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SPOC and the WBSP Patch: Advancing Non-Invasive Lung Cancer Detection

By Dr. Baruh Polis, Technion – Israel Institute of Technology

One of the central ambitions of the LUCIA project is to move lung cancer diagnostics and risk assessment beyond conventional clinical paradigms and toward minimally invasive, data-driven, and patient-friendly technologies.

Among the most promising developments emerging from the project are two complementary technological platforms:

1. The **SPOC** analytical framework
2. and the Wide-Biomarker-Spectrum Multi-Use Sensing Patch (**WBSP**), often referred to within the consortium as the "patch".

Together, these technologies represent an important step toward future remote and non-invasive approaches for lung cancer screening and monitoring.

The Challenge of Early Lung Cancer Detection

Lung cancer remains the leading cause of cancer-related mortality worldwide, largely because many patients are diagnosed at advanced stages of disease.

Although low-dose CT screening has significantly improved early detection among high-risk populations, major challenges still remain:

1. accessibility,
2. cost,
3. radiation exposure,
4. patient adherence,
5. and the difficulty of implementing large-scale personalized monitoring programs.

The LUCIA project was designed specifically to address these limitations through the integration of:

- ✓ artificial intelligence,
- ✓ molecular biomarkers,
- ✓ wearable sensing technologies,
- ✓ environmental and lifestyle data,
- ✓ and multi-omics approaches.

Within this ecosystem, the SPOC platform and the WBSP patch occupy a particularly important translational position.

The WBSP Patch: Toward Continuous and Remote Diagnostics

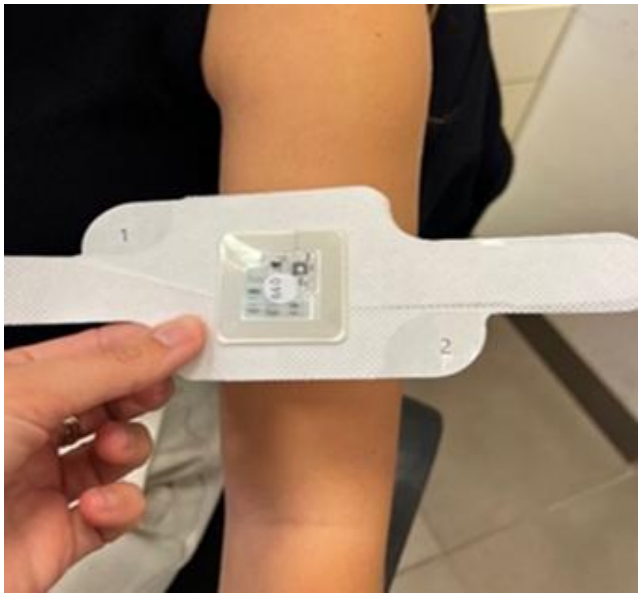
The WBSP was developed as a non-invasive sensing technology capable of collecting physiological and biochemical information in real-world settings. The devices were successfully manufactured, distributed to clinical sites, and integrated into ongoing clinical studies.

The WBSP technology is an innovative, wearable, minimally invasive platform for continuous or longitudinal physiological and biochemical monitoring in real-world settings. Within the LUCIA framework, the PATCH system supports the acquisition of dynamic patient-derived data, including physiological parameters, environmental exposure indicators, and selected biomarker-related signals, thereby enabling more comprehensive characterization of individual health trajectories outside conventional clinical environments. Its lightweight and patient-friendly architecture facilitates remote monitoring, improves longitudinal data density, and enhances patient compliance during extended observation periods.

By enabling decentralized and real-time data collection, WBSP contributes substantially to personalized medicine approaches and supports the integration of digital health technologies into modern oncology and preventive healthcare research.

Importantly, the external reviewers highlighted the technology as a highly promising direction for future clinical applications. In their assessment, the consortium developed and deployed “non-invasive sensing devices” that contribute substantially to the project’s innovation potential and translational relevance.

The reviewers also specifically noted that a revised WBSP concept may serve as a future “go-to-market production” candidate following the completion of clinical validation activities.



This is a particularly important milestone.

The concept of wearable diagnostic technologies capable of supporting distant monitoring and decentralized clinical assessment is increasingly attracting attention across modern medicine. Such systems may eventually allow:

1. longitudinal patient monitoring,
2. improved screening accessibility,
3. earlier identification of biological changes,
4. reduced dependence on hospital-centered diagnostics,
5. and more personalized risk stratification.

