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Detection of Lung Cancer using Breath Analyzer

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Abstract - *The aim of this paper is to present a pilot breath analysis using an analyzer to determine the existence of lung cancer in a person by analyzing his breath. The objective is to determine whether the person is suffering from lung cancer or not within in few minutes of time. With this the person can take precautions or avail medical treatment if the cancer cells are at an early stage. Early stage of disease is amenable to curative surgery, but to date, no inexpensive screening processes have been able to detect cancer at a stage which will alter the overall survival rate. Current methods of detecting lung cancer such as computed tomography scans are time-consuming, expensive and require invasive confirmation of the diagnosis.*

Key Words*: *Analyzer, Electronic nose, lung cancer; breath, detection, invasive.

1.INTRODUCTION

Lung cancer, also called as carcinoma of the lungs is caused due to the uncontrolled growth of cells in the tissues of the lung. Most of the cases of the lung cancer is due to smoking. The treatment of this deadly disease and its outcomes depends on the type of cancer, stage i.e degree of spread and person's overall health performance.

Exhaled breath analysis is becoming an increasing area of interest for studying the respiratory system and function. The exhaled breath contains over 250 chemical entities including nitric oxide, carbon monoxide and volatile organic compounds (VOCs)[1]. Exhaled breath has been analysed in nonmalignant respiratory disorders such as chronic obstructive pulmonary disease (COPD), asthma, bronchiectasis, cystic fibrosis and pulmonary fibrosis [2-5]. Measurement of VOCs in the gaseous phase of exhaled breath has become an area of increasing research including in lung cancer [6-8]. Some are now in early clinical development [8]. Other adaptations of the VOC methods include solid phase micro extraction (SPME) which is a virtual array of surface acoustic wave (SAW) gas sensors with an imaging recognition technique. Possible biomarkers indicative of pulmonary carcinogenesis [9].

2. LITERATURE REVIEW

A biosensor can detect the tumor markers from the exhaled breath because of the changes produced by the ill organism within its body. Acetone, methanol, butanol, hydrocarbons are the main compounds present in the exhaled breath from humans. There is not a single specific component in the exhaled breath capable of acting as a marker for the diagnosis of lung cancer. A range of biomarkers and its combination should be selected. The compounds of interest are generally to be found at 1-20 parts per billion (ppb) in healthy human breath but can be increased 10-100-fold in the breath of sick patients. Organic compounds can be analyzed using gas chromatograph/mass spectrometry analysis (GC/MS)

Novel materials for the detection of the selected organic compounds can be developed in order to increase the sensitivity of the devices.

A single sensor is very difficult to achieve and rather impractical in terms of cost and power required to run it and gather data. Since the device is supposed to be affordable for both personal use and large scale deployment, it is more feasible to build an array of sensors, which will in turn reduce the processing power required and hence the cost. An array of sensors in turn can also be called as a single sensor if it is giving a single output which is supposed to be the case here.

A similar research project analyses the ability of an E-Nose (Electronic Nose)[10], a device commonly used for odor testing, to look for patterns in the readings of the sensor for healthy subjects, smokers, and other subjects with various respiratory issues. A stark difference in the pattern of readings was observed which implied that lung cancer can be detected using this technique with an accuracy of 91.9% accuracy. A list of sensors can also be prepared based on the same study for detection of different gasses [11]. A possible approach can be to eliminate the gasses by testing for their quantities in lab to pin down on which sensors and hence which gasses and compounds need to be taken into account [12]. In general, gases that can be found in the human

exhaled samples are nitrogen, oxygen, carbon dioxide, water vapor, argon and other VOCs (volatile organic compounds) whose concentration levels can be indicated in parts per billion levels [13]. A major spectrum of the VOCs may vary in different individuals but rest of the VOCs usually appear in all the breath samples in a given population. And also, no specific VOC can be found uniquely in the diseased subject apart from very rare diseases [14]. Usually the levels of concentration of VOCs differ from a diseased subject when compared to healthy subject. For example, a typical population of breath samples might contain around 3000 different VOCs in total. However, the number of common VOCs found in the breath of all patients, which might be indicative of a given clinical state, ranges from only a few to tens of VOCs[15]. When aiming to recognize a disease using breath analysis, the sensor dynamic range could be considered according to the concentration levels of the VOCs in the exhaled breath. An additional consideration could be lowering the sensitivity to variations in the overall VOC background [16].

