

Pyelonephritis

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THE STORY IN ONE SENTENCE

Pyelonephritis is when bacteria (usually from the bladder) travel up into the kidney tissue and cause infection there.

“Pyelonephritis means fever, pain in the flank (the side of your back), and tenderness when you tap the back over the kidney. Admit the patient if the infection is severe or they cannot take pills. Give IV antibiotics. Use imaging (like a CT scan) to check for blockages or abscesses.”

Normal anatomy — the body's job

The kidneys filter blood and make urine, which flows one way—down the ureters into the bladder and then out—keeping bacteria flushed away and the kidney tissue clean.

BODY'S JOB

Each kidney sits high in the back, filtering waste and extra water from the blood to make urine. The urine drips down a narrow tube called the ureter into the bladder, where it is stored until you pee. At the junction where the ureter meets the bladder, a one-way valve keeps urine from flowing backward. This constant downward flow acts like a river, sweeping bacteria out before they can climb up and reach the kidney. The kidney tissue itself has a rich blood supply and immune cells that patrol for germs, but it is not designed to fight off a large bacterial invasion if bacteria get past the normal defenses.

1. Blood enters the kidney through the renal artery, carrying waste and extra water.
2. Tiny filters in the kidney (nephrons) pull out waste and water to make urine.
3. Urine collects in the kidney's center (the renal pelvis) and drains down the ureter.
4. The ureter is a narrow tube that carries urine one way—down into the bladder.
5. At the bladder, a valve at the ureter opening keeps urine from flowing backward.
6. When you pee, urine leaves the bladder through the urethra, flushing bacteria out with it.
7. This one-way downward flow keeps the kidney clean and bacteria-free.

What breaks

Bacteria (usually *E. coli* from the bowel) travel backward up the ureter and invade the kidney tissue, causing infection and swelling.

CLINICAL TERM

Ascending bacterial infection of the renal parenchyma and pelvis, most commonly by uropathogenic *E. coli*, facilitated by urinary obstruction, vesicoureteral reflux, instrumentation, or host factors (pregnancy, diabetes, immunosuppression).

How the body compensates

The body fights the infection with fever and inflammation, trying to kill bacteria and wall off the damage. For a while, vital signs may look stable even as the infection spreads, so you must watch for warning signs that the patient is heading toward sepsis or abscess formation.

1. The hypothalamus (the brain's thermostat) raises body temperature to create a fever, because many bacteria grow poorly at higher temperatures and the immune system works better when warm.
2. White blood cells (neutrophils) flood the kidney tissue, releasing chemicals to kill bacteria and calling for more immune help. This causes the kidney to swell and press on its outer capsule, which produces the sharp flank pain.
3. The body may keep blood pressure and heart rate near normal at first by tightening blood vessels elsewhere (vasoconstriction) and releasing adrenaline, even though the infection is serious. This is the dangerous middle stage—vital signs look okay, but the infection is still spreading.
4. Nausea and vomiting occur because the vagus nerve (which connects the gut to the brain) senses the kidney inflammation and triggers the brain's vomiting center to shut down digestion, saving energy for fighting infection.
5. The kidneys try to keep filtering blood, but inflamed tissue works less efficiently. If both kidneys are infected or one kidney is badly damaged, waste products (creatinine, urea) start to build up in the blood.
6. The key crash points to watch for are: bacteria spilling into the bloodstream (sepsis with low blood pressure, confusion, fast breathing), gas-forming bacteria creating pockets of air in the kidney tissue (emphysematous pyelonephritis, seen in diabetics), or pus collecting in an abscess that antibiotics cannot reach. Once these happen, the patient can decline quickly, so catch the warning signs early—persistent high fever despite antibiotics, worsening pain, confusion, or dropping blood pressure.

