Biopsy

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Diagnostic techniques, like MRI, Ultrasound, CT, or PET, are very useful but in some cases when suspicious tissue (a lesion) is discovered, a doctor may want to get a sample of the suspected cancer. Removal of a sample is called a biopsy.

Some other 'biopsies' only require giving a sample of blood or other bodily product (urine, saliva, etc.).

This page contains information on:

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This video explains both fine needle aspiration (FNA) and core needle biopsy (CNB), two types of biopsies that are explained in the following paragraphs.

Types of Tissue Biopsies

A tissue **biopsy** is the removal of either a portion of a lesion (incisional) or the entire lesion (excisional). The tissues are then sent to a lab where a pathologist will diagnose the sample.

There are several different types of biopsy. The type used depends on the goal of the biopsy (i.e. remove the entire lesion or obtain a small sample), the cancer type and the location of the cancer.

1. Incisional Biopsy

An incisional biopsy removes only a portion of a suspected tumor.[1] This technique is used when a lesion is too large to remove entirely or when the location of the tumor would result in unacceptable amounts of scarring. Incisional biopsies may require local anesthesia and may or may not require stitches.

2. Excisional Biopsy

An excisional biopsy removes the entire tumor and some surrounding tissue.[1] If a diagnosis of cancer results, the biopsy will have removed the entire tumor. An excisional biopsy is done using local anesthesia and is the most invasive of all the biopsy techniques. The wound may need to be stitched closed or a skin graft may be needed. These biopsies usually produce a scar.

An excisional biopsy removes the entire tumor (red cells) and nearby healthy tissue (tan cells).

3. Types of excisional and incisional biopsies.

- **Punch**

  A punch biopsy is used to collect a deep sample of skin and is usually used for large lesions or lesions on the palm, sole, finger/toe, face, and ear. This technique removes a portion of skin approximately ¼ inch deep and may result in a scar.

- **Shave**

  A shave biopsy removes the epidermis and a small portion of the dermis, the top two layers of the skin. This technique uses a surgical blade or razor to shave off a portion of the skin. This procedure is easy on a patient because it is relatively pain free (done under local anesthesia) and requires no stitches. Shave biopsies are not normally used for suspected melanoma because the cut is not deep enough to allow measurement of the depth to which the lesion has spread.

- **Needle**

  A needle biopsy is rarely used to obtain skin tissue; it is usually used to remove a sample from internal organs, lymph nodes, or deep skin areas. These techniques involve the use of a small, hollow needle and is sometimes aided by an imaging technique such as x-ray. There are two types of needle biopsy, fine needle aspiration (FNA) and core needle biopsy. They differ in the amount of tissue removed. Core needle biopsies remove a larger tissue sample than FNA.[1] More about these below.

Needle biopsies are used to take samples of a suspected tumor (red cells). Normal cells (tan) may also be collected. They can differ in the type of needle used and the number of samples taken.

Fine Needle Aspiration (FNA)

Procedure
FNA is done with a small, 20-27 gauge needle (same size or smaller than most needles used in ordinary blood test, the larger the gauge the smaller the needle). The area is sterilized with alcohol to prevent infection. The needle is then inserted and aimed at the center of the lesion. When the needle reaches the lesion a very small piece is removed by suction. This is repeated to ensure that a proper amount of usable sample is obtained. Local anesthesia is not used in most cases because the sting from a local anesthesia needle is more painful than the FNA procedure itself. If the lesion is non-palpable the doctor may use ultrasound or other imaging techniques to help guide the needle precisely into the suspicious lesion.[2]

Analysis
Samples are sent to a pathologist specially trained in cytology (cellular abnormalities) to be processed and interpreted. The samples are placed on glass slides and stains are used to reveal the details of the cells. The diagnosis will generally come back as one of five options:[2], [3]

- *Benign* - the mass is not of much concern and will not cause any significant problems as long as it remains unchanged.
- *Atypically indeterminate* - a diagnosis cannot be obtained from the sample. Other tests are needed to determine the nature of the lesion.

- *Suspicious/probably malignant* - not a diagnosis of cancer. This type of diagnosis requires additional investigation because the sample has abnormal characteristics. This lesion should be biopsied with a more complete method to determine whether a malignancy (cancer) is present.
- *Malignant* - a diagnosis of cancer; should be biopsied and tested for exact tumor makeup to prepare for treatment.
- *Unsatisfactory* - a diagnosis cannot be determined from the sample because of insufficient sample size, processing or other machine or human errors.

