Imaging of the Urinary Tract

National Kidney and Urologic Diseases Information Clearinghouse

U.S. Department of Health and Human Services

NATIONAL INSTITUTES OF HEALTH

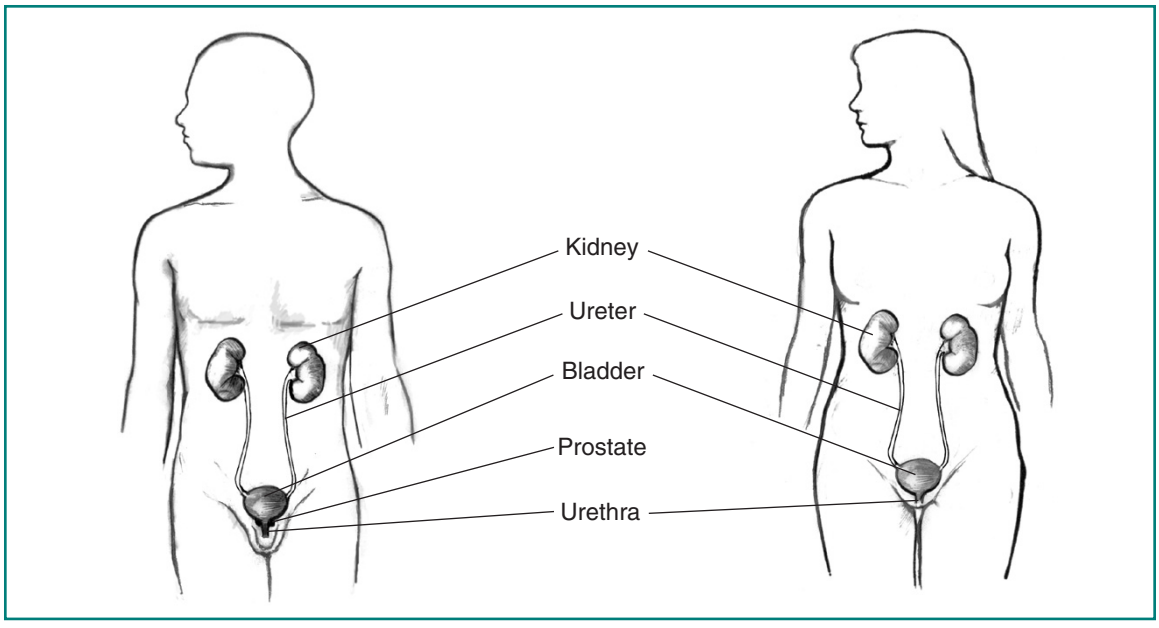
NIDDK
NATIONAL INSTITUTE OF DIABETES AND DIGESTIVE AND KIDNEY DISEASES

What is the urinary tract?

The urinary tract is the body's drainage system for removing wastes and extra water. The urinary tract includes two kidneys, two ureters, a bladder, and a urethra. The kidneys are a pair of bean-shaped organs, each about the size of a fist and located below the ribs, one on each side of the spine, toward the middle of the back. Every minute, a person's kidneys filter about 3 ounces of blood, removing wastes and extra water. The wastes and extra water make up the 1 to 2 quarts of urine an adult produces each day. Children produce less urine each day; the amount produced depends on their age. The urine travels from the kidneys down two narrow tubes called the ureters. The urine is then stored in a balloonlike organ called the bladder. When the bladder empties, urine flows out of the body through a tube called the urethra at the bottom of the bladder.

What does "imaging" mean?

In medicine, "imaging" is the general term for any technique used to provide pictures of bones and organs inside the body. Imaging techniques include conventional radiology, or x rays; ultrasound; magnetic resonance imaging (MRI); computerized tomography (CT) scans; and radionuclide scans. Imaging helps the health care provider see the causes of medical problems.



Male and female urinary tracts

What problems could require imaging of the urinary tract?

Imaging can help the health care provider find the cause of

- urinary retention—the inability to empty the bladder completely
- urinary frequency—urination eight or more times a day
- urinary urgency—the inability to delay urination
- urinary incontinence—the accidental loss of urine
- blockage of urine
- abdominal mass—swelling in a specific part of the abdomen
- pain in the groin or lower back
- blood in the urine
- high blood pressure
- kidney failure

One symptom can have several possible causes. The health care provider can use imaging techniques to determine, for example, whether a urinary tract stone or an enlarged prostate is blocking urine flow. Imaging can help clarify kidney diseases, tumors, urinary tract infections (UTIs), urinary retention, small bladder capacity, and urinary reflux—the backward flow of urine.