Domino effect

1. Bacteria (usually *E. coli*) enter the urethra and multiply in the bladder — *E. coli* normally lives in the bowel. It can reach the urethra from the skin near the anus, especially in women (shorter urethra) or after catheter use. Once in the bladder, it attaches to the bladder wall and multiplies in the urine.
2. Bacteria ascend the ureter and invade the kidney tissue — Normally, urine flows one way—down—and flushes bacteria out. But if a stone or clot blocks the ureter, urine backs up and carries bacteria with it. Or if the valve at the bladder-ureter junction is weak (VUR), urine and bacteria reflux backward when the bladder contracts. Either way, bacteria reach the renal pelvis and invade the kidney tissue itself.
3. The immune system mounts a strong inflammatory response in the kidney — White blood cells (neutrophils and macrophages) detect bacterial toxins (like lipopolysaccharide from *E. coli*) and release cytokines (IL-1, IL-6, TNF-alpha) to call for help. These chemicals dilate blood vessels, increase blood flow, and make vessel walls leaky, so fluid and more white cells pour into the kidney tissue. The kidney swells, stretching the tight capsule around it, which causes sharp pain in the flank (side of the back).
4. The hypothalamus raises body temperature, causing fever — Cytokines (especially IL-1) travel through the bloodstream to the hypothalamus (the brain's temperature control center) and reset the thermostat higher. The body shivers and constricts skin blood vessels to generate and trap heat, producing a high fever (often 38.5°C or 101.3°F and above). This fever helps the immune system work better and slows bacterial growth.
5. The kidneys become tender, and the patient feels sick — The swollen kidney presses on nerve endings in the capsule and surrounding tissue, causing costovertebral angle (CVA) tenderness—pain when the back over the kidney is tapped. The vagus nerve senses the inflammation and signals the brain's vomiting center, producing nausea and vomiting. The patient may also have burning with urination (dysuria) (burning with urination) if the bladder infection is still present.
6. If untreated, bacteria may spill into the bloodstream or form abscesses — If the infection is not controlled with antibiotics, bacteria can break through the kidney tissue into the renal veins and enter the bloodstream (bacteremia). This triggers a body-wide immune alarm (sepsis) with low blood pressure, fast heart rate, confusion, and rapid breathing as the body tries to keep vital organs alive. Or pus may collect in a pocket (abscess) within or around the kidney, which antibiotics cannot reach and which may need to be drained with a needle or surgery.

7. Antibiotics kill the bacteria, and the inflammation resolves — IV antibiotics (like ceftriaxone or fluoroquinolones) reach high levels in the blood and urine, killing the bacteria. Once the bacterial load drops, the immune system mops up the remaining germs, cytokine release stops, the fever breaks, and the kidney swelling goes down. If a blockage caused the infection, it must be removed (stone removal, stent placement) so urine can flow freely again and prevent reinfection.
8. The kidney tissue heals, though scarring may occur with severe or repeated infections — Mild pyelonephritis usually heals completely. But if the infection was severe or happened multiple times (especially in childhood with VUR), scar tissue can replace normal kidney tissue, reducing the kidney's ability to filter blood and raising the risk of high blood pressure or chronic kidney disease later.

Symptoms · what the patient feels, and why

- High fever (often 101°F or higher): Bacteria have climbed from the bladder up into one or both kidneys. The immune system floods the area with white blood cells and releases chemicals called cytokines (alarm signals) that reset the body's thermostat upward to help fight the infection.
- Flank pain (one-sided back pain just below the ribs): The kidney sits tucked behind the belly, below the ribs on each side. When it swells from infection (like a balloon filling with fluid), it stretches the thin capsule wrapped around it, and that triggers sharp pain on that side of the back.
- Chills and shaking: The body raises its core temperature to fight bacteria. Shivering is the muscle's way of making heat quickly, so the person feels freezing cold even though their actual temperature is climbing.
- Nausea and vomiting: The kidneys sit near the gut, and inflammation next door irritates nerves that connect to the stomach. Cytokines in the bloodstream also signal the brain's vomiting center (the area postrema) to trigger nausea.
- Pain or burning when peeing: Bacteria usually start in the bladder before moving up. The bladder lining becomes red and raw (inflamed), so passing urine over it stings like rubbing salt on a scrape.
- Frequent, urgent need to pee (often only small amounts come out): The inflamed bladder wall is extra sensitive and sends 'full' signals to the brain even when only a little urine is inside. The person rushes to the bathroom but can squeeze out only a few drops.
- Cloudy or foul-smelling urine: Dead white blood cells, bacteria, and bits of damaged tissue clump together in the urine like debris. Bacteria also make waste chemicals that smell strong and bad.
- Blood in the urine (pink, red, or tea-colored): Inflammation tears tiny blood vessels in the bladder or kidney lining, so red blood cells leak into the urine and change its color.

