Lab On Chip

Kalthoum Nemmour

Salomée Amstutz

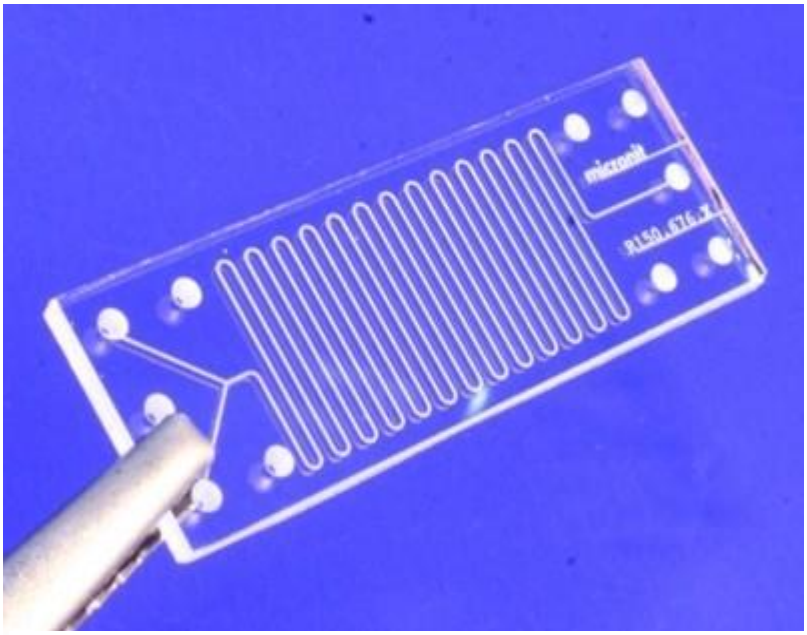
Joshua Jonasch

February, 2015- Biology

Index

1. Preface 2
2. Introduction 2
3. Description of engineering technique 3
4. Interview 4
5. Discussion 5
6. Summary 7
7. References 8

1. Preface



http://en.wikipedia.org/wiki/Lab-on-a-ch 1

Our topic is about the Lab-on-chip (LOC), on the following pages we will take a closer look to this topic. For helping people suffering from severe diseases it is indispensable to get the diagnostic done as fast as possible so the treatment can be started early. Chips are one possibility to improve the diagnosis. We chose this topic because Lab-on-chip is a new technology with huge opportunities. It brings several advantages along. Especially countries with a low healthcare may benefit from this technology.

2. Introduction

The context of LOC is that we can better analyse special, rehearsed diseases. With the chip and the technologies doctors have a fast diagnosis tool and can provide treatment earlier.

We focused on the use of LOC in the tropical field. Tropical diseases consist of a group of debilitating and fatal infections that occur primarily in rural and urban settings of tropical and subtropical countries. Accurate diagnosis is crucial for timely intervention. We present an integrated lab-on-chip using microfluidics technology coupled with reverse transcription (RT), PCR amplification, and microarray hybridization for the simultaneous identification and differentiation of 26 tropical pathogens that cause 14 globally important tropical diseases.

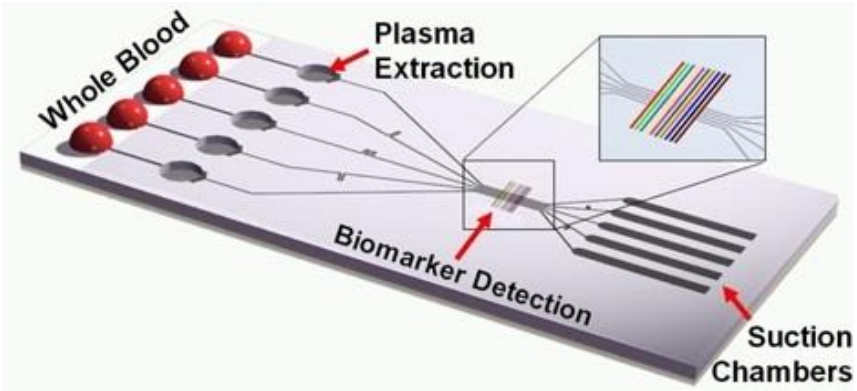
Tropical pathogens often cause febrile illnesses in humans and are also responsible for considerable morbidity and mortality. The similarities in clinical symptoms provoked by these pathogens make diagnosis difficult. Thus, early, rapid and accurate diagnosis

will be crucial in patient management and in the control of these diseases. So it is very interesting that they found a „new“ way to provide exact analyses of special diseases.

