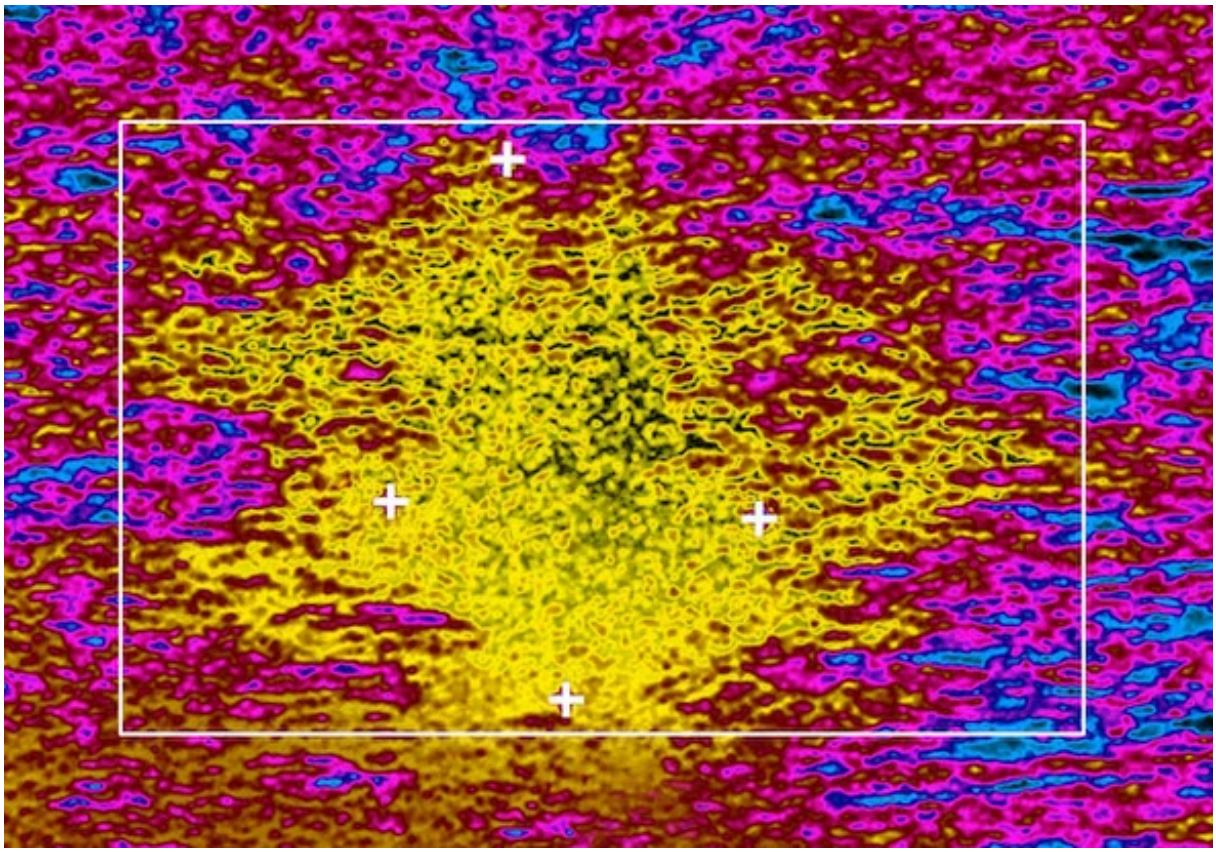
Observations

A New Way to "See" Cancer

Combining near-infrared light with ultrasound could let doctors image tumors with unprecedented accuracy

By Quing Zhu on December 22, 2017



An ultrasound of breast cancer, which only shows the tumor indistinctly. Credit: Getty Images

It's difficult to detect what we cannot see. This universally understood notion remains one of the biggest challenges in cancer detection, diagnosis, and treatment today. Many forms of cancer go undetected until a later stage, making them hard to treat and putting patients at greater risk of death. On the flip side, many existing tests provide too many false positives that lead to risky surgeries.

For breast cancer patients, false positives and early diagnosis have followed this trend. A recent study published in *Annals of Surgery* found that rates of a

contralateral prophylactic mastectomy—removing both breasts—more than tripled from 2002 to 2012, particularly among younger women. These findings are surprising considering only about one third of the women in the study indicated high-risk factors for breast cancer, and other research has demonstrated that removing a healthy breast does not improve chances for survival.