- Confusion or sudden weakness (especially in older adults): Severe infection can release bacteria or toxins into the bloodstream (sepsis). The brain is very sensitive to changes in oxygen, blood flow, and inflammatory chemicals, so older people may become confused, dizzy, or very tired instead of having classic fever and pain.
- Very low blood pressure or fast heart rate: If bacteria spill into the blood (bacteremia) and trigger sepsis, blood vessels dilate (widen) all over the body and leak fluid. Blood pressure drops because there is less fluid pushing against the vessel walls. The heart speeds up to try to pump enough blood to the organs.

Focused exam

- Costovertebral angle (CVA) tenderness — tap the back where the kidney sits, between the ribs and the spine: In pyelonephritis, bacteria have climbed into the kidney tissue itself, making the kidney swollen and sore. When you tap that spot and it hurts, it tells you the infection has reached the kidney, not just the bladder below. The kidney is inflamed from the inside out.
- Flank pain — sharp or aching pain on one side of the body, between the ribs and the hip: The kidney is inflamed and swollen because bacteria invaded the tissue. Flank pain tells you the infection traveled upstream from the bladder into the organ itself. It is a sign of deep infection, not surface irritation.
- Fever — temperature above 38°C (100.4°F): Pyelonephritis means bacteria are inside kidney tissue, not just in urine. The immune system raises body temperature to slow down bacterial growth and speed up the immune response. Fever tells you the body is fighting a deep, tissue-level infection.
- Burning with urination (Dysuria) — pain or burning when urinating: The infection usually starts in the bladder and climbs up the ureter to the kidney. Burning with urination (Dysuria) is the clue that the urine pathway is inflamed from bottom to top. It shows the bladder was the entry point for the bacteria that later reached the kidney.
- Nausea, vomiting, or loss of appetite: When pyelonephritis gets severe, the body releases cytokines (immune alarm chemicals) that trigger nausea and shut down appetite. This tells you the infection is causing systemic inflammation, not just local kidney pain. It is a warning that the body is working hard to contain the infection.
- Signs of sepsis — confusion, very fast or very slow heart rate, fast breathing (over 20 breaths per minute), low blood pressure (systolic under 100 mm Hg): Pyelonephritis can spill bacteria from the kidney into the bloodstream, causing urosepsis. The heart races to pump oxygen, breathing speeds up to blow off carbon dioxide, and blood pressure drops because blood vessels relax in response to toxins. Confusion means the brain is not getting enough oxygen. These vital sign changes mean the infection is overwhelming the body's defenses and urgent treatment is needed to prevent shock and death.

Diagnostics · every test answers a question

- Urinalysis with microscopy → Are there white blood cells, bacteria, or protein in the urine that prove infection is present in the urinary tract?
- Urine culture and sensitivity → Which exact bacteria caused the infection, and which antibiotics will kill it?
- Blood cultures (two sets from different sites) → Has the bacteria spilled from the kidney into the bloodstream, causing bacteremia or sepsis?
- Complete blood count (CBC) → How hard is the immune system fighting, and is the infection severe?
- Basic metabolic panel (BMP) with creatinine → Is the kidney still filtering waste, or is the infection damaging kidney function?
- Serum lactate → Is the body going into shock and switching to oxygen-starved metabolism?
- Renal ultrasound or CT scan of the abdomen and pelvis (without and with contrast) → Is there a blockage (stone, tumor, or stricture) trapping bacteria in the kidney, or an abscess forming?
- Pregnancy test (urine hCG) in all women of childbearing age → Is the patient pregnant, which changes treatment urgency and antibiotic choice?

