decrease the risk of herniation, although this can delay treatment in the patient with PAM.⁸ It's not recommended to perform a CT scan before lumbar puncture in patients with possible meningitis unless they have an altered level of consciousness, papilledema, seizure, impaired cellular immunity, or focal neurologic signs.⁸ Complications associated with lumbar puncture include headache, infection, bleeding, cerebral herniation, and back pain.⁸ If a CT scan or MRI is performed, the following may be seen: multifocal parenchymal lesions, pseudotumoral lesions, meningeal exudates, hemorrhagic infarcts, and necrosis.²

Treatment

At this time, the treatments used for PAM are ineffective, with death occurring more often than resolution of symptoms. The most common treatment is amphotericin B (AmB), which causes lysis of the amoeba's cell membrane.^{2,5} However, AmB can also cause lysis of human cell membranes, making it especially toxic to the kidneys.² This medication should be used cautiously in patients with renal impairment.⁹ Common adverse reactions to AmB include chest pain, hypotension, diarrhea, hyperbilirubinemia, increased liver enzymes, nausea, vomiting, chills, fever, and nephrotoxicity.⁹ The high toxicity and low efficacy of AmB highlights the need for a safer and more effective treatment.²

Azoles such as fluconazole may be given as an adjunctive treatment with AmB.⁵ These drugs should also be used cautiously in patients with renal impairment. Mild adverse reactions associated with azoles include headache, dizziness, diarrhea,

PAM stages

Stage 1

- Severe headache
- Fever
- Nausea
- Vomiting

Stage 2

- Stiff neck
- Seizures
- Altered level of consciousness
- Hallucinations
- Coma

nausea, and vomiting.⁹ Life-threatening adverse reactions include Stevens-Johnson syndrome and torsades de pointes.⁹

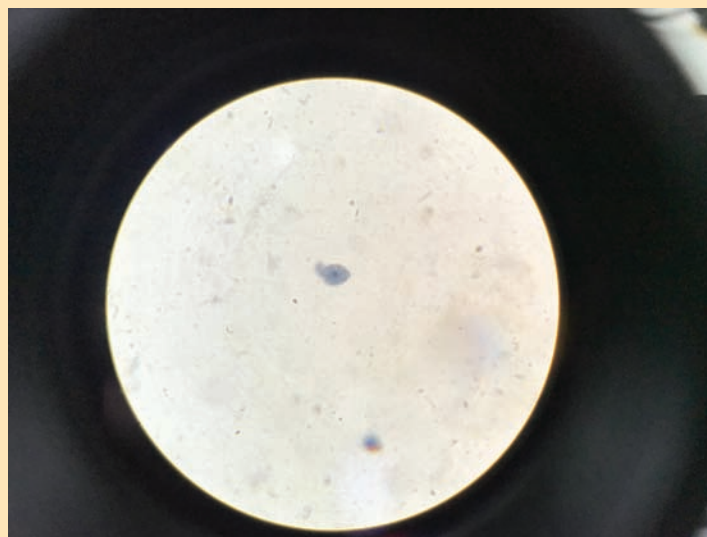
Miltefosine, a breast cancer drug with amoeba-killing activity, is a newer treatment that has shown promising results.^{1,4} It was used for two of the five patients in the US who've survived PAM.⁵ Miltefosine should be used cautiously in patients with renal impairment.⁹ Common adverse reactions include abdominal pain, anorexia, diarrhea, vomiting, and dizziness; Stevens-Johnson syndrome can also develop.⁹

Because patients with PAM have increased ICP, I.V. mannitol may be used to decrease it. Mannitol increases the tonicity of the plasma, causing fluid to be pulled from the brain into the intravascular space where it then exits the body in urine. Mannitol doesn't cross an intact blood-brain barrier; however, if the patient is experiencing intracranial hemorrhage and the vessels are damaged, it can enter the brain and cause worsening cerebral edema.^{4,10}

