DRESS TO IMPRESS

IDENTIFYING AND MONITORING PAH IN SYSTEMIC SCLEROSIS

A sensitive and non-invasive screening tool

SCLERODERMA AND PULMONARY HYPERTENSION

Pulmonary hypertension is a condition which is a known complication of scleroderma, and can affect up to 40% of individuals with the disease. With a 50% mortality rate within three years of PAH diagnosis, pulmonary arterial hypertension (PAH) is the primary cause of death in scleroderma or systemic sclerosis.

According to the World Health Organisation (WHO) classification, pulmonary hypertension in people with scleroderma is categorised as group 1 pulmonary hypertension. It is regarded as one of the most severe and fatal complications of the illness.

Pulmonary hypertension in scleroderma refers to increased blood pressure in the pulmonary arteries, the blood vessels that carry blood from the heart to the lungs. Scleroderma, an autoimmune disease affecting connective tissues, can lead to structural changes and narrowing of the lung blood vessels, restricting blood flow and causing elevated pulmonary artery pressure. This condition can result in symptoms such as shortness of breath, fatigue, chest pain, and ankle swelling, and requires a comprehensive diagnostic evaluation and specialized management by healthcare professionals.

Our product aims to detect pulmonary hypertension, so patients with PAH alongside scleroderma can be identified early and treated before their condition reaches a less treatable stage. The high mortality rate seeks as a reminder for just how imperative it is to deal with this issue, as so many people have fallen victim to this unforgiving condition.

HOW DOES OUR PROPOSED TECHNOLOGY WORK?

Our proposal is a jacket with electrodes that uses Electrical Impedance Tomography (EIT) to detect pulmonary arterial hypertension in those with scleroderma.

EIT is a radiation-free, non-invasive imaging technique that can be used to detect PAH. EIT is used to reconstruct a specific area of the human body using imaging based on its electrical conductivity (electrical impedance distribution). It involves placing electrodes on the surface of the area of interest, here it would be the chest, and passing small electrical currents through them. The resulting voltage measurements are processed to reconstruct the impedance distribution.

While EIT is still being researched and developed for clinical use, using our knowledge on EIT from several journal articles and online sources (available by scanning the QR code) we believe it can potentially be used to detect pulmonary hypertension by placing the electrodes on the chest inside the **IMPRESS jacket**.

Pulmonary hypertension is characterized by increased blood pressure in the pulmonary arteries, which supply blood to the lungs. This increase in pressure can lead to changes in lung tissue and blood flow, which will be detectable with EIT.

1) Setting up the EIT equipment: EIT involves placing a series of electrodes around the chest in a belt or a vest-like configuration. These electrodes measure changes in electrical impedance within the lungs. Our design features these electrodes in a wearable jacket that hugs the chest and is secured in place by the jacket's zip.

2) Current Injection: A small electrical current is injected into a pair of electrodes, known as the 'current-carrying' electrodes. The current is usually at a low frequency and in the range of a few milliamperes.

3) Measuring the Voltage: The resultant voltage distribution is measured across the remaining electrodes, called the 'voltage-sensing' electrodes. These voltage measurements are sensitive to the electrical impedance distribution within the chest.

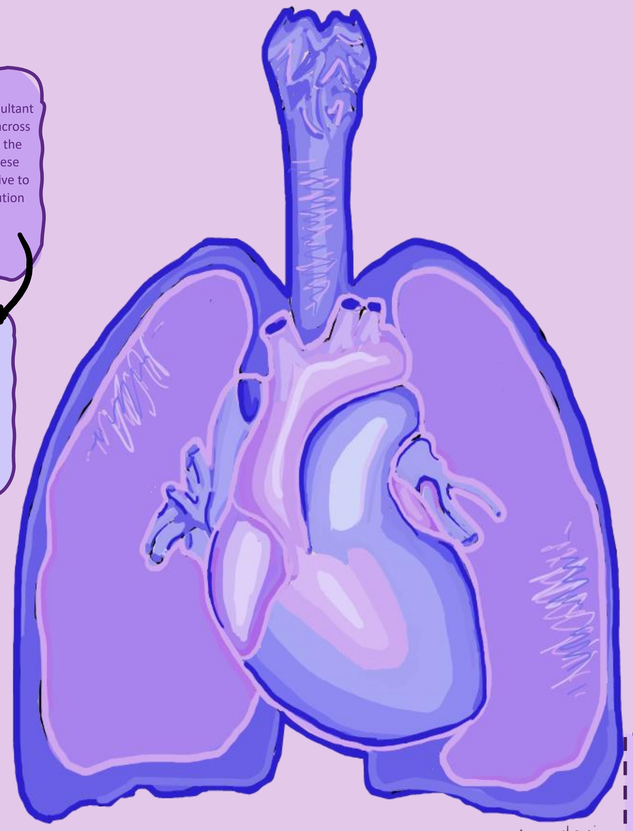
4) Repeating Measurements: The current injection and voltage measurement process is repeated several times with different pairs of current-carrying electrodes. Each reading provides a different set of voltage data.

