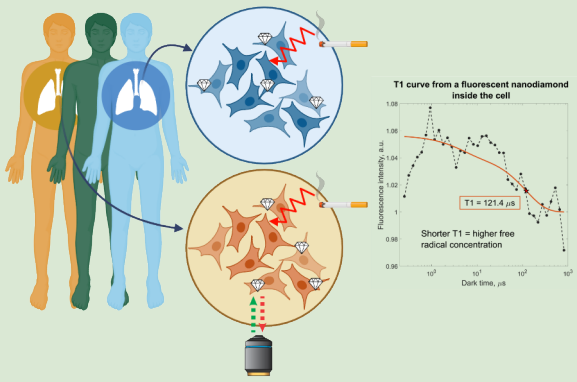
Nanodiamonds can be used for **direct, all-optical, highly sensitive monitoring of free radical production** inside live primary cells in health and disease



Want to know more about our research?

Harnessing the power of nanodiamond magnetometry for free radical detection in primary cells

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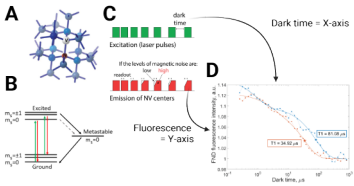
BACKGROUND

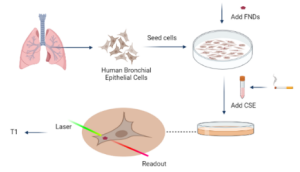
Nanodiamond magnetometry is a new technique for free radical detection. It senses the spins of unpaired electrons in the sample and can, in principle, achieve single-spin resolution[1], while requiring as little as one cell for the analysis. Our group has successfully applied nanodiamond magnetometry to various live cells[2-5].

In this study, we use it to detect free radicals in primary human airway epithelial cells exposed to cigarette smoke extract (CSE).



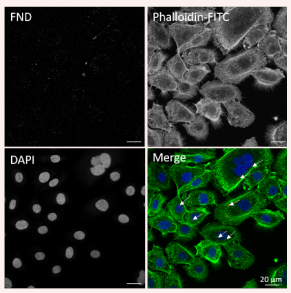
Fluorescence intensity of nitrogen-vacancy centers in nanodiamonds **(A)** depends on their quantum state **(B)**, which, in turn, is affected by external spins. With a specific laser pulsing sequence **(C)** we can read out these quantum states and infer the free radical concentration around the particle **(D)**.
Shorter T1 = more radicals!

METHODS

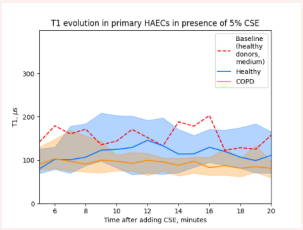


Cells from **3 healthy and 3 COPD donors** were incubated with nanodiamonds and then **exposed to CSE (0%, 5%, 15%, 35%).** T1 changes were monitored from the start of the exposure **for 20 minutes.**
We validated the method in BEAS-2B cell line, using DCFDA assay as a control.

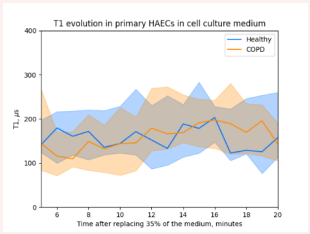
RESULTS



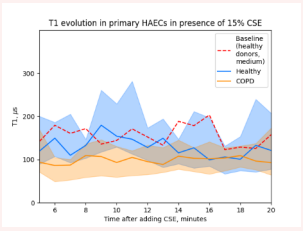
Fluorescent nanodiamonds are successfully internalized by the primary human airway epithelial cells after 2 hours of incubation (1 μg/mL in the cell culture medium).



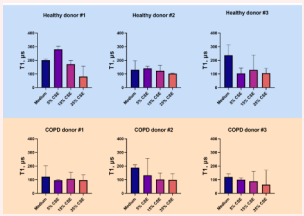
Adding CSE to the cells from COPD patients significantly shortens T1 (p=0.0007 from two-way ANOVA).
Cells from COPD patients are sensitive to lower CSE concentrations than cells from healthy donors (at 5%, p=0.0968).



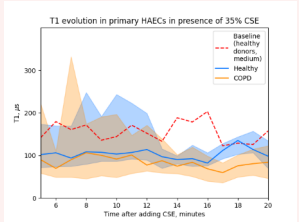
Without the trigger, there are no significant differences in T1 values between the cells from COPD patients and cells from healthy donors (p=0.6990).



The differences between healthy donors and COPD patients are the most pronounced at **15% CSE** (p=0.0247).

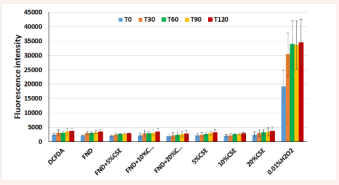


Cells from different donors with the same health status show slightly different response to CSE.

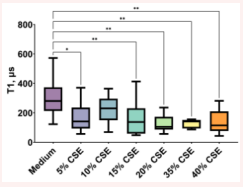


At high CSE concentration (35%), cells from healthy and COPD donors show the same response (p=0.3189).

VALIDATION IN BEAS-2B CELL LINE



Conventional assays, such as **DCFDA, do not show the effect of CSE within 2 hours.** Diamond magnetometry shows a **drop in T1 after 10 minutes** of CSE exposure.



CONCLUSIONS

- Nanodiamond magnetometry shows **increased free radical** production in the cells exposed to CSE **within the first 20 minutes** - earlier than other conventional assays, such as DCFDA.
- Cells from **COPD donors do not show higher free radical load without the stressor.**
- At the same time, cells from **COPD donors are more sensitive to CSE** than cells from healthy donors. Further research is needed into the underlying molecular mechanisms.
- Nanodiamond magnetometry captures the **cell variability between different donors with the same health status.** It might be a useful tool for personalized medicine.

REFERENCES

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