Towards an anti-cancer vaccine?

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Translated from Le Journal de Montréal, March 26, 2018

Scientists at Stanford University have used pluripotent stem cells to create a vaccine which prevents the development of several types of cancers.

In the first stages of embryonic development, the stem cells are characterized as pluripotent, which means that they are capable of forming into all the types of cells necessary for the functioning of the mature organism (nervous cells, skin cells, intestinal cells etc.). Once growth has finished, this plasticity of embryonic cells should obviously disappear; for example, if neurons which allow us to think should suddenly decide to behave like skin cells and to no longer transmit nerve signals, the entire organism will suffer.

This is, however, what occurs during the development of a cancer; rather than conform to their specialized functions, the cancerous cells instead adopt a behaviour analogous to that of pluripotent stem cells where they reproduce very rapidly, in an autonomous manner and without taking into account the constraints normally imposed by the environment which surrounds them. In other words, the cancerous cells are very similar to embryonic stem cells, a similarity well illustrated by the presence at their surface of several antigens normally found exclusively in the embryonic cells.

ACTIVATE THE IMMUNE SYSTEM

A practical application of this resemblance between cancerous and embryonic cells is the development of an anti-tumor vaccine. The principle is as follows: because the stem cells contain a wide range of surface antigens which are also present in cancerous cells, the injection of stem cells can activate a highly diversified immune response which thus has a high probability of neutralizing the growth of tumors. This is not a recent idea; about a century ago, the German scientist Frederick Schöne had already observed that vaccination of animals with fetal extracts prevented the growth of tumors. However, the routine use of fetal extracts as vaccination agents in humans is obviously not ethically possible, which blocked the development of this approach.

A VACCINE BASED ON PLURIPOTENT CELLS

There is, though, an alternative to fetal cells: the works of English biologist John Gurdon and of Japanese doctor Shinya Yamanaka (Nobel prize in Medicine 2012) have shown that it is possible to induce specialized cells (a skin cell, for example) to go “back to the future” and become once more immature and pluripotent. These cells, which they called “induced pluripotent stem cells (iPS)” possess the property of being able to transform into all types of cells and thus present numerous similarities to embryonic stem cells and, consequently, to cancerous cells.

A recent study suggests that these pluripotent iPS cells could effectively be used as an antitumor vaccine[1]. The researchers first observed that the iPS cells generated from mouse fibroblasts showed numerous similarities to cells derived from several types of cancer, indicating that they possessed the potential to provoke an antitumor immune response. This turned out to be correct when their research showed that immunisation with these cells prevented the growth of different types of cancers (breast, lung and melanoma) in the treated animals. This anticancer effect is certainly due to activation of the immune system since the T lymphocytes isolated from the animals immunized with iPS cells blocked the growth of tumors in non-vaccinated animals.

An important point in this study is that the vaccine seems to also be effective at eliminating the residual cancer cells which remain following treatments, such as after surgery, and could thus contribute to diminishing the chance of recurrence. Because it is possible to quite rapidly generate iPS cells following tissue resection, these observations suggest that this approach could become personalized, in that it would be possible to produce an anti-tumor vaccine adapted to each patient in the weeks following diagnosis and thus improve their chances of survival.

(1) Kooreman NG al. Autologous iPSC-based vaccines elicit anti-tumor responses *in vivo*. Cell Stem Cell, published online February 8 2018.

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