What steps does the health care provider take before ordering imaging tests?

Before ordering imaging tests, the health care provider

- asks about specific urinary tract symptoms, when they began, and their frequency
- considers general medical history, including any major illnesses or surgeries
- may ask female patients whether pregnancy is suspected
- asks about medication use—both prescription and over the counter—the amount of fluid consumed each day, and the use of alcohol and caffeine
- performs a physical exam

These steps help the health care provider determine the possible causes of the urinary tract problems and what to look for in an imaging test.

What are the imaging techniques?

The health care provider can use several different imaging techniques depending on factors such as the person's general medical history and urinary tract symptoms.

Conventional Radiology

X-ray machines have been used to diagnose diseases for about 100 years. X rays of the urinary tract can help highlight a kidney stone or tumor that could be blocking the flow of urine and causing pain. For men, an x ray also shows the size and shape of the prostate—a walnut-shaped gland that surrounds the urethra at the neck of the bladder and supplies fluid that goes into semen. Conventional x rays do involve some exposure to ionizing radiation—radiation that is strong enough to damage some cells. Two common x-ray procedures include the injection of a special dye, called contrast medium, which shows the shape of the urinary tract.

Intravenous pyelogram (IVP). An IVP is an x ray of the urinary tract. Contrast medium is injected into a vein in the person's arm, travels through the body to the kidneys, and makes urine visible on the x ray. The contrast medium also shows any blockage in the urinary tract. The procedure is performed in a health care provider's office, outpatient center, or hospital by an x-ray technician, and the images are interpreted by a radiologist—a doctor who specializes in medical imaging; anesthesia is not needed. An IVP can help locate problems in the kidneys, ureters, or bladder that may be caused by urinary retention or reflux.

IVP image

Voiding cystourethrogram (VCUG). A VCUG is an x-ray image of the bladder and urethra taken while the bladder is full and during urination, also called voiding. As the person lies on the x-ray table, a health care provider inserts the tip of a thin, flexible tube called a catheter through the urethra into the bladder. The bladder is filled with contrast medium to make it clearly visible on the x-ray images. The x-rays are taken from various angles while the bladder is full of contrast medium. The catheter is then removed and x-ray images are taken during urination. The procedure is performed in a health care provider's office, outpatient center, or hospital by an x-ray technician. The technician is supervised by a radiologist while the images are taken. The radiologist then interprets the images. Anesthesia is not needed, but sedation may be used for some people. A VCUG can reveal abnormalities of the inside of the urethra and bladder and is usually used for children to detect vesicoureteral reflux—the abnormal flow of urine from the bladder back into the upper urinary tract. A VCUG can also show whether the flow of urine is normal when the bladder empties, blockages from an enlarged prostate in men, and an abnormal bladder position in women.

Ultrasound

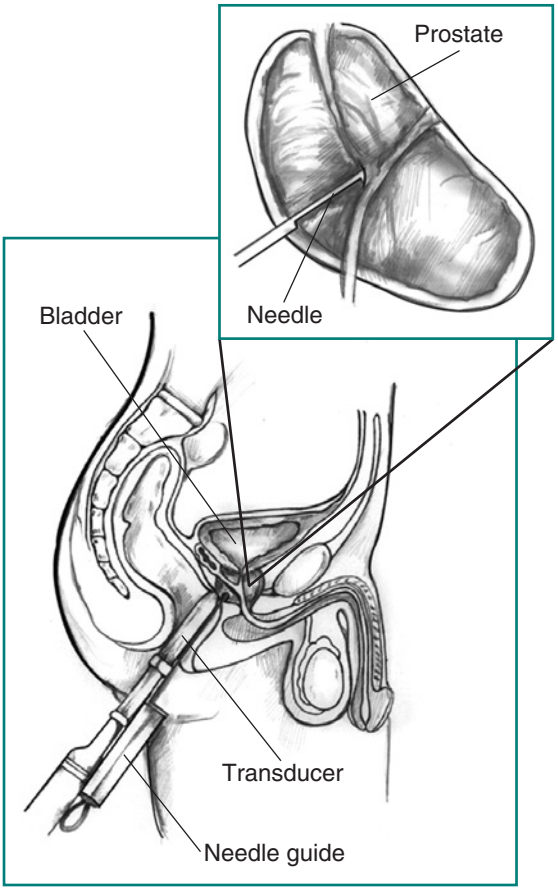
Ultrasound uses a device, called a transducer, that bounces safe, painless sound waves off organs to create an image of their structure. The transducer can be moved to different angles to make it possible to examine different organs. The procedure is performed in a health care provider's office, outpatient center, or hospital by a specially trained technician, and the images are interpreted by a radiologist; anesthesia is not needed. The images can be used to provide information that is valuable in diagnosing and treating a variety of diseases and conditions.

