Investigating Inflammatory Conditions in Extravascular Body Fluids: An Important New Parameter

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doi.org/10.33548/SCIENTIA1243

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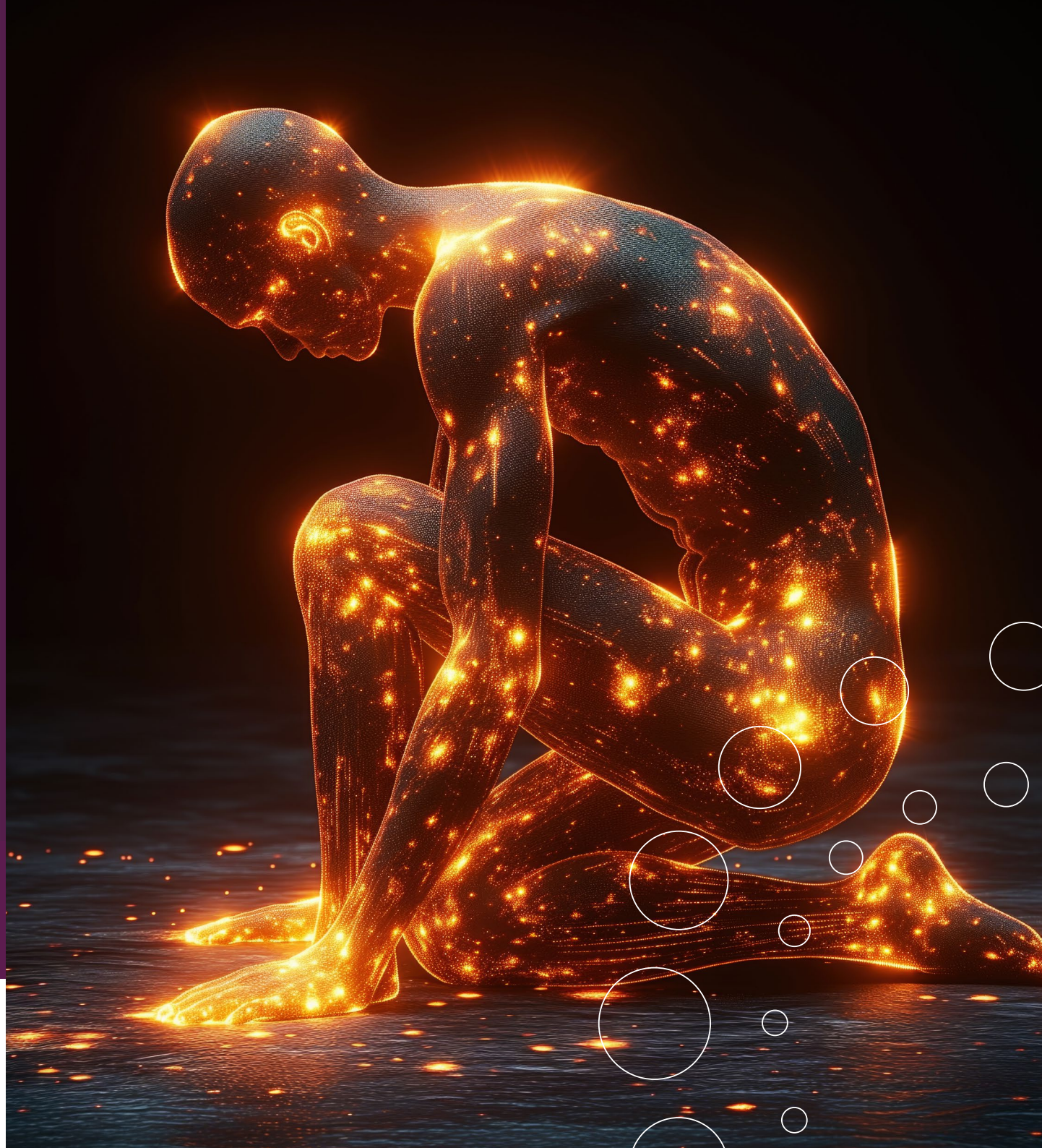
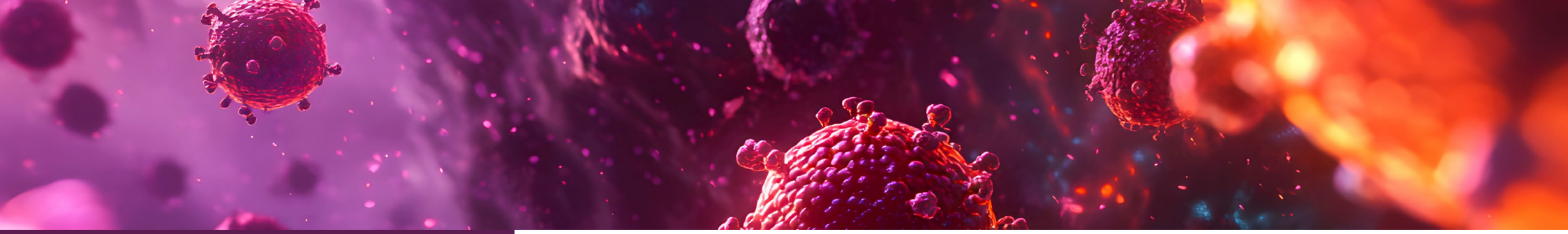