Treatment logic

- Blood cultures (two sets from different sites), then start IV antibiotics within 1 hour — ceftriaxone 1-2 grams IV daily, or ciprofloxacin 400 mg IV every 12 hours if local resistance is low → Antibiotics kill the bacteria (usually *Escherichia coli*) that climbed into the kidney tissue. Ceftriaxone is a cephalosporin that breaks open bacterial cell walls. Ciprofloxacin is a fluoroquinolone that stops bacteria from copying their DNA. Starting antibiotics fast stops the infection from spreading into the bloodstream and causing sepsis. It also reduces kidney damage from prolonged inflammation.
- IV fluids — 1-2 liters of normal saline or lactated Ringer's over the first few hours, then maintenance fluids to keep urine output above 0.5 mL per kilogram per hour → Fluids keep blood pressure up and kidneys perfused (fed with blood flow) so they can filter waste and fight infection. Fluids also dilute bacteria in the urine and help flush them out. In sepsis, fluids prevent shock by filling the blood vessels that have relaxed and leaked fluid into tissues.

- Urgent imaging (renal ultrasound or CT scan) and urology consult for drainage if obstruction or abscess is found — percutaneous nephrostomy (a tube through the skin into the kidney) or ureteral stent (a small tube inside the ureter) to bypass the blockage → Draining trapped urine washes out bacteria and pus, and relieves pressure that is damaging the kidney. A nephrostomy or stent lets urine flow again so antibiotics can reach the infection and the kidney can heal. Without drainage, antibiotics cannot reach bacteria trapped behind a blockage, and the kidney can be permanently damaged or lost.
- Switch to oral antibiotics after fever is gone for 24–48 hours and the patient can eat and drink — ciprofloxacin 500 mg twice daily, or levofloxacin 750 mg once daily, or trimethoprim-sulfamethoxazole if culture shows sensitivity — for a total of 7 days for uncomplicated cases or 10–14 days for complicated cases (pregnancy, diabetes, immunosuppression, or obstruction) → Oral antibiotics finish killing any bacteria hiding in kidney tissue and prevent relapse. A full course (7–14 days depending on severity) is needed because the kidney is a thick organ where bacteria can hide in tiny pockets. Stopping too early lets bacteria grow back and cause another infection.
- Hospital admission for IV antibiotics and monitoring for pregnant women, immunocompromised patients (HIV, transplant, chemotherapy), anyone with sepsis signs, or patients who cannot keep down oral antibiotics → Hospital care with IV antibiotics gets medicine into the bloodstream fast and at high levels, which is critical when the infection is severe or the patient is high-risk. Close monitoring (vital signs every few hours, repeat labs) catches worsening sepsis early so doctors can add pressors (medicines to raise blood pressure) or ICU care if needed. This prevents death from septic shock.
- Pain control — acetaminophen 650–1000 mg every 6 hours, or ibuprofen 400–600 mg every 6–8 hours (if kidney function is normal and patient is not dehydrated) → Pain medicines reduce flank pain and fever by blocking prostaglandins (chemicals that cause inflammation and sensitize pain nerves). Acetaminophen works in the brain to lower the fever set-point. Ibuprofen (an NSAID) also reduces swelling in the kidney. This makes the patient more comfortable while antibiotics work.
- Follow-up urine culture 1–2 weeks after finishing antibiotics to confirm the infection is cleared → A negative follow-up culture (no bacteria growing) proves the antibiotics worked and the kidney is no longer infected. If bacteria are still there, it means the infection was not fully cleared (treatment failure) or a new infection started, and the patient needs more antibiotics or imaging to look for a hidden abscess or stone.