As mentioned before this technology is quite new. It all started in 1979, when S.C. Terry developed a special gas chromatograph. This was the first LOC analysis system. The LOC research seriously started as a few research groups in Europe developed microtechnics that they need for analysis systems (for example micropumps, flowsensors). A big boost in research and commercial interest showed up in the mid-1990s, when the technology provided new interesting tools for genomics applications, like DNA microarrays. The military also started to support the research in this area.

LOC technology can be used worldwide. Especially in countries with a low healthcare it is very useful because the LOC is cheaper than traditional analysing techniques.

3. Description of engineering technique



http://www.theengineer.co.uk/more-sector 1

A Lab-on-a-Chip (LOC) device integrates and automates multiple miniaturized laboratory functions into a system that fits on a single microprocessor chip up to a maximum of a few square centimeters in size. For example it can separate and analyze components of a mixture. For integrating this device only uses a very small fluid volume on the scale of nano liters to pico liters. The LOC devices are also often named “Micro Total Analysis Systems”. LOC is related to microfluidics which defines mainly the physics, the manipulation and study of minimal amounts of fluids. It also reduces the waste and exposure to dangerous chemicals. The device is mainly used in medical and biotechnical fields.

Lab-on-a-chip technology takes an important part in improving global health, particularly through the development of point-of-care testing devices. Especially in countries with only few healthcare resources, infectious diseases that could normally

be treated in a developed nation are a main cause for deaths. Also in countries with poor healthcare clinics they possess the medication to treat a certain illness but lack the diagnostic tools to identify the diseases. So researchers now believe that LOC technology could solve this problem by bringing new diagnostic instruments. This technology should help these healthcare providers in poorly equipped clinics by performing diagnostic tests with no laboratory support.

We specialized in the biotechnical use of the LOC especially in the tropical field, because many infections are common in the tropical and subtropical regions. The LOC technology would therefore be very useful there.

4. Interview

As interview partner we contacted Lisa Fong-Poh, who is principal investigator at the Singapore Immunology Network and professor at the National University of Singapore. We contacted her via email and it turned out she was kindly willing to answer our following questions regarding the article “An Integrated Lab-on-Chip for Rapid Identification and Simultaneous Differentiation of Tropical Pathogens” of which she was one of the authors.

1. What were the objectives of your research?
   To develop a lab-on-chip that could detect the clinically important pathogens affecting the tropics
2. How did you get the idea in the first place?
   The challenge is to keep improving the current molecular diagnostics
3. What are the impacts on daily life?
   Enable faster and accurate detection of clinically important pathogens. This will improve containment, clinical management, and treatment
4. What exactly did you do?
   Design of the panel of pathogens and primers and probes
5. What was the most difficult problem?
   The design and optimization of the primers and probes to get them working
6. What are the expectations for the future of the lab-on-chip?
   The panel of pathogens should increase in numbers in the future

7. Does the lab-on-chip have disadvantages? If yes which ones?
   Yes, cost will still be a limiting factor
8. Did this project have a big expenditure? Was it justified?
   The expenditure was on the high side, but it wasn't big comparatively. Thus, it was justified
9. Who could benefit of it?
   Public health and reference laboratories worldwide
10. What do the results signify? Did you achieve what you wanted to?
    Yes, as we were able to push the limits for the engineering aspect and also the molecular diagnostics aspects with this achievement
11. How did you finance the research?
    Commercialization research grant and contributions from the industry
12. How would you use the results now?
    To further refine the detection sensitivity
13. How can we continue to research about it?
    To improve the sensitivity of the system

Unfortunately we did not have the chance to visit a lab or observe the procedure of the LOC so we could not take any photographs.