Some of the VOCs related to lung cancer are tabulated below:

VOC	CAS NO	HEALTHY (ppb)	DISEASED (ppb)
Methanal (Formaldehyde)	50-00-0	52.1	90.2
Butane	106-97-8	4.4	0.0
Isoprene	78-79-5	98.1 42.90 82	72.9 147.40 52
Pentane	109-66-0	6.54	15.80
Dimethyl sulfide	75-18-3	7.3	6.6
Propanol	123-38-6	0.0 0.75	8.3 1.31
Acetone	67-64-1	628 386.0 760	459 408.7 742
2-Methylpentane (isohexane)	107-83-5	0.68	3.40
Methanol	67-56-1	142	119
Butanal	123-72-8	1.32 7.8 0.27	2.55 26.1 0.64
Ethyl acetate	141-78-6	1.12	22.89
2-Butanone	78-93-3	1.35	3.18
Benzene	71-43-2	1.09	2.31
Acetonitrile	75-05-8	10	15
Isopropanol	67-63-0	3.21 34.4 94	7.19 157.9 244
1-Propanol	71-23-8	0.00	13.15
Pentanal	110-62-3	0.0 0.19	0.5 0.47
2-Pentanone	107-87-9	1.80	8.77
Toluene	108-88-3	1.97	3.87
Octane	111-65-9	0.49	1.49
Octane	111-65-9	0.49	1.49
Hexanal	66-25-1	0.0 0.21	0.2 0.91
Ethylbenzene	100-41-4	1.45 0.33	18.38 0.59
Xylenes	1330-20-7	0.76	1.68
Styrene	100-42-5	2.13	0.44
Heptanal	111-71-7	0.15	0.34
1,2,4-Trimethylbenzene	95-63-6	0.15	0.36
Octanal	124-13-0	0.3 0.24	1.3 0.56
Decane	124-18-5	5.09	13.86
2,2,4,6,6-Pentamethylheptane	13475-82-6	0.02	0.06
Nonanal	124-19-6	0.8 0.31	5.8 1.07
2-Propenenitrile	107-13-1	2.62	4.24

***CAS NO:** Chemical Abstract Service Number

3. METHODOLOGY

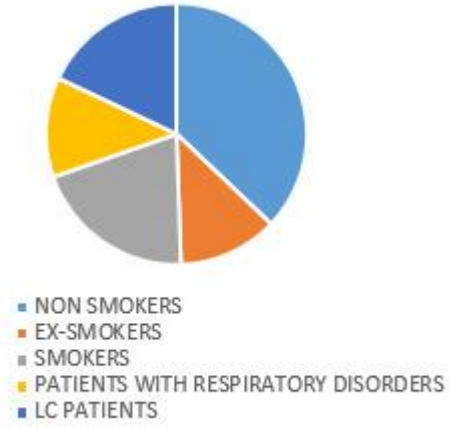
A. Study Design

Many people dream of a handheld device for diagnosing lung cancer as well as other deadly diseases. It would be of greater help if we able to provide an instant and accurate indication regarding the disease. We would use an array of sensors to detect various gasses exhaled by a person, and compare the results with a set threshold, this would give us a reliable reading on the condition of the person. In order to get a reliable baseline to compare the results we have to build up a database of information, taken with the consent from various focus groups. The analysis of a particular person is compared to this data. Furthermore we want the device to be a simple, easy to use one so it may be of use to as many people as possible.

The design was a cross-sectional, observational study of a cohort of subjects with newly diagnosed lung cancer prior to any treatment, and healthy non-smokers, ex-smokers,

smokers, and patients with respiratory conditions, matching for age, gender and smoking history where appropriate. Lung cancer patients were recruited from the Multidisciplinary Lung Cancer Clinic, and the Respiratory Medicine and Oncology departments at the Prince of Wales Hospital. Control subjects comprised respiratory clinic patients, research and hospital staff, patients' relatives and local residents.