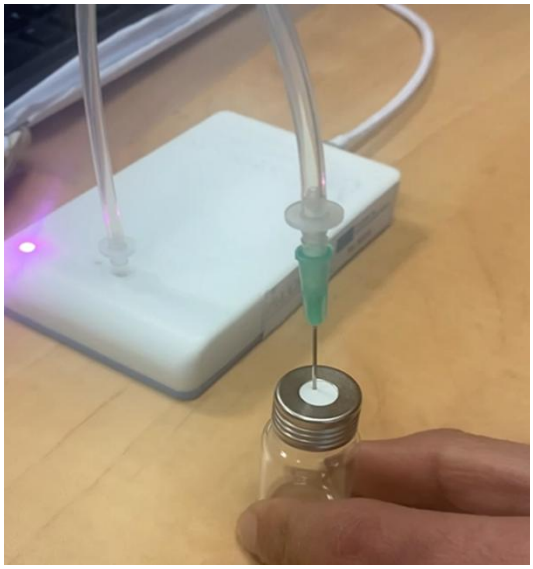
For lung cancer, a disease in which timing is often critical, these possibilities are especially significant.

The Value of SPOC

The SPOC (Spectrometry-on-Card) technology in LUCIA primarily analyzes blood samples to detect lung cancer–related volatile and semi-volatile organic compounds and other molecular signatures. Additional biological matrices collected within the broader LUCIA workflow include breath, sweat, skin headspace, and tumour tissue samples, but SPOC itself specifically focuses on blood-sample analysis. The system uses a miniaturized sensor platform composed of multiple sensing layers and sensor chips arranged within a dedicated SPOC "tower," enabling simultaneous analysis of complex chemical mixtures.

The measurements are performed by introducing the blood sample into a sensor array containing 6 sensors with 8 chips each, generating 48 parallel electrical resistance signals recorded over time.

Of note, SPOC measurements can be completed within approximately 5–20 minutes, and the generated spectrometric data are transmitted digitally for further computational analysis and clinical interpretation.



Moreover, SPOC enables the integration and interpretation of complex multimodal datasets generated throughout the project, including:

1. biomarker measurements,
2. omics data,
3. imaging,
4. environmental exposure information,
5. and patient-derived clinical parameters.

The importance of such integrated analytical systems cannot be overstated.

Modern cancer biology is inherently multidimensional. Single biomarkers rarely capture the complexity of carcinogenesis or disease progression. Instead, clinically meaningful prediction increasingly depends on combining diverse biological and environmental signals into unified computational models.

Within LUCIA, SPOC contributes to this integrative layer: transforming heterogeneous data streams into clinically interpretable information that may support future diagnostic and risk-prediction strategies.

The platform therefore represents more than a technical tool. It reflects a broader shift toward systems-level precision medicine.

From Research Infrastructure to Clinical Translation

One of the most notable achievements of the current LUCIA phase is that these technologies are no longer purely conceptual.

According to the project review, the consortium has already:

- produced and deployed sensing devices,
- established technical infrastructures,
- integrated analytical workflows,
- and initiated multimodal clinical data generation at scale.

This transition from conceptual development toward operational clinical deployment marks an important maturation point for the project.

At the same time, the reviewers emphasized that continued clinical recruitment and long-term follow-up remain critical for validating these technologies under real-world conditions.

The ultimate success of wearable diagnostics and AI-supported biomarker systems will depend not only on technological sophistication, but also on:

- dataset robustness,
- reproducibility,
- clinical usability,
- patient adherence,
- and integration into healthcare workflows.

Looking Ahead

The combination of wearable sensing, AI-supported interpretation, and multi-omics analysis represents one of the most forward-looking aspects of the LUCIA project.

Technologies such as the WBSP patch and the SPOC framework illustrate how future cancer diagnostics may evolve: from episodic hospital-based testing toward continuous, personalized, and minimally invasive monitoring ecosystems.

While substantial validation work still lies ahead, the progress achieved so far demonstrates the feasibility and scientific potential of this approach.

The LUCIA consortium continues to work toward translating these innovations into clinically meaningful tools that could ultimately improve early lung cancer detection, risk assessment, and personalized screening strategies.

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