Abdominal ultrasound. In abdominal ultrasound, the health care provider applies a gel to the person's abdomen and moves a hand-held transducer over the skin. The gel allows the transducer to glide easily, and it improves the transmission of the signals.

The procedure is performed in a health care provider's office, outpatient center, or hospital by a specially trained technician, and the images are interpreted by a radiologist; anesthesia is not needed. An abdominal ultrasound can create images of the entire urinary tract. The images can show damage or abnormalities in the urinary tract. Abdominal ultrasounds are also commonly used to take pictures of fetuses in the womb and of a woman's ovaries and uterus.

Transrectal ultrasound with prostate biopsy. Transrectal ultrasound is most often used to examine the prostate. In a transrectal ultrasound, the health care provider inserts a transducer slightly larger than a pen into the man's rectum next to the prostate. The ultrasound image shows the size of the prostate and any abnormal-looking areas, such as tumors. Transrectal ultrasound cannot be used to definitively diagnose prostate cancer.

To determine whether a tumor is cancerous, the health care provider performs a biopsy. For the biopsy, the health care provider uses the transducer and ultrasound images to guide a needle to the prostate. The needle is then used to remove a few pieces of prostate tissue for examination with a microscope. A transrectal ultrasound with prostate biopsy is usually performed in a health care provider's office, outpatient facility, or hospital by a doctor; light sedation and local anesthesia are used. The biopsied prostate tissue is examined in a laboratory by a pathologist—a doctor who specializes in diagnosing diseases. The biopsy can reveal whether prostate cancer is present.