If the patient develops seizures, phenytoin or diazepam may be prescribed.⁴ Common adverse reactions associated with phenytoin include hypotension, diplopia, nystagmus, gingival hyperplasia, and nausea.¹⁰ Life-threatening adverse reactions include cardiac arrest, Stevens-Johnson syndrome, toxic epidermal necrolysis, acute hepatic failure, agranulocytosis, aplastic anemia, and angioedema.¹⁰ Common adverse reactions to diazepam include dizziness, drowsiness, and lethargy.¹⁰

In some cases, hypothermia has been used in combination with other treatments, including AmB; miltefosine; and cranial pressure-alleviating therapies such as craniotomy, hyperosmolar therapy, and shunt placement.^{1,3} In patients treated with controlled hypothermia in a hyperbaric chamber with a core body temperature between 89.6° F (32° C) and 93.2° F (34° C), a full neurologic recovery was observed.^{3,5} It's believed that hypothermia may be helpful because it prevents

***N. fowleri* trophozoite stage in light microscope**



cerebral edema.³ Hypothermia may also stop the development and/or pathogenicity of microbes and play an important role in inflammation, metabolism, free-radical production, apoptosis (cell death), neurogenesis (growth and development of nervous tissue), and angiogenesis (growth of blood vessels).³

Nursing management

When administering AmB, check the patient's I.V. site at least once per hour because I.V. AmB can irritate the tissues.¹⁰ It's also recommended to monitor vital signs every 30 minutes for 2 to 3 hours after administering AmB.¹⁰ Ensuring adequate fluid intake, whether I.V. or oral, will help protect the patient's kidneys.

If you're administering an azole, be aware of the risk of QT prolongation and torsades de pointes. Measure the patient's QT interval before administering the azole. This medication isn't appropriate for a patient with a prolonged QT interval. Additionally, caution should be used because some of the azoles such as fluconazole may antagonize the effects of AmB.¹⁰



Did you know?

Between 1962 and 2020, 5 people out of 151 diagnosed with PAM have survived.¹ Of the five who survived, one patient experienced permanent brain damage.¹ Due to the rarity of this infection, there aren't many controlled trials or clinical studies regarding treatment.⁵ This is an area where additional research needs to be conducted to find more effective treatments for better patient outcomes.

Monitor the patient's platelet count during treatment with miltefosine because it can cause thrombocytopenia and agranulocytosis.¹⁰ Monitor blood urea nitrogen and serum creatinine before and throughout treat-

ment.¹⁰ Dosing may need to be adjusted if kidney function starts to decline.

When administering mannitol, monitor vital signs, urine output, central venous pressure, and pulmonary arterial pressures before and during treatment.¹⁰ Throughout treatment, monitor the patient for signs and symptoms of dehydration, such as decreased skin turgor and tachycardia. There's also a risk of fluid overload, so observe for edema and crackles in the lungs. To monitor intake and output more closely, the healthcare provider may order an indwelling catheter.

Phenytoin should be used cautiously in patients with a variety of cardiac abnormalities; review the patient's ECG before administration. If the patient has a seizure or is determined to be at risk for a seizure, seizure precautions such as padding side rails should be put into place to reduce the risk of injury. During a seizure, ensure safety and note the seizure start time, length, and associated movements such as tonic-clonic. If the patient has a seizure and you can safely move them, place them on their side to prevent aspiration of oral secretions.¹¹ Objects in the environment that can cause injury should be moved to ensure patient safety.

When caring for a patient with meningitis, assess the patient's level of consciousness per healthcare provider orders and based on nursing judgment. A commonly used tool for monitoring level of consciousness is the Glasgow Coma Scale. It's important to maintain a low-stimulation environment, such as a quiet room with dim lights. The following

nursing interventions may be used to help prevent increased ICP: maintain head of bed at 30 degrees; avoid flexion of the neck; avoid flexion of the hips; minimize suctioning; keep the environment quiet; space care activities; and administer medications as needed to control vomiting, cough, and constipation.¹¹

Reducing the risk

Currently, there's no way to control *N. fowleri* in lakes and rivers; the best way to prevent PAM is through risk reduction.¹ *N. fowleri* trophozoites aren't very hardy, but cysts can survive weeks to months in cold temperatures.¹ In the US, PAM is seasonal, with trophozoites becoming active in the summer and dormant in the winter.⁶

Cases in the US are mostly seen in Southern states, with half of all cases in Texas and Florida.¹ PAM is also seen more commonly in male individuals and children.¹ Understanding that these groups are more at risk, educational community outreach can be initiated. Nurses should also be educated on the importance of asking about associated risk factors when obtaining a health history.