The Triple Test (TT) Method in Breast Cancer
After the biopsy is diagnosed by a pathologist all aspects of the case should be considered by a clinician, this is called the triple test method or TT. The triple test method considers the results of the physical examination, imaging (mammography, MRI, etc.) results and the cellular (cytological) findings of the pathologies (based on the biopsy samples). When all of these aspects are considered, a FNA is very accurate. The false positive and false negative rates are similar to biopsies obtained by more invasive surgeries. The TT method should always be used to diagnosis a breast mass using FNA.2

Preparation and Side Effects
There is no special preparation for a FNA, no fasting, special diet, etc. In almost all cases FNA will be done in the doctor's office and not in a hospital. There is very little pain associated with a FNA and the procedure is very safe, resulting in only a little bruising and tenderness around the biopsy area.

Core Needle Biopsy

Biopsies are samples of tissue that are removed for closer examination.

Procedure
Core needle biopsy (CNB) is similar to a fine needle aspiration (FNA), except that a larger (11-18 gauge) needle is used and the pathology report is different. Because the needle is larger than in a FNA, local anesthesia is used to numb the area before insertion. A small nick in the skin is made and the doctor inserts the needle through this nick. At least three, usually more, samples are taken from each breast mass to ensure an adequate sample. In most cases the doctor will use an imaging technique, such as ultrasound, to help guide the needle into the desired tissue. Steri-Strips™ are used to close the small cut and a larger bandage is placed on top to protect the wound.4

Analysis
A core biopsy sample is studied differently than a FNA sample. The larger size of the sample allows the pathologist to look at the way groups of cells are organized instead of looking at individual cells. In CNB a trained pathologist looks for changes associated with a variety of diseases.4 Because cancer cells are dividing in an abnormal fashion, they make the tissue around them appear disorganized. By examining collections of cells (tissue) instead of individual cells, pathologists get a good sense for the health of the organ from which the sample was removed. The study of tissues is called histology and the study of abnormal tissues is called histopathology.

Preparation and Side Effects
You should limit alcohol consumption the day before and do not take any products containing aspirin 5 days before the procedure because alcohol and aspirin can thin the blood and result in excessive bleeding. After the procedure there may be discomfort, bruising, and bleeding. These will be short term and pain can be managed with pain medications (except aspirin). The bandages covering the wound will need to be changed and the wound cleaned.

FNA vs Core Biopsy

Below is a table comparing Fine Needle Aspiration and Core Needle Biopsy.2, 5, 6

	Fine Needle Aspiration **(FNA)**	Core Needle Biopsy **(CNB)**
Sample Removed	Removes only a very small portion of the lesion	Removes a small portion in most cases, occasionally removes the entire lesion
Needle Size	22-27 gauge	11-18 gauge
Pathology Type	Cytopathology	Histopathology
Interpretation Time	Immediately	Delayed
Diagnostic Abilities	Limited ability to specifically diagnose benign lesions No ability to differentiate between *in situ* and invasive breast cancer	Strong ability to specifically diagnose benign lesions. Some ability to differentiate between *in situ* and invasive breast cancer.
Disadvantages	Cannot be used for additional study	More invasive, time consuming, expensive
Advantages	Inexpensive, quick, readily available, and very safe	Can be used for additional study and has more specific diagnostic abilities than FNA

Effectiveness	Sensitivity: 75.8-98.7% Specificity: 60-100% Positive Predictive Value: 93.5-100%	Sensitivity: 91-99.6%% Specificity: 98-100% Positive Predictive Value: 100%

Watch a video about Sensitivity and Specificity of Medical Tests

Frequently Asked Questions about Biopies

General Biopsy Questions

What is a biospy

Biopsy is the removal of cells, tissue, or fluid for examination. These procedures are generally very simple and can prevent extensive surgical removal.

What is the difference between an aspiration and a biopsy?

Aspiration is the removal of something by suction. Biopsy is the removal and examination of tissue, cells, or fluids. FNA is a type of biopsy that removes cells through suction using a syringe.

What is the difference between and core needle biopsy and a fine needle aspiration?

There are a few differences between the two. A core needle biopsy is done with a larger needle and a small incision is made in the skin above the area to be biopsied. The incision allows for easier insertion of the needle, but is not needed when performing an FNA because the needle used is very thin. Refer to this table comparing fine needle aspiration and core needle biopsy for more detailed information.

Questions About Fine Needle Aspirations

What information is obtained from a fine needle aspiration?