Medications

Ciprofloxacin (Cipro) · Fluoroquinolone antibiotic

Ciprofloxacin kills bacteria by breaking the DNA inside them. Bacteria (like *E. coli*, the most common cause of pyelonephritis) have a special enzyme called DNA gyrase (like a tiny machine

that twists and untwists their DNA so they can copy it and grow). Ciprofloxacin jams this machine, so the bacteria can't copy their DNA, can't divide, and die off. This stops the infection in the kidney.

1. Ciprofloxacin enters the bacterial cell.
2. It binds tightly to DNA gyrase (the enzyme that uncoils and recoils bacterial DNA).
3. DNA gyrase stops working, so the bacteria can't fix breaks in their DNA or copy it.
4. The bacteria die because they can't reproduce or repair themselves.
5. The infection clears as the bacteria are killed and flushed out by the immune system and urine.

SAFETY WATCH

Can damage tendons (especially the Achilles tendon in the heel)—stop immediately if you feel sudden heel or leg pain. · May worsen muscle weakness in people with myasthenia gravis (a nerve-muscle disorder). · Can cause dizziness, headache, or upset stomach. · Avoid in pregnancy (may harm the baby's developing cartilage) and in children under 18 (except in special cases) for the same reason. · Take with a full glass of water and stay well-hydrated to protect the kidneys. · Do NOT take with dairy products, calcium, or antacids within 2 hours—they block absorption. · Rarely can affect heart rhythm (QT prolongation) or cause confusion or seizures in older adults.

Ceftriaxone (Rocephin) · Third-generation cephalosporin antibiotic (beta-lactam)

Ceftriaxone kills bacteria by breaking down their outer wall. Bacteria build a tough protective shell called the cell wall (like a brick wall around a house) using a chemical lattice called peptidoglycan. Ceftriaxone blocks the enzymes (called penicillin-binding proteins) that glue the bricks together. Without a sturdy wall, the bacteria burst open and die. It works especially well against gram-negative bacteria like *E. coli* and *Klebsiella*, which cause most kidney infections.

1. Ceftriaxone enters the bloodstream (via IV or IM injection) and travels to the kidneys.
2. It binds to penicillin-binding proteins on the bacterial cell wall.
3. These proteins can no longer build or repair the peptidoglycan wall.
4. The bacteria's wall weakens and breaks open under pressure.
5. The bacteria die, and the infection starts to clear within 24–48 hours.

SAFETY WATCH

Generally safe and well-tolerated. · Can cause diarrhea (sometimes loose stools from disrupting normal gut bacteria). · Allergic reactions are possible—rash, itching, or (rarely) severe anaphylaxis. If you have a severe penicillin allergy, tell your doctor (about 10% cross-react). · Can form crystals in the gallbladder (especially in newborns) or kidneys if you are dehydrated—drink plenty of fluids. · Do NOT mix with calcium-containing IV fluids in newborns (can form dangerous crystals in the blood). · Safe in pregnancy (category B) and preferred over fluoroquinolones. · May rarely cause low blood counts or liver enzyme changes—monitored in long courses.

Piperacillin-Tazobactam (Zosyn) · Extended-spectrum penicillin plus beta-lactamase inhibitor

This is a two-part antibiotic team. Piperacillin kills bacteria by breaking their cell wall (just like ceftriaxone), but many bacteria have learned to fight back by making an enzyme called beta-lactamase (like a pair of scissors that cuts the antibiotic apart). Tazobactam is a shield—it blocks the beta-lactamase scissors so piperacillin can do its job. Together, they kill a very wide range of bacteria, including resistant gram-negative bugs (like ESBL-producing *E. coli* or *Pseudomonas*) and some anaerobes (bacteria that live without oxygen). This combo is saved for severe infections or patients who are very sick, have other health problems, or may have resistant bacteria.

1. Piperacillin and tazobactam are infused into a vein.
2. Tazobactam enters bacteria and ties up their beta-lactamase enzymes, protecting piperacillin.
3. Piperacillin binds to penicillin-binding proteins on the bacterial cell wall.
4. The wall-building process stops, the wall breaks down, and the bacteria burst.
5. A broad spectrum of bacteria—including many resistant strains—are killed, and the infection clears.