The only way for a person to get infected is when contaminated water enters the nose.¹ The following recommendations from the CDC may help decrease the risk:¹

- hold your nose shut when your head goes below the water
- use nose clips when swimming
- keep your head above water
- avoid activities in fresh water during times of increasing water temperatures
- avoid sediment in fresh water.

It's recommended that swimmers avoid stirring up the sediment/soil when swimming because it may contain trophozoites and cysts.⁶ Another risk factor is poorly chlorinated pools. Education should be provided about this risk and patients with pools asked about their upkeep.

Instruct patients about the safe use of nasal irrigation. Tap water isn't safe because it may contain bacteria and protozoa, both of which can cause illness.⁷ The patient

should use sterile, distilled, or filtered water purchased at the store or boiled water.^{5,7} If using boiled water, teach patients that it's good for 24 hours if placed in a closed container.⁷ Lastly, the device used for nasal irrigation should be clean and dry before use.

Important! Health history

The rarity of PAM paired with the lack of research on effective treatments leaves patients who develop the infection at severe risk. Nurses can play an important role by providing education and raising awareness. By asking patients about recent swimming activities or use of nasal irrigation, we can help decrease diagnosis time and improve outcomes. ■

REFERENCES

- Centers for Disease Control and Prevention. Parasites—*Naegleria fowleri*—Primary amebic meningoencephalitis (PAM)—amebic encephalitis. 2021. www.cdc.gov/parasites/naegleria/general.html.
- Martínez-Castillo M, Cárdenas-Zúñiga R, Coronado-Velázquez D, Debnath A, Serrano-Luna J, Shibayama M. *Naegleria fowleri* after 50 years: is it a neglected pathogen? *J Med Microbiol*. 2016;65(9):885-896.

- Defillo A, Nussbaum PE, Hariharan P, Mebane A, Nussbaum ES. Hypothermia as an adjunctive treatment in pediatric patients with *Naegleria fowleri*: a systematic review. *J Pediatr Neurol Neurosci*. 2021;5(1):105-110.
- Baig AM, Khan NA. Tackling infection owing to brain-eating amoeba. *Acta Trop*. 2015;142:86-88.
- Pervin N, Sundareshan V. *Naegleria*. In: *StatPearls*. Treasure Island, FL: StatPearls Publishing; 2022. www.ncbi.nlm.nih.gov/books/NBK535447.
- Maciver SK, Piñero JE, Lorenzo-Morales J. Is *Naegleria fowleri* an emerging parasite? *Trends Parasitol*. 2020;36(1):19-28.
- US Food and Drug Administration. Is rinsing your sinuses with neti pots safe? 2021. www.fda.gov/consumers/consumer-updates/rinsing-your-sinuses-neti-pots-safe.
- Johnson KS, Sexton DJ. Lumbar puncture: technique, indications, contraindications, and complications in adults. UpToDate. 2021. www.uptodate.com.
- Vallerand AH, Sanoski CA. *Davis's Drug Guide for Nurses*. 16th ed. Philadelphia, PA: FA Davis Company; 2019.
- Tenny S, Patel R. Mannitol. In: *StatPearls*. Treasure Island, FL: StatPearls Publishing; 2022. www.statpearls.com/ArticleLibrary/viewarticle/24732.
- Williams LS, Hopper PD. *Understanding Medical-Surgical Nursing*. 6th ed. Philadelphia, PA: F.A. Davis Company; 2019.

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