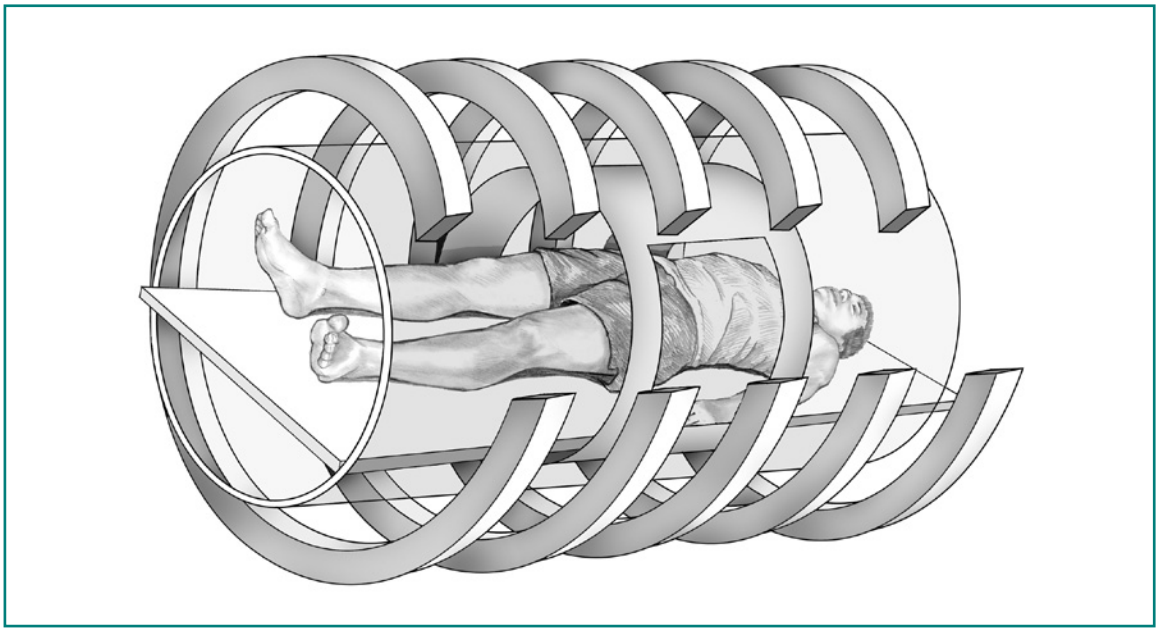


Transrectal ultrasound with prostate biopsy

MRI

Magnetic resonance imaging is a test that takes pictures of the body's internal organs and soft tissues without using x rays. MRI machines use radio waves and magnets to produce detailed pictures of the body's internal organs and soft tissues. An MRI may include the injection of contrast medium. With most MRI machines, the person lies on a table that slides into a tunnel-shaped device where the images are taken. The device may be open ended or closed at one end; some newer machines are designed to allow the person to lie in a more open space. During an MRI, the person is usually awake but must remain perfectly still while the images are being taken. A sequence of images taken from different angles may be needed to create a detailed picture of the urinary tract. During the sequencing, the person will hear loud, mechanical knocking and humming noises. The procedure is performed in an outpatient center or hospital by a specially trained technician, and the images are interpreted by a radiologist; anesthesia is not needed, though light sedation may be used for people with a fear of confined spaces.

Magnetic resonance angiogram (MRA). An MRA is a type of MRI that provides the most detailed view of kidney arteries—the blood vessels that supply blood to the kidneys. An MRA can show kidney artery stenosis, which is the narrowing of a kidney artery that restricts blood flow to the kidney. Kidney artery stenosis can cause high blood pressure and lead to reduced kidney function and eventually kidney failure.



MRI

CT Scans

Computerized tomography scans use a combination of x rays and computer technology to create three-dimensional (3-D) images. A CT scan may include the injection of contrast medium. CT scans require the person to lie on a table that slides into a tunnel-shaped device where the x rays are taken. The procedure is performed in an outpatient center or hospital by a specially trained technician, and the images are interpreted by a radiologist; anesthesia is not needed. CT scans can show stones in the urinary tract, obstructions, infections, cysts, tumors, and traumatic injuries.

CT scan

Radionuclide Scans

A radionuclide scan is an imaging technique that relies on the detection of small amounts of radiation after injection of radioactive chemicals. Because the dose of the radioactive chemicals is small, the risk of causing damage to cells is low. Special cameras and computers are used to create images of the radioactive chemicals as they pass through the urinary tract. Radionuclide scans are performed at a health care provider's office, outpatient center, or hospital by a specially trained technician, and the images are interpreted by a radiologist; anesthesia is not needed. Radioactive chemicals injected into the blood can provide information about kidney function. Radioactive chemicals can also be put into the fluids used to fill the bladder and urethra for x ray, MRI, and CT imaging.

What preparations are needed for an imaging test?

Preparations for an imaging test mostly depend on the purpose and type of test. In general, the health care provider will want to know whether the person is allergic to any foods or medications, is pregnant, or has had any recent illnesses or medical conditions. Specific preparations could include any of the following:

- fasting for 12 hours before the test
- drinking several glasses of water 2 hours before the test so the bladder is full—for some ultrasound tests
- taking a laxative, which is a medication that loosens stool and increases bowel movements, to clear the colon—for a transrectal ultrasound
- taking an enema, which involves flushing water, laxative, or sometimes a mild soap solution into the anus using a special squirt bottle, about 4 hours before the test—for a transrectal ultrasound
- talking with the technical staff about any implanted devices that may have metal parts that will affect MRI or MRA images, such as heart pacemakers, intrauterine devices (IUDs), hip replacements, and implanted ports for catheterization; metal plates, pins, screws, and surgical staples, as well as any bullets or shrapnel in the body, may also cause a problem if they have been in place fewer than 4 to 6 weeks
- taking a sedative before an MRI or CT scan if the person feels anxious or has difficulty holding still in enclosed spaces

People undergoing an imaging test should listen to the health care provider's instructions carefully and ask questions if something is not understood.

What happens after imaging tests?

After most imaging tests, the person can immediately resume normal activity. Tests that involved placing a catheter in the urethra may produce some mild discomfort for a few hours after the procedure. Drinking an 8-ounce glass of water every half-hour for 2 hours may help reduce the discomfort. The health care provider may recommend taking a warm bath or holding a warm, damp washcloth over the urethral opening to relieve the discomfort. A transrectal ultrasound may produce some discomfort. A prostate biopsy may produce pain in the area of the rectum and the perineum, which is between the rectum and the scrotum. A prostate biopsy may also produce blood in the urine and semen.

For catheterization or biopsy, the health care provider may prescribe an antibiotic for 1 or 2 days to prevent an infection. People with signs of infection—including pain, chills, or fever—should call a health care provider immediately.