Investigating Inflammatory Conditions in Extravascular Body Fluids: An Important New Parameter

Diagnosing disorders of the brain and other organs can often feel like solving a challenging puzzle. Analyzing non-blood body fluids provides valuable clues that can help address this complexity. To enhance this process, Dr. Petr Kelbich from Jan Evangelista Purkyně University and Masaryk Hospital in Ústí nad Labem, Czech Republic, introduced an innovative method called Cytological-Energy Analysis.

At the core of this approach is the Coefficient of Energy Balance (KEB), a mathematical concept that offers deeper insights into immune cell activity and energy requirements during inflammation. By using this method, doctors can identify issues in different organs with greater precision, making diagnoses more accurate and efficient.

Dr. Kelbich initially introduced this method for diagnosing central nervous system (CNS) disorders through cerebrospinal fluid (CSF) analysis.

Cytological Investigation of CSF and the Coefficient of Energy Balance (KEB)

The first step of this method involves a cytological analysis of CSF. The cells found in CSF can offer valuable insights and help detect various CNS disorders. For example:

- Plasma cells (Figure 1): Associated with antibody production during inflammation.
- Foam cells (Figure 2): Indicating tissue damage.
- Erythrophages (Figure 3): Suggesting bleeding in the CSF compartment.
- Tumor cells (Figure 4): Pointing to malignant infiltration of the meninges.
- Different pathogens (Figures 5 and 6): Pointing to infection in CNS.

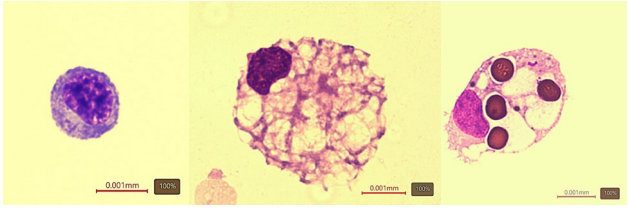


Figure 1: Plasma cell in CSF

Figure 2: Foam cell in CSF

Figure 3: Erythrophage in CSF

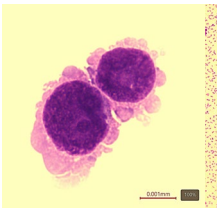


Figure 4: Tumour cells in CSF

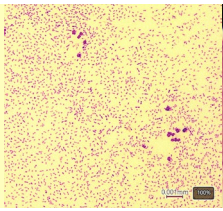


Figure 5: Bacteria *Streptococcus pneumonia and Neisseria meningitidis* in CSF

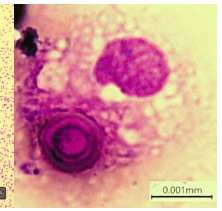
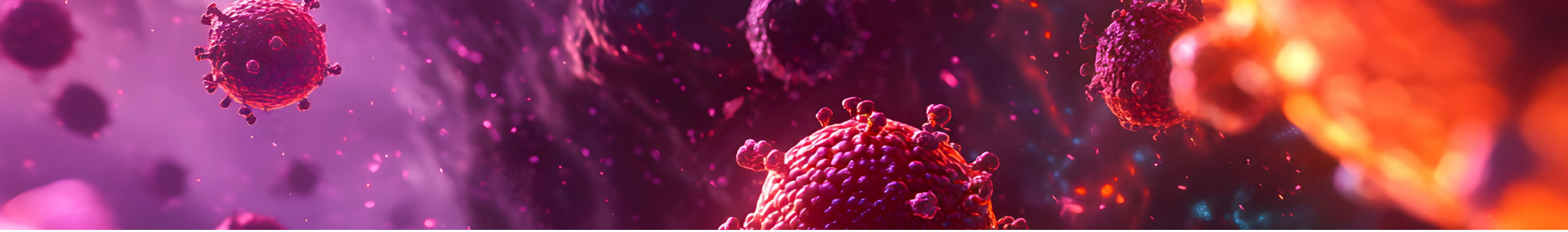


Figure 6: Yeast *Cryptococcus neoformans* in CSF

However, simply observing the cells isn't always enough. That's where the Coefficient of Energy Balance (KEB) plays a crucial role—it calculates energy production in the affected area by analyzing glucose and lactate molar concentrations. This reveals the activity of immune cells and the severity of inflammation.