5. Discussion

5.1 History/Progress/Future

The first successful Lab-on-Chip (LOC) was built and tested in 1979. However, the research only "properly" got going in the early 1990's as new technology like micropumps or flowsensors became available. Since then, interest in LOC research continuously increased. Even though the application of LOCs is still comparatively modest, a growing interest by various companies, research groups and also the military has been registered over the past few years. Not only application developments have taken place, but also the research has taken important steps of downsizing LOCs by using nanotechnology. Many papers and books have been published, covering the various aspects of LOCs, including the bioanalytical processes, but also the engineering side, regarding the fluid transport or the production of LOCs themselves. One of the current main problems is the still

relatively high cost of engineering/manufacturing LOCs. An interesting approach towards this problem has been taken in 2014 by using a commercially available 3D-printer, which could produce a cheap basis for multiple developments. "*The templates are reusable, can be fabricated in under 20 min, with an average cost of 0.48 US$, which promotes broader access to established LOC configurations with minimal fabrication requirements, relieves LOC fabrication from design skills and provides a versatile LOC development platform."* (Comina G.,Optical Devices Laboratory - Department of Physics, Chemistry and Biology (IFM), Linköping University)

5.2 Advantages and Disadvantages of LOCs

LOCs sport many advantages compared to traditional analysing techniques performed in labs. They have a massively lower fluid consumption, which reduces the reagents costs and also the need for large volumes of a sample, a better process control because of the faster response of a small system. Also, a "normal" Lab can't be transported and directly used on fieldwork but LOCs can be used everywhere.

However, there is also a number of disadvantages which are still very present in today's LOC application and research. As already stated in our interview, cost is still the main limiting factor. On such a small scale, physical and chemical effects like the capillary force, surface roughness or reactions with the construction material of the LOC can complicate the processes. Even though the standards of precision in microfabrication are high, they can still seem relatively poor in direct comparison with precision engineering on a larger scale.

6. Summary

The LOC technology is actually very simple. It is a little device which automates miniaturized laboratory functions on a very small chip. It works almost like a big laboratory. The LOC device separates and analyses multiple components of a mixture. This technology marked a big step in science.

http://www.st.com/web/en/press/t3420 1

Particularly in the tropical fields it is very useful. The LOC technology helps researchers to analyze more patients and it is also faster and more precise than a normal lab. There is the hope to reach improvement of containment, clinical management and especially better treatment with this technology, but there still are some problems with the investigation.

The LOC technology brings many advantages especially compared to analyzing techniques performed in a normal lab. First of all LOCs can be transported very easily. The technology achieves better and faster results so it has e better process control. It also has a much lower fluid consumption and because of this the costs are lower and it reduces the need for large volumes of a sample. Still there are also a few disadvantages. A big problem with which researches struggles are the high production costs. Also the material which is used for the LOC brings along complications.

We had the chance to talk to the author of a published paper. She told us about her experiences with this technology. Her goal of this research was to detect the clinically important pathogens that affect the tropical regions. With this technology she reached her goal. She had a few problems with the design and optimization of the primers and probes to get them working. Even though her project had a big expenditure it was worth.

Our conclusion is that LOC is very important and useful in the science and as mentioned before it marked a big step. An important expectation for the future is that LOC helps to increase the panel of pathogens.

7. References

http://en.wikipedia.org/wiki/Lab-on-a-chip#History

http://www.ncbi.nlm.nih.gov/pubmed/24281262

http://www.med.nus.edu.sg/bch/lisang.htm

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4117454/

http://en.wikipedia.org/wiki/Lab-on-a-chip

http://www.epa.gov/rpdweb00/docs/cleanup/nanotechnology/chapter-3-lab-on-a-chip.pdf

http://www.theengineer.co.uk/more-sectors/medical/news/lab-on-chip-device-promises-hiv-diagnosis-in-10-minutes/1008004.article

http://www.st.com/web/en/press/t3420

http://www.malariajournal.com/content/13/1/179

“An Integrated Lab-on-Chip for Rapid Identification and Simultaneous Differentiation of Tropical Pathogens” - Paper