5) Acquiring Data: A data acquisition system is used to record the voltage readings from the voltage-sensing electrodes. The system includes analogue-to-digital converters (ADCs) and amplifiers in order to capture and process the data.

6) Reconstructing the Data: After the voltage measurements are obtained, an algorithm is utilised to reconstruct the impedance distribution within the lungs. The reconstructed impedance distribution is then visualised as an image or multiple images, allowing medical professionals to analyse and interpret the data.

7) Analysing the EIT images: The reconstructed EIT images can be analysed to observe the lung tissue and identify potential abnormalities associated with pulmonary hypertension. These abnormalities can include changes in lung ventilation, blood flow patterns, or regional differences in electrical impedance.

8) Correlating with other established clinical findings and investigations: The EIT findings must be cross examined with other clinical data, such as the patient's symptoms, pulmonary function tests, and potentially other imaging modalities (for example, echocardiography, cardiac catheterisation, CT scan) to establish a diagnosis of pulmonary hypertension.



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CONS

The specific details of EIT data acquisition can vary depending on the system and application. Different EIT systems may employ different electrode configurations, current patterns, measurement techniques, and reconstruction algorithms.

It is crucial to remember that EIT is still being developed for the detection of pulmonary hypertension, and that its clinical application for this purpose may vary. Its clinical implementation must be established by additional research on its sensitivity, specificity, and accuracy in identifying pulmonary hypertension. Further research and validation studies are necessary to determine the effectiveness of using a wearable EIT device for this purpose.

PROS

The use of EIT makes it possible to evaluate lung function, measure pulmonary arterial pressure, analyse changes in the respiratory tract, estimate the volumes of chest fluid and study ventilation and perfusion. It is additionally a non-invasive technique which is low cost, safe and easy to use and suitable for bedside measurement or intensive care unit monitoring.

Our **IMPRESS jacket** allows PAH to be detected much earlier as it is more efficient, non-invasive and less costly than traditional diagnosis methods such as cardiac catheterisations. While our jacket can be used early on in primary care to identify if a patient has PAH with scleroderma, traditional methods require a combination of clinical evaluation, imaging tests, and functional assessments. This may include echocardiography, pulmonary function tests, right heart catheterization, and imaging techniques like CT scans or MRI. These are much more expensive to carry out and require longer times as there are long hospital waiting lists and high demands for CT scans and MRI. Being able to detect PAH without all these tests will help patients with this condition start treatment as early as possible and improve their livelihoods

COSTING

We estimate the jacket alone to cost £20-£30 without the EIT belt sewn into the fabric. The EIT belt will be more costly, ranging at £110 - £150 (pricing from ResearchGate EIT hardware list – totalling $162). Additional costs may include designing the app (£25-£50). This would total to a price ranging at £155 - £230 for our jacket. Although this appears expensive, our jackets are reusable and will be distributed to primary healthcare workers to use on more than one patient.

CLINICAL TRIALS

STEP 1 : Create a prototype, by testing out various materials and designs to ensure a comfortable experience for patients.

STEP 2: incorporate a small group of healthy volunteers to wear the prototype. The appropriate EIT graphs will be displayed on an app connected to the jacket. Beforehand, all volunteers will need to sign a consent form after having read about the mechanisms of the equipment and role of the electrodes. This is will be the pilot stage.

STEP 3: 2 groups constituting of roughly a hundred people each will be tested. One group will contain patients with a diagnosis of scleroderma at high risk of developing PAH, and the other group will have patients that have been already diagnosed with PAH using cardiac catheterization and scleroderma. This will test the reliability of the jacket and mechanisms of the EIT equipment, and how easily a primary healthcare worker can interpret the graphs that are drawn based on the information obtained via EIT. A group of primary healthcare workers will be required to examine these graphs through the app and help patients fit into the jackets.

