Detect a cancer in under 10 minutes

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A new test takes advantage of a difference in the DNA structures in cancer cells to detect the presence of a cancer in just a few minutes.

EARLY DETECTION

The identification of new tests, which enable to rapidly diagnose the presence of cancer, has long represented a very active topic of research. These efforts are necessary due to a grim reality: when they attain an advanced stage, cancer cells are extremely difficult to eliminate and current anticancer treatments are generally much more effective when they are directed against small tumours. Early detection of these tumours, before they succeed in evolving into mature cancers, could thus greatly increase the chances of survival for the patients. The best example of the utility of this approach is colonoscopy, a technique that allows the detection of colorectal tumour precursors (adenomas) before they reach an advanced stage. The significant decrease in mortality associated with colorectal cancer in many Western nations is a direct result of the colonoscopy programs which are now offered to people at risk (family history of cancer, people aged 50 or over).

However, this type of screening is sufficiently daunting from a technical point of view, that it remains limited to this single form of cancer. The discovery of a more universal diagnostic test which is less invasive and is performed on an abundant tissue that is easy to obtain, such as blood, would offer considerable advantages in terms of cancer screening at the level of the entire population.

DIFFERENT STRUCTURES

Significant progress along these lines was recently described by an Australian research team[1]. These scientists made the stunning discovery that the DNA of cancer cells exhibits unique structural modifications and that it is possible to exploit these differences in order to specifically detect the presence of cancer cells in a person's blood.

This difference is found in the methylation profile of the DNA, an epigenetic modification that is involved in controlling the expression of genes. While in normal cells the methylation of DNA is distributed in a fairly uniform way along the length of the genome, the authors discovered that the methylation profile was quite different in the DNA of cancer cells: rather than being uniform, the methylation was concentrated in certain very specific regions, located one after the other while separated by long segments which were totally lacking this methylation. This specific signature was observed in all of the cancer samples tested by the authors, including those obtained from some of the most frequent forms of cancer including those of breast, prostate, colon and from lymphomas.

DISTINCT PROPERTIES

Another stunning discovery was that the different methylation profile modifies the chemical properties of dissolved DNA, particularly its interaction with some metals. The authors observed that the presence of molecular islands containing a strong density of methylation increased the solubility of DNA isolated from cancer cells while also enhancing its interaction with metallic nanoparticles. Inversely, when DNA was normally methylated (as is the case in non-cancerous cells) the molecule tended to agglomerate and to be less soluble, which reduced its affinity for the metal.

The important point is that it is possible to actually use this difference in biochemical properties to rapidly determine whether the DNA present in a given sample is normal or from a cancer. This test is based on the properties of golden nanoparticles to form aggregates in the presence of salt, a process that can be visualized as a change in solution color from pink to blue. When a sample containing the cancerous DNA is added, the interaction of this DNA with the particles prevents the formation of an aggregate and the solution remains pink: on the other hand, when the DNA is normal it does not interact with the nanoparticles of gold and so they can agglomerate, turning the solution blue.

More than 200 samples derived from different types of cancers and from normal tissues were tested and the test is currently able to detect the presence of cancerous DNA with an efficiency of 75-90%, which is excellent for this stage in the development of a new technology. In addition, the sensitivity of the test seems excellent with signals obtained using as little as 1 pg of DNA (a thousandth of a billionth of a gram) and the result can be visualized very quickly by eye, in less than 10 minutes.

The discovery that the methylation profile of DNA represents a nearly universal marker for cancer could thus revolutionize our means of detecting the presence of the disease in its earliest stages. What makes this even more interesting is that the test is simple, inexpensive and can provide a response in just a few minutes. Much remains to be done towards validating this technique, but the potential for this approach is undeniable because it uses cutting-edge discoveries from biochemistry in cancerology. It is to be hoped that this type of detection will become routine practice in the near future and allow us not only to diagnose the presence of tumours at an early stage but also for precisely monitoring tumour status following anticancer treatments.

(1) Sina AA et al. Epigenetically reprogrammed methylation landscape drives the DNA self-assembly and serves as a universal cancer biomarker. Nat Commun. 2018; 9: 4915.

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