Physicians must therefore strike a careful balance that enables both early and accurate detection to enable longer lifespans for cancer patients. One solution—a clear image of a tumor and its features—is not yet available to doctors, but scientists are working diligently to develop the technology to produce a readable, inexpensive "snapshot." Without an accurate understanding of whether a tumor is likely to be aggressive and spread, doctors and patients are forced to make difficult decisions about treatment.

Enhanced imaging will be critical to early detection, and ultimately survival for women who, for example, are diagnosed with cancers of the breast, colon, skin and ovaries. According to the Centers for Disease Control, ovarian cancer causes more deaths than any other malignancy of the female reproductive system. Ovarian cancer has vague early-stage symptoms that enable it to go undetected easily. Further, women's ovaries are small, and embedded deep within the abdominal cavity.

While ovarian and skin cancers are fatal for women, breast cancer is the most common cancer in women in the U.S. Researchers estimate there will be 252,710 new cases of invasive breast cancer and 40,610 breast cancer deaths in 2017. Because detection and diagnosis tools still leave uncertainty, many at-risk patients, based on family history, testing for the *BRCA1* or *BRCA2* mutation, and other factors, opt for risk-reduction surgery—where the numbers of such operations have tripled over the past decade alone, particularly among younger women.

Ultrasounds are currently the most common technology used to assist x-ray mammograms in identifying benign versus solid tumors, but the ultrasound alone can paint an incomplete picture of a tumor. As such, doctors typically rely on other types of imaging and a biopsy.

Once a patient has begun chemotherapy treatment following these examinations, the ultrasound is not sensitive enough to assess the tumor's response to treatment. Ultrasounds show tumor morphology changes that often occur later than natural

changes during early stage chemotherapy. The early changes, however, are critical to oncologists to determine if the selected treatment is working or if a different treatment or surgery may be a better option.

Ovarian cancers, similar to breast cancers, feed off of additional blood vessels in the body. Often referred to as the “silent killer” because symptoms that resemble those of indigestion are easy to miss, ovarian cancer is first detected through CT with contrast, MRI with contrast and FDG-PET. The high costs of these tests and exposure to radiation put patients at a disadvantage from the beginning.

To truly understand the onset and severity of the cancer, doctors must be equipped with better visual tools to distinguish benign from malignant tissue. From here, engineering a better imaging technique may provide details about tumors that would help determine which treatments would be most effective—and could dramatically improve cancer treatment, particularly for the most common tumor types.

To better fight breast and ovarian cancers, initial research is underway to develop new imaging techniques with funding from the National Institutes of Health.

In 2016, a group of engineers and doctors at Washington University in St. Louis launched efforts to determine if an imaging-based technique could provide a more detailed view of the cancer and enable women to make an informed decision for treatment options at the onset. This process combines an ultrasound with an additional optical imaging component—diffused near-infrared light. Preliminary findings in a pilot study suggest that, after just a couple of weeks, the technique can show how a patient’s breast tumor is responding to a particular chemotherapy regimen, based on the amount of vascular activity and changes. The combined ultrasound-infrared technique shows promise that it can track a tumor’s response to chemotherapy, regardless of its genetic markers.

Sign up for *Scientific American*’s free newsletters. Sign Up

With ovarian cancer, the researchers applied similar principles combining ultrasound with photoacoustic technology. The light is absorbed by the suspected tumor and

generates a slight temperature change that converts to sound waves. The sound waves can be detected and analyzed as markers of a cancerous tumor. This technique is not only safer, but costs far less than the other imaging processes.

While still early, this research is promising based on a small group of pilot patient data. Malignant ovarian tissue revealed high vascular content with quite diffused vascular distribution patterns, and benign ovarian tissue demonstrated low vascular content. With a clear understanding of risk and diagnosis, the expectation is that both patients and surgeons can better determine whether surgery is required. Researchers and doctors are studying and striving to deliver non-invasive imaging technologies to enable women to make much more informed decisions about surgery and have a better quality of life. If we can provide a better look, a better image, it might just make for a better future.

The views expressed are those of the author(s) and are not necessarily those of Scientific American.

ABOUT THE AUTHOR(S)

Quing Zhu

Quing Zhu is a professor of biomedical engineering at Washington University in St. Louis.

Scientific American is part of Springer Nature, which owns or has commercial relations with thousands of scientific publications (many of them can be found at www.springernature.com/us). Scientific American maintains a strict policy of editorial independence in reporting developments in science to our readers.

© 2020 SCIENTIFIC AMERICAN, A DIVISION OF NATURE AMERICA, INC.

ALL RIGHTS RESERVED.