B. Subjects:



Subjects were recruited to the following groups with the following criteria:

i. Non-smokers: Have never smoked, or have smoked less than 1 pack year and have no known diseases nor are taking any medication;

ii. Ex-smokers: Have ceased smoking for at least one year or more;

iii. Smokers: Current smokers;

iv. **Respiratory disorders:** Patients who have conditions such as asthma, pleural effusion, COPD and bronchiectasis. These were included to provide subjects who could develop lung cancer but who currently have other inflammatory lung inflammatory diseases.

v. **Lung Cancer:** Patients who have been diagnosed with primary cancer of the lung and confirmed by cytology or histopathology, but who had not yet undergone any treatment and/or therapy. After informed consent was obtained, a questionnaire was administered regarding medical conditions, current medications and smoking history, such as pack years. Measurements taken with a six channel electronic detection module **ENS-MK3**.Time response curve from each channel was evaluated for rate to peak height rate, peak height, recovery time and area under the curve.

Premise: It was found that the exhaled breath from human contains over 250 chemical entities including nitric oxide, carbon monoxide and volatile organic compounds.

Results:

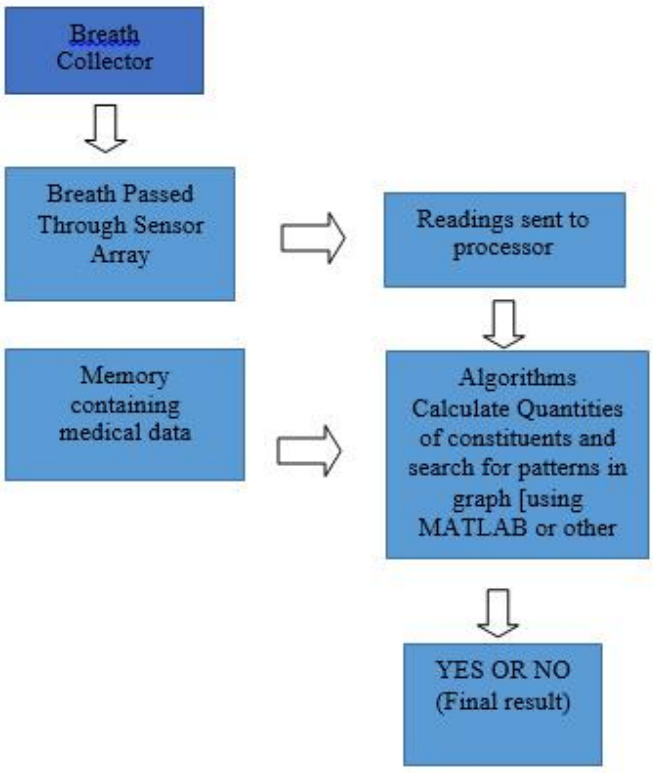
Rate to Peak Height: Patients with lung cancer had significantly lower rate to peak heights when compared to control subjects in channel one.

Peak Height: Lung cancer patients showed different patterns of response for channel one. Lung cancer patients had significantly lower peak height values when compared to test subjects.

Rate of Recovery: The same pattern was repeated with rates of recovery when it came to lung cancer patients. The rates of recovery of lung cancer patients in channel 3 was significantly lower when compared to the control group.

The results of the study add weight to the arguments that it is possible to differentiate between lung cancer patients and normal patients using breath analysis.

C. Block Diagram



D. Description

The above block diagram can be modeled as a device which first collects air content from the breath of the person who wants to use it. This air content is then passed to an array of Chemical sensors which sense cancer causing gases like Methanal, Butane, Propanal, Acetone etc. The sensor gives the estimate of these gases in ppb units. The readings from the sensors is sent to a processor. The processor can now process the data inputted from the sensor to calculate the constituents present in the breath exhaled by the user. An algorithm is designed on how to calculate the content of gases present and gives us graph depicting the percentage of these gases present. This algorithm is burnt on to the processor and the final result from the processor is compared with the pervious set of the data which is collected and stored separately from the revious trend sets. Finally the result is given based on the comparisons and if the contents have a high autocorrelation with the healthy case the result is declared as NO and if the matches with diseased case then the result is declared as YES.

4. CONCLUSION

Exhaled breath analysis in the study of lung cancer has been increasingly exciting in the recent years with an evidence that both gaseous and non-gaseous compounds can be identified in the exhaled breath of human. Our model can also be extended to next level to determine the advanced stages of lung cancer and also to prescribe proper medication to the patient suffering from lung cancer. Our model can be an effective tool to detect within less span of time and also it is the least expensive.

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