Microfluidics: The Future of Testing?

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The past few decades have seen a promising trend in point-of-care diagnostics, with microfluidic technologies at the cornerstone of this emerging field. Microfluidic devices are platforms the size of a microscope slide, or smaller, that are comprised of various circuits connected by miniature tubing systems. These technologies can be coupled to many common analytical detection techniques and promise rapid simultaneous analyses and automatic reporting, while utilizing minute volumes of samples and reagents *(1)*.

Microfluidic chips are typically made out of a transparent polymer, polydimethylsiloxane, through a process called photolithography. A silicon plate is covered with a printed "photomask." With exposure to UV light, the pattern on the photomask is transferred to a light-sensitive chemical "photoresist" on the silicon substrate. The photoresist resists subsequent chemical treatments, allowing an inverse image of the photomask pattern to be engraved into the silicon. This engraved image serves as a mold for the chip. Polydimethylsiloxane is poured over the mold and hardened to create the final chip. More recently, 3D printing has been employed to create microfluidic chips, which has greatly simplified the process of creating 3D chips. A 3D printer builds the shape of the circuits with plastic and is then submerged in polydimethylsiloxane to produce the chip.

A recent article in *Nature (2)* highlights the potential for microfluidics to change the face of diagnostics commencing with genetic diseases. For example, a microfluidic chip capable of purifying, counting, and analyzing circulating tumor cells (CTCs) from a blood sample has been built. CTCs are cells that slough off from a primary tumor into circulation and are the precursor to metastatic cancer. CTCs harbor genetic mutations that are specific to the tumor of origin. Therefore, isolation and characterization of CTCs hold promise for advancing personalized medicine. However, due to challenges faced by current assays, including specificity and sensitivity, the application of CTCs has been limited to prognosis and evaluating response to therapy rather than to diagnosis. Microfluidic chips like this one would allow for automated rapid genetic testing at a lower cost, and make it possible for minimally trained technicians to perform testing. The chips also promise availability of rapid genetic testing in low-income areas and field stations where maintenance of conventional methods is impractical owing to limitations in infrastructure *(3)*.

While the abilities of microfluidic technologies are numerous and encouraging, in practice there are many challenges with their effective implementation into a clinical setting as a lab-on-a-chip device. Many platforms still require preanalytical specimen processing, which takes time and puts restrictions on the applicability of the technology, especially at the point of care. For example, amplifying DNA and RNA to detect genetic anomalies traditionally requires thermocycling, creating difficulties for use in areas without access to medical technology. To address these challenges, microfluidic chip developers are currently employing alternate methods for sample analysis and enrichment, while simplifying and lowering cost of production.

The successful adoption of lab-on-a-chip devices in the clinic depends on a collaborative effort between developers, investors and laboratorians. Once this is realized, microfluidic technologies could revolutionize diagnostics, expanding its applications well beyond cancer to include other areas such as Alzheimer and infectious disease, while moving genetic testing closer to the patient at the point of care.

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