SAFETY WATCH

Generally safe but more side effects than narrower antibiotics. · Common: diarrhea, nausea, vein irritation at the IV site. · Allergic reactions possible (rash, hives, or severe anaphylaxis)—especially if you are allergic to penicillin or cephalosporins. · Can lower potassium levels (hypokalemia)—monitored with blood tests. · Rarely causes low white blood cells (neutropenia) or low platelets (bleeding risk) with longer use. · Can trigger *Clostridioides difficile* (C. diff) colitis—severe diarrhea from disrupting gut bacteria; tell your doctor if diarrhea is bloody or does not stop. · Safe in pregnancy (category B) but used only when benefits outweigh risks.

Levofloxacin (Levaquin) · Fluoroquinolone antibiotic

Levofloxacin works just like ciprofloxacin—it kills bacteria by jamming their DNA machinery. It blocks DNA gyrase and another enzyme called topoisomerase IV (both wind and unwind bacterial DNA so it can be copied). Without these enzymes, the bacteria can't reproduce or repair DNA damage, so they die. Levofloxacin covers gram-negative bacteria (*E. coli*, *Klebsiella*, *Proteus*) and some gram-positive bugs, and it reaches high levels in the urine and kidney tissue.

1. Levofloxacin is absorbed (if oral) or infused (if IV) into the bloodstream.
2. It enters bacterial cells in the kidneys.
3. It binds to DNA gyrase and topoisomerase IV, stopping them from working.
4. Bacterial DNA breaks apart and cannot be repaired or copied.
5. The bacteria die, and the infection clears.

SAFETY WATCH

Can damage tendons (especially Achilles tendon)—stop immediately if you feel sudden heel or leg pain. · May worsen muscle weakness in myasthenia gravis. · Avoid in pregnancy (may harm baby's cartilage) and in children under 18 except in special cases. · Can cause dizziness, headache, nausea, or diarrhea. · Rarely affects heart rhythm (QT prolongation), causes confusion, or triggers seizures. · Take with plenty of water; avoid dairy, calcium, and antacids within 2 hours. · Increased risk of aortic aneurysm or dissection (a tear in the body's main artery) in older adults or people with heart/blood vessel disease—use with caution.

Cefepime (Maxipime) · Fourth-generation cephalosporin antibiotic (beta-lactam)

Cefepime kills bacteria by breaking down their cell wall, just like ceftriaxone, but it is a fourth-generation cephalosporin, so it resists many beta-lactamase enzymes and covers an even wider range of bacteria. It works especially well against gram-negative bacteria (including *Pseudomonas aeruginosa*, which can cause severe kidney infections in hospitalized or catheterized patients) and some gram-positive bacteria. It is often chosen for very sick patients or suspected resistant infections.

1. Cefepime is infused into a vein.
2. It travels to the kidneys and enters the space around bacteria.
3. It binds to penicillin-binding proteins on the bacterial cell wall.
4. The wall-building process stops, the wall weakens and breaks, and the bacteria die.
5. The infection begins to clear within 24–48 hours.

SAFETY WATCH

Generally safe. · Can cause diarrhea, nausea, or vein irritation. · Allergic reactions possible (rash, itching, or severe anaphylaxis)—about 10% cross-reactivity with severe penicillin allergy. · Rarely causes neurotoxicity (confusion, seizures, or encephalopathy) in people with kidney problems or high doses—dose must be adjusted if your kidneys are not working well. · Safe in pregnancy (category B). · Can trigger *C. diff* colitis with prolonged use.

Ertapenem (Invanz) · Carbapenem antibiotic (beta-lactam)

Ertapenem is a very strong antibiotic that kills bacteria by breaking their cell wall, just like penicillins and cephalosporins. But carbapenems are the most resistant to beta-lactamase enzymes—they can punch through almost all the bacteria's defenses. Ertapenem covers a broad spectrum, including ESBL-producing *E. coli* and *Klebsiella* (bacteria that have learned to resist most other antibiotics). It is often used when a patient has had repeated infections, is very sick, or when culture results show resistant bacteria. It is given once daily by IV or IM.