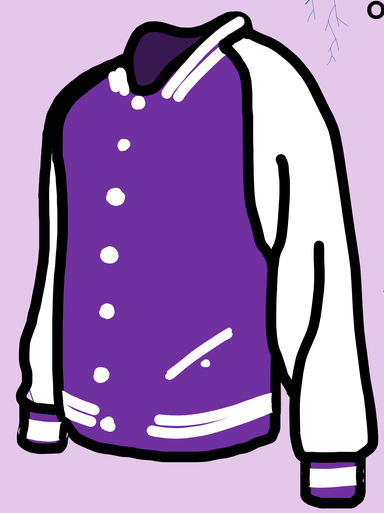
STEP 4: After being tested on thousands of participants of varying age, height, gender, weight and ethnicity, a survey will be sent out to GPs. The survey will ask how GPs found the experience of using the jacket to monitor and diagnose patients who have scleroderma with PAH, and if any changes should be made to improve their overall experience. Once these adjustments are made, and regulatory authorities such as MHRA gives the green light, initial roll out in GP surgeries can take place. Large scale production can occur, and costing can be implemented.

SCAN ME FOR REFERENCES

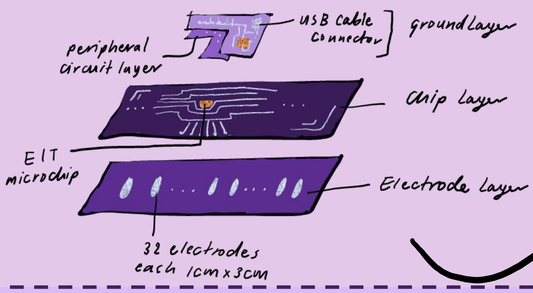
TEAM MEMBERS AND ROLES

Nayanika Banerjee – Team Leader, Conceptualist, App designer
Biology, Chemistry, Physics and Computer science
Mariam El-Husseiny – Research of EIT and applications
Biology, Chemistry and Maths
Ashmi Vasudeva – Product and Idea Research
Biology, Chemistry and Religious Studies

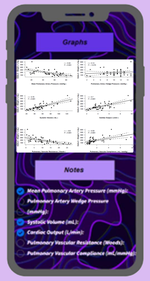
OUR JACKET'S DESIGN



EIT belt sewn into jacket.

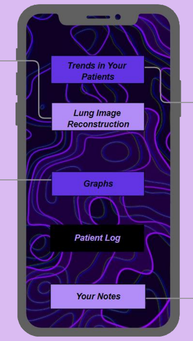


IMPRESS Jacket App
Primary healthcare workers can download our app to routinely monitor patients and co-ordinate care with the secondary and tertiary care physicians



EIT LUNG IMAGE RECONSTRUCTION
Making it possible to evaluate lung function, measure pulmonary arterial pressure, monitor the respiratory profile, analyse changes in the shape of the upper respiratory tract, estimate the volumes of chest fluid, study ventilation and lung perfusion.

GRAPHICAL REPRESENTATIONS
Whilst the EIT jacket is on the patient, information will be translated into graphs that can be easily interpreted by primary healthcare workers.

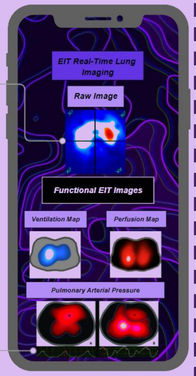


API PATTERN DISCOVERY
With the use of API technology, patterns can be detected and the future of a patient's health can be predicted using trends.

KEEPING TRACK OF PATIENTS
GPs are able to take notes based on patients' previous EIT scans, such as changes in patterns that could indicate an underlying health issue.

TRANSFORMING RAW IMAGES INTO FUNCTIONAL EIT IMAGES
By identifying EIT waveforms and regions of interest, the raw images can be transformed into functional EIT images for primary health care workers to read off from directly with ease.

USING WAVEFORMS FROM GRAPH TO DETERMINE PAH
Graph of waveforms displayed at bottom. The dashed lines represent the pixels corresponding to the pulmonary area, and the dark red regions relate to the cardiac pixels. This will help in the identification of PAH.



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