The sample obtained from a fine needle aspiration is sent to a pathologist where it will be examined. The pathologist will determine if the lesion is cancerous or not. Other information also may be obtained from the sample, such as the characteristics of the lesion.

What do I have to do to prepare for a fine needle aspiration?

There is no special preparation the day of the exam. However you should tell your doctor about any medications you are on. Some medications will cause excessive bleeding and should be stopped days before the procedure. It is a good idea to wear a two piece outfit, because you will need to change into a gown.

What is the procedure?

Fine needle aspiration is a fairly simple procedure usually performed in a doctor's office with no anesthetic. FNA is performed using a small, 20-27 gauge, needle (larger gauge corresponds to a smaller needle). The person performing the exam will first clean the skin above the area to be sampled to prevent infection. Then the needle is inserted into the center of the lesion and small sample of cells is removed. Because the sample taken is very small this procedure will be repeated 4 or more times to ensure an adequate sample is obtained. In some cases ultrasound will be used to accurately guide the needle into the lesion.

Will the procedure hurt?

People interpret pain differently, but the FNA procedure is done using a very thin needle that should cause little or no discomfort. If you are nervous about the procedure speak to your healthcare provider and they should be able to accommodate you. After the procedure the area may be a little sore and bruised, but there are no other serious side effects.

What kind of anesthetic will be used?

In most cases no anesthesia is used when performing an FNA because the needle used is very thin. You can ask for a local anesthetic, but receiving the anesthetic may actually sting more than the FNA procedure.

How accurate is fine needle aspiration?

The accuracy of FNA depends on the experience of the practitioner. Don't be afraid to ask about the experience of the person doing the biopsy or the pathologist examining the sample.

Questions About Core Needle Biopsy

Why do I need a core needle biopsy?

A core needle biopsy is done after a suspicious lesion is detected, either by an imaging technique or clinical finding. This procedure will remove a sample of cells that will be sent to a pathologist to determine whether the lesion is cancerous or benign.

What do I have to do to prepare for a core needle biopsy?

There is no special preparation the day of the exam. However you should tell your doctor about any medications you are on. Some medications will cause excessive bleeding and should be stopped days before the procedure. It is a good idea to wear a two piece outfit, because you will need to change into a gown. If you are to receive a sedative, you should arrange for a ride home after the procedure.

How is a core needle biopsy performed?

Core needle biopsy is a simple procedure usually performed in a doctor's office with a local anesthetic. CNB is performed using an 11-18 gauge needle (larger than the one used in FNA). The person performing the exam will first clean the skin above the area to be sampled to prevent infection. A small nick will be made in the skin and the needle is inserted through this nick into the center of the lesion. When the lesion is reached a sample of tissue is removed. Steri-Strips are used to close the small cut and a larger bandage is placed to protect the wound. In some cases ultrasound will be used to accurately guide the needle into the lesion.

Will the procedure hurt?

People interpret pain differently, but the core biopsy procedure is done with local anesthetic. Other than the sting from the anesthesia injection, you should not feel any pain. If you do experience significant pain, be sure to tell someone. After the procedure the area may be a little sore and bruised, but there are no other serious side effects. If you are nervous about the procedure speak to your health care provider and they should be able to accommodate you. In most cases a local anesthetic is used. This numbs the area to be biopsied preventing any feelings of pain and is administered with a very small needle, which usually only causes a slight sting. If you are nervous or anxious about the procedure, speak with your healthcare provider.

What information is obtained from a core needle biopsy?

The sample obtained from a core needle biopsy is sent to a pathologist where it will be examined. The pathologist will determine if the lesion is cancerous or not. Other information also may be obtained from the sample, such as the characteristics of the lesion.

Liquid Biopsies

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Currently in the works is a method to accurately screen for (and track) cancer safely, quickly, cheaply, and non-invasively: liquid biopsies. Although liquid biopsies are not yet routine in the clinic (right now, physicians rely on tissue samples) 7, there are many companies (including Illumina's GRAIL, Johnson & Johnson, Pathway Genomics, Epic Sciences, Guardant Health, and many others) developing blood-based cancer tests.