1. Ertapenem is infused or injected.
2. It travels to the site of infection in the kidneys.
3. It binds to penicillin-binding proteins on the bacterial cell wall.
4. The wall stops being built and repaired, weakens, and bursts.
5. Even resistant bacteria (like ESBL producers) are killed, and the infection clears.

SAFETY WATCH

Generally well-tolerated. · Common: diarrhea, nausea, headache, or pain/swelling at the injection site. · Allergic reactions possible (cross-reactivity with penicillin allergy is about 1–10%). · Can lower the seizure threshold (risk of seizures), especially in people with brain disorders or kidney problems—dose adjusted if kidneys are impaired. · Can trigger *C. diff* colitis. · Safe in pregnancy (category B) but used only when needed.

Trimethoprim-Sulfamethoxazole (Bactrim, Septra) · Sulfonamide antibiotic combination (folate synthesis inhibitor)

This is a two-drug team that kills bacteria by starving them of folate (a vitamin-like molecule bacteria need to build DNA). Bacteria make their own folate from scratch using a two-step process. Sulfamethoxazole blocks the first step, and trimethoprim blocks the second step. With both steps blocked, the bacteria can't make DNA, can't divide, and die. It works against many gram-negative bacteria (including *E. coli*) and some gram-positive bugs. It is often used for

simple, uncomplicated pyelonephritis in areas where resistance is low, but resistance is rising in many places, so it is used less often as a first choice.

1. Sulfamethoxazole blocks the enzyme that makes the first folate building block.
2. Trimethoprim blocks the enzyme that makes the second folate building block.
3. Without folate, bacteria can't make the nucleotides needed for DNA.
4. Bacteria stop dividing and die.
5. The infection clears as the bacteria are eliminated.

SAFETY WATCH

Common: nausea, vomiting, loss of appetite, rash. · Can cause serious allergic reactions, including Stevens-Johnson syndrome (a severe, life-threatening skin rash)—stop immediately if you develop a rash, mouth sores, or peeling skin. · Increases potassium levels (hyperkalemia)—dangerous in people with kidney disease or on certain blood pressure medicines. · Can lower blood counts (anemia, low white cells, low platelets), especially in older adults or people low in folate. · Avoid in late pregnancy (can harm the baby) and in newborns (can cause yellowing of the skin and eyes (jaundice)). · Drink plenty of water to prevent kidney crystals. · Interacts with many drugs (warfarin, methotrexate, diabetes medicines)—tell your doctor all your medicines.

Nitrofurantoin (Macrobid, Macrochantin) · Nitrofurantoin antibiotic

Nitrofurantoin kills bacteria in the bladder by damaging multiple parts inside them—it gets activated by bacterial enzymes into toxic byproducts that break DNA, proteins, and cell walls all at once. It concentrates very well in the urine but does NOT reach high levels in the kidney tissue or bloodstream, so it is excellent for bladder infections (cystitis) but NOT recommended for kidney infections (pyelonephritis). Guidelines say NOT to use it for pyelonephritis because it does not get to the kidney tissue where the infection is.

1. Nitrofurantoin is absorbed in the gut and filtered into the urine by the kidneys.
2. It concentrates in the bladder urine.
3. Bacterial enzymes convert it into reactive, toxic molecules.
4. These molecules damage bacterial DNA, proteins, and cell structures.
5. Bacteria in the bladder die, clearing simple bladder infections.

SAFETY WATCH

Common: nausea (take with food to reduce this), headache, urine turns dark yellow or brown (harmless). · Can cause lung problems (pulmonary fibrosis) with long-term use (months to years)—rare but serious; stop if you develop a new cough or shortness of breath. · Can cause liver damage (rare)—stop if you develop yellowing of skin or eyes, or severe stomach pain. · Can cause nerve damage (peripheral neuropathy—tingling, numbness) in people with kidney disease or long-term use. · Do NOT use if your kidneys are not working well (creatinine clearance <30 mL/min)—drug does not work and side effects increase. · Avoid in late pregnancy (near delivery) and in newborns—can cause red blood cell destruction (hemolysis) (red blood cell breakdown) in babies. · Safe in early/mid pregnancy for bladder infections.