Some people have reactions to the contrast medium or the sedatives, though the risks are generally low. Signs of contrast medium reactions include hives, itching, nausea, vomiting, headache, and dizziness. Contrast medium can cause kidney damage in people with certain conditions, such as impaired kidney function and diabetes. In most people, the kidney damage has no symptoms and goes away within a week or so. In rare cases, contrast medium causes lasting kidney damage. Signs of kidney damage include

- high blood pressure
- little or no urination
- edema—swelling, usually in the hands, face, feet, or ankles
- tiredness
- generalized itching or numbness
- headaches
- weight loss
- appetite loss
- sleep problems

Reactions to sedatives are rare but possible. Signs of sedative reactions include changes in breathing and heart rate. People with signs of reactions to the contrast medium or the sedatives should call a health care provider immediately.

How soon will test results be available?

The results of simple tests such as x rays and abdominal ultrasound can be discussed with the health care provider soon after the test. Results of other tests such as a prostate tissue biopsy, MRI, and CT scans may take several days to come back. The health care provider will talk with the patient about these results.

Points to Remember

- The urinary tract is the body's drainage system for removing wastes and extra water.
- "Imaging" is the general term for any technique used to provide pictures of bones and organs inside the body.
- Imaging helps the health care provider find the causes of urinary tract problems.
- The health care provider will consider a person's general medical history and urinary tract symptoms to decide what imaging technique to use.
- Urinary tract imaging techniques include conventional radiology, or x rays; ultrasound; magnetic resonance imaging (MRI); computerized tomography (CT) scans; and radionuclide scans.
- Preparations for an imaging test mostly depend on the purpose and type of test.
- After most imaging tests, the person can immediately resume normal activity.
- Results for simple tests are available soon after the test, while other test results may take several days to come back.

Hope through Research

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) has many research programs aimed at understanding, diagnosing, and treating urinary tract problems, including urinary tract stones, enlarged prostate, urinary incontinence, and kidney failure. The NIDDK also sponsors studies to improve diagnostic imaging techniques and devices. For example, current state-of-the-art methods using MRI techniques with rapid image acquisition rates make possible high-resolution, 3-D images of the kidneys. Semiautomated image analysis can determine kidney size and the location of cystic structures. MRI may also permit simultaneous estimation of kidney function.

Participants in clinical trials can play a more active role in their own health care, gain access to new research treatments before they are widely available, and help others by contributing to medical research. For information about current studies, visit *www.ClinicalTrials.gov.*

For More Information

American Urological Association Foundation
1000 Corporate Boulevard
Linthicum, MD 21090
Phone: 1–800–828–7866 or 410–689–3700
Fax: 410–689–3998
Email: auafoundation@auafoundation.org
Internet: www.UrologyHealth.org

National Kidney Foundation
30 East 33rd Street
New York, NY 10016
Phone: 1–800–622–9010 or 212–889–2210
Fax: 212–689–9261
Internet: www.kidney.org

Acknowledgments

Publications produced by the Clearinghouse are carefully reviewed by both NIDDK scientists and outside experts. This publication was reviewed by Sam B. Bhayani, M.D., Washington University School of Medicine.

You may also find additional information about this topic by visiting MedlinePlus at *www.medlineplus.gov.*

This publication may contain information about medications. When prepared, this publication included the most current information available. For updates or for questions about any medications, contact the U.S. Food and Drug Administration toll-free at 1–888–INFO–FDA (1–888–463–6332) or visit *www.fda.gov.* Consult your health care provider for more information.

National Kidney and Urologic Diseases Information Clearinghouse

3 Information Way
Bethesda, MD 20892–3580
Phone: 1–800–891–5390
TTY: 1–866–569–1162
Fax: 703–738–4929
Email: nkudic@info.niddk.nih.gov
Internet: www.urologic.niddk.nih.gov

The National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC) is a service of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). The NIDDK is part of the National Institutes of Health of the U.S. Department of Health and Human Services. Established in 1987, the Clearinghouse provides information about diseases of the kidneys and urologic system to people with kidney and urologic disorders and to their families, health care professionals, and the public. The NKUDIC answers inquiries, develops and distributes publications, and works closely with professional and patient organizations and Government agencies to coordinate resources about kidney and urologic diseases.

This publication is available at *www.urologic.niddk.nih.gov.*

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

NIH Publication No. 12–5107
January 2012

The NIDDK prints on recycled paper with bio-based ink.