The KEB formula:

$$KEB = 38 - 18* \frac{[\text{lactate}]}{[\text{glucose}]}$$



This formula enhances these insights by estimating the production of adenosine triphosphate (ATP), offering a clearer understanding of metabolic activity and energy demands within the CSF (Figure 7).

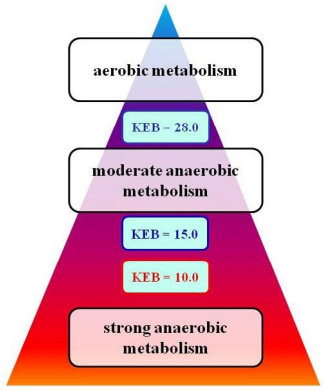


Figure 7: Energy Pyramid

The energy pyramid illustrates the energy dynamics in normal and inflamed CSF conditions.

Under normal conditions, CSF metabolism is predominantly aerobic, yielding high ATP production and KEB values above 28.0 (Figure 8).

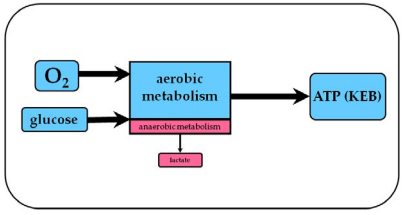


Figure 8: Normal condition - an aerobic metabolism in the CSF compartment

During inflammation, immune cell activation increases glucose and oxygen consumption, shifting to anaerobic metabolism. This change can result in reduced ATP production and lower KEB values (Figure 9):

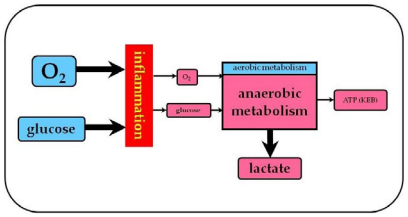


Figure 9: Inflammatory response in the CSF compartment leads to the development of an anaerobic metabolism

- **KEB values above 28.0** indicate aerobic metabolism, which is typical in the absence of inflammation or during mild serous inflammation (Figure 10).
- **KEB values between 28.0 and 15.0** suggest moderate anaerobic metabolism, commonly reflecting the increased energy demands of an activated immune system during a "serous" inflammatory response (Figure 11).

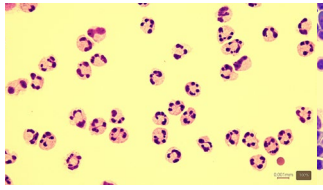


Figure 10: Predominance of neutrophils with KEB = 28.8 in CSF in the case of non-inflammatory reaction in CSF of patient with systemic sepsis

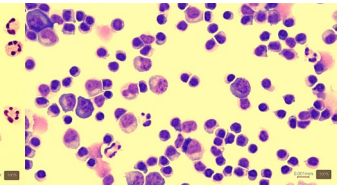


Figure 11: Predominance of lymphocytes with KEB = 19.2 in CSF in the case of serous inflammation in the CNS induced by spirochete *Borrelia sp.*

- **KEB values below 10.0** signify strong anaerobic metabolism, typically associated with an intense inflammatory response. This process is characterized by the rapid release of reactive oxygen species by immune cells to combat pathogens, a phenomenon known as the oxidative burst.

The oxidative burst of neutrophils is central to purulent inflammation, a reaction typically triggered by extracellular bacteria in the CNS (Figure 12). In contrast, the oxidative burst of macrophages is crucial for combating intracellular pathogens, fungal infections, or tumor development (Figure 13).

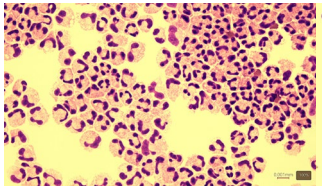


Figure 12: Predominance of neutrophils with KEB = -265.7 in CSF in the case of purulent inflammation in the CNS induced by extracellular bacteria *Neisseria meningitidis*

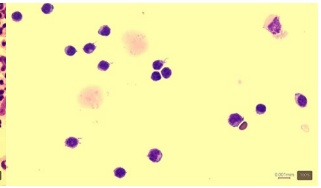