Red flags

- Confusion, extreme drowsiness, or trouble waking up (may mean bacteria are in the bloodstream, causing sepsis)
- Very low blood pressure, racing heart, or cold, clammy skin (signs of septic shock—the body's circulation is failing)
- Vomiting so severe the person cannot keep down fluids or medicine (risk of dehydration and worsening kidney damage)
- No urine output or very little urine over several hours (the infected kidney may be shutting down)
- Pregnancy (pyelonephritis can trigger early labor and harm the baby; always needs hospital treatment)

Nursing priorities

1. Draw two sets of blood cultures from different sites before giving any antibiotics, then start IV antibiotics within 60 minutes of triage. — Blood cultures catch bacteremia in 20 percent of pyelonephritis cases but only grow the right organism if drawn before antibiotics kill the bacteria. Delayed antibiotics increase mortality in sepsis, so the one-hour window is critical.
2. Check vital signs every 2 hours and measure serum lactate (a blood chemical showing how much oxygen tissues are getting) immediately if fever is above 101 degrees or systolic blood pressure is below 90. — High fever with low blood pressure or lactate above 2 means sepsis. These patients need 30 milliliters per kilogram IV crystalloid (salt water) bolus within 3 hours and may need ICU transfer for vasopressors (medicines that raise blood pressure).

3. Start an IV line with at least an 18-gauge catheter and give normal saline at 125 to 200 milliliters per hour unless the patient has heart failure. — Fever and vomiting cause hypovolemia (low blood volume) that drops kidney blood flow and worsens kidney damage. Adequate hydration helps antibiotics reach infected tissue and flushes bacteria out through urine.
4. Collect a clean-catch urine sample for urinalysis and culture before the first antibiotic dose, and check if urine output is at least 0.5 milliliters per kilogram per hour. — Urine culture identifies the exact bacteria and guides antibiotic switching after 48 hours. Low urine output signals either severe dehydration or urinary obstruction that needs emergency imaging and drainage.
5. Monitor temperature every 4 hours and give acetaminophen (Tylenol) 650 milligrams by mouth or IV for fever above 101 degrees. — Persistent fever after 72 hours of correct antibiotics suggests abscess, obstruction, or resistant bacteria. Fever control also reduces rigors and patient discomfort, helping them tolerate oral fluids.
6. Notify the provider immediately if the patient has one-sided flank pain that gets worse despite IV fluids and pain medicine, or if a renal ultrasound or CT shows hydronephrosis (swelling of the kidney from blocked urine). — Obstruction with infection is a urological emergency. Pressure from trapped infected urine destroys nephrons (kidney filtering units) within hours and causes septic shock. A urology consult for stent or percutaneous nephrostomy must happen within 6 hours.
7. Teach the patient to finish the full 14-day antibiotic course even after hospital discharge and return if fever comes back or flank pain worsens. — Short antibiotic courses allow bacteria to survive in kidney tissue and cause relapse within 2 weeks. Incomplete treatment also breeds antibiotic resistance, making future infections harder to treat.
8. Assess pain level every 4 hours with a 0-to-10 scale and give scheduled IV ketorolac (Toradol) 15 to 30 milligrams every 6 hours or opioids if pain is above 6. — Severe flank pain from kidney inflammation and capsule stretching prevents deep breathing and mobility. Untreated pain raises cortisol and blood sugar, slowing immune response and healing.

Sources

- IDSA Clinical Practice Guideline for Acute Uncomplicated Cystitis and Pyelonephritis (2011)
- Surviving Sepsis Campaign International Guidelines (2021)
- UpToDate Clinical Overview: Acute Pyelonephritis
- CDC: Urinary Tract Infection Guidelines

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