Liquid biopsies require only a small sample of blood. Traditional biopsies can be painful, costly, time-consuming, and potentially risky for the patient.8 The biomarkers that can found in a liquid biopsy include circulating tumor cells (CTCs), tumor DNA (specifically referred to as "cell-free **c**irculating **t**umor DNA" or ctDNA) and RNA fragments that have been shed from tumor cells. There's also exosomes, tiny bubble-like structures (vesicles) released from cells. Exosomes can carry a variety of proteins, DNA, and RNA throughout the body.9

Liquid biopsies can be used to detect and stage cancer. They are also likely to be used to track the response of patients to cancer treatments. A large amount of information can be gained by looking at the different disease-specific items found in blood. Liquid biopsies provide scientists and clinicians a way to learn about the genetic defects in a tumor. They can see what tumor suppressor genes are broken, what oncogenes are activated, changes in the number of copies of genes, or abnormal epigenetic alterations (i.e. methylation) of cancer-associated genes. 10.

Biomarkers found in liquid biopsies	Description

Circulating **T**umor **C**ells (CTCs)	Cells can break off from tumors and enter the bloodstream, where they are referred to as CTCs. If they stop and grow at a site distant from the primary tumor, they will have metastasized 9. CTCs are rare and difficult to isolate 11. CTC detection has been associated with worse outcomes for patients with early breast cancer 12.
Cell-free **c**irculating **t**umor DNA (ctDNA)	DNA can be released into the bloodstream from tumor cells dying from apoptosis or necrosis 13. It may also be released by living tumor cells and CTCs 14. ctDNA can be single-stranded or double-stranded, and the pieces are different lengths. Importantly, ctDNA carries the mutations found in the tumor 14 and can be used to create mutation profiles of the cancer. ctDNA analysis has been shown to be more sensitive at detecting mutations than CTCs 10.
Cell-free **mi**croRNA (miRNA)	miRNAs are tiny, non-protein-coding nucleic acid sequences (about 19-22 nucleotides long). They regulate the transcription of genes 15. miRNA can be released by tumor cells into the bloodstream, and research shows that they can alter gene expression in cells far from where they originated 16. Studies suggest that the types of miRNAs released is tissue and cancer specific. This makes miRNA profiling from liquid biopsy samples a promising method for detecting cancer and tracking treatment responses 15.
Exosomes	Exosomes are tiny vesicles (~30-100 nm in diameter) that move through the bloodstream and carry proteins, RNA, DNA. They function in cell-to-cell communication 17. Exosomes can be isolated from blood samples and analyzed for biomarkers specific to cancer 18.
DNA Methylation	Looking at epigenetic changes, specifically at methylation patterns, on circulating DNA is another way of detecting cancer 19. Tumor suppressor genes may be silenced by the addition of methyl groups (-CH3) to specific parts of their DNA sequence.

Currently, liquid biopsies can't conclusively tell whether or not a patient has a tumor somewhere (a traditional tissue biopsy would be the only way to be completely sure). They are likely to be very useful in helping physicians decide whether or not a more invasive tissue biopsy would be wise. This is especially important when testing sites like the brain and lungs, where traditional biopsies can be dangerous/harmful. Also, by including liquid biopsies in routine blood screens, doctors may be able to detect evidence of cancer in asymptomatic individuals early in cancer progression 13, and they can take the necessary steps to treat it before it becomes advanced/widespread.

Another benefit of a liquid biopsy deals with the issue of tumor heterogeneity.20 Almost all cancers start out as one defective cell. Over time, and many cell divisions, the subpopulations of daughter cells gain mutations and become different from one another; the cancer cells in a single tumor are similar to each other, but not identical. Cancer evolves. During a traditional biopsy, a physician cuts out a few tiny sections of the (suspected) tumor. Cells in another, (un-biopsied) part of that same tumor may be slightly different, and may even respond to treatment differently. Liquid biopsies have the potential to reveal details about cells from all parts of the tumor, and a provide a more complete picture of what genes that particular tumor relies on.

Conducting liquid biopsies for tumor-specific mutations should be useful post-treatment as a way to gauge how successful a treatment is working/worked.13 Detection of ctDNA in the blood after surgery could identify patients who will need additional treatment.20 Also, one reason relapse occurs is because a tumor develops resistance to the therapies being used; a treatment works for a while, but the few cancer cells that aren't affected by the drug will proliferate and take over. Physicians could detect this resistance earlier by screening for common resistance mutations in the ctDNA floating around in patients' blood.20 This would help guide drug selection for additional treatments.

Liquid biopsies for cancer detection/tracking aren't yet being used regularly. The tests have to be standardized and validated with large numbers of samples; there are multiple methods of extracting and analyzing tumor cells, cell-free nucleic acids, and exosomes from a blood sample, and different testing methods may give different results. Plus, biomarkers in liquid samples will also need to be validated as reliable and cancer-specific in large-scale clinical trials, and these need to be compared to traditional tissue biopsies before using them in the clinic.15 Because ctDNA is found at very low levels in blood, the approved tests will have to be very sensitive.10

Liquid Biopsy (Blood test) Research Results:

- A 2018 study demonstrated that that liquid collected by Pap tests could also be used to detect endometrial

and ovarian cancers. Dubbed PapSEEK by the researchers, this test was shown to detect the majority of endometrial cancers and many ovarian cancers from existing patients. The detection was improved by taking samples closer to the source of the endometrial/ovarian cells. Work is ongoing to improve the sensitivity of the test. The test dis not show ANY false positives in this group of women.[21]

- In a 2016 study, researchers from the Dana-Farber Cancer Institute took 180 patients with non-small cell lung carcinoma (NSCLC), 120 of whom had been recently diagnosed, and 60 of whom had relapsed after their initial treatments. The cell-free DNA in the blood samples of the patients were tested for mutations in two genes that are commonly mutated in NSCLC (the EGFR and KRAS genes). Each patient also had a standard tissue biopsy, and the results of the two tests were compared. Liquid biopsies were faster; the turnaround time for results was about 3 days for the liquid biopsy versus 12 days for the new patients and 27 days for the patients whose tumors were drug-resistant. Analyzing the cell-free DNA in the blood was also just as accurate as the conventional biopsy, and the liquid test was even able to catch some EGFR resistance mutations that the conventional test missed.[22]

- In 2015, researchers from the Memorial Sloan Kettering Cancer Center discovered that they could analyze the free-floating tumor DNA in liquid biopsies to predict how breast cancer patients would respond to certain treatments. They looked at blood samples from 587 patients, some of whom were receiving the hormone drug fulvestrant plus a placebo, and the rest who were receiving fulvestrant plus buparlisib, a drug that blocks a pathway that can promote resistance to hormone therapies (the PI3K pathway). Patients who had a mutation in the PIK3CA gene (a mutation which activates that PI3K pathway) dramatically benefitted from the combination treatment compared to those who received a placebo (7 months of progression-free survival versus 3.2 months).[23] With the information obtained from liquid biopsies, doctors could identify patients who wouldn't benefit from certain drugs and can help them avoid any unnecessary side effects.

- Researchers at the University of Texas M. D. Anderson Cancer Center completed a study in 2015 in which they extracted exosomes from the blood of three patients with pancreaticobiliary cancers (two pancreatic, one ampullary) and analyzed the DNA and RNA gene sequences inside the exosomes. They were able to obtain the same information they would have from a tissue biopsy (an invasive procedure for a visceral organ like the pancreas). They were able to characterize the tumor mutations, gene copy-number changes, possible treatment responses, and targets for immunotherapies.[24]

- A paper published in *The Lancet Oncology* in 2015 compared data from liquid and tissue biopsies in metastatic colorectal cancer patients. The isolated DNA from the blood of patients to look for *KRAS*, *PIK3CA*, and *BRAF* mutations. They also quantified how much DNA there was, and examined the levels of 15 different proteins. The researchers saw that the anti-angiogenesis drug regorafenib benefited certain groups of patients based on what mutations they had and the concentrations of certain proteins—data that could be collected from blood samples. The blood test could also predict clinical outcomes and detect new mutations that the tumors had acquired since the initial tissue biopsies.[25]

Other Types of 'Liquid' Biopsies: Saliva, Sputum, Breath, Urine, Stool

Saliva-based tests:
At the 2016 Annual Meeting of the American Association for the Advancement of Science (AAAS), researchers from UCLA presented a device called electric field-induced release and measurement (EFIRM), which is used to identify signs of lung cancer in saliva. Requiring only one drop of saliva, this method would be even less invasive than getting blood drawn. The test detects ctDNA in saliva. The ctDNA can be examined for common EGFR mutations found in lung cancer. Samples can be collected and analyzed in less than 20 minutes, and an appropriate tyrosine kinase inhibitor (TKI), a drug that targets these EGFR mutations, can be prescribed—all without the hassle, cost, and risk of an invasive tissue biopsy. The researchers hope this quick method can extend to other biomarkers for cancer, such as mutations in PIK3CA, PTEN, and TP53 that are found in mouth (oral) cancers.[26]

In addition to ctDNA, research has shown that protein tumor markers are increased in the saliva of oral cancer patients, specifically the proteins Cyfra 21-1, TPS, and CA125.[27] Researchers can also look for abnormal RNAs (specifically long non-coding or lncRNAs) in saliva samples to check for oral cancer. The level of one lncRNA, referred to as HOTAIR, was found to be higher in the saliva samples of oral cancer patients whose tumors had spread to other parts of the body (metastasized).

Sputum
Sputum is a thick mixture of saliva, mucus and other material that can be brought up from the throat and air passages leading to the lungs. Sputum contains cells and DNA and can be examined for abnormalities, including some that indicate the presence of lung cancer.[28], [29] Although it is not a very sensitive test, examination of cells in sputum is still used to detect lung cancer. In part because of the poor sensitivity of the test, routine screening for lung cancer via sputum samples is not recommended.[28]

Recent advances have improved the test considerably. The ThinPrep® preparation technique has been shown to provide additional sensitivity.[30] Research is now being performed to assess the value of looking at fluorescence in

body fluids to detect cancer[31] and to look for the presence of genetic defects and specific genes that could indicate the presence of cancer.[32], [33]

Breath tests:
Just like one can take a breathalyzer test to measure alcohol levels, researchers are developing methods to detect cancer with a simple breath test. In a 2015 study published in the journal Gut [34], researchers collected breath samples from 484 patients, 99 of whom had been diagnosed with stomach (gastric) cancer. The scientists measured the levels of 130 chemicals (called volatile organic compounds, or VOCs) released by cells into the patients' breath. VOCs are carbon-based chemicals that evaporate into the air at relatively low temperatures. They have names like 3-hydroxybutan-2-one, hexadecanal, and 4-methyloctane. The researchers found differences in the amounts of eight of these compounds between cancer-patients and cancer-free patients. In a similar study, researchers from Emory University and Georgia Tech analyzed two breath VOCs from fifty female patients, 25 with and 25 without lung cancer. After looking at the levels of 422 different chemicals, the researchers found the amounts to be different for 75 of them between the two groups.[35]

This research suggests that VOCs can be used to create a "breath print". Comparing patients with standard sets would be an easy way for physicians to check if a patient is likely to have some kinds of cancer. A 2015 review of breath tests for cancer reports that breath tests have also been researched for other types of cancer, including breast cancer, head and neck cancer, and mesothelioma. [36] Further research will have to be done to verify cancer-specific VOC patterns and to standardize the collection and analysis processes before these tests can be used in the clinic.

Urine tests:
Urine tests may become a more common early-detection test for cancer.

- Bladder cancer: This is already being used in the clinic. Physicians can check for cancer or pre-cancerous cells in the urine, see if there is any blood in the urine (a possible first sign of bladder cancer), or check for the levels of proteins linked to cancer such as NMP22, carcinoembryonic antigen (CEA), and bladder tumor-associated antigen (BTA).[37]
- Prostate cancer: A 2016 study identified four different messenger RNAs (mRNAs) that may serve as biomarkers for prostate cancer by comparing mRNA levels in urine samples of patients with and without prostate cancer.[38]
- Kidney cancer: A study from 2015 showed that physicians could look at the levels of two proteins, aquaporin-1 and perlipin-2, which are elevated in kidney cancer.[39]
- Pancreatic cancer: The possibility of a urine test for pancreatic cancer, which is often too late in tumor progression to be effectively treated, is also being studied. A 2015 study published in Clinical Cancer Research reported on a three-protein biomarker panel that could be used to detect patients who had early-stage pancreatic cancer.[40] The researchers looked at the levels of different proteins in 18 patients: six controls, six with chronic pancreatitis, and six with pancreatic ductal adenocarcinoma. Three of these proteins (LYVE1, REG1A, and TFF1) were elevated in cancer patients compared to the healthy patients and those with pancreatitis. Using urine samples, the researchers were able to predict stage 1 and 2 pancreatic cancer with over 90% accuracy.

Stool tests:
A stool (fecal) DNA test is considered a type of liquid biopsy.

- Colorectal cancer: A stool test to detect colorectal cancer was approved by the FDA in 2014 and covered by Medicare.[41] This test, called Cologuard® detects elevated levels of mutant DNA from cancer cells, and also detects hemoglobin (a chemical found in blood). This fecal DNA test is an improvement upon the previous fecal immunochemical test (FIT), which only checks for blood in the stool. The Cologuard® sample can also be easily collected at home and sent off for analysis in a prepaid box. Though false-positives limit the test's accuracy, it is much less invasive than a colonoscopy. Learn more about false-positive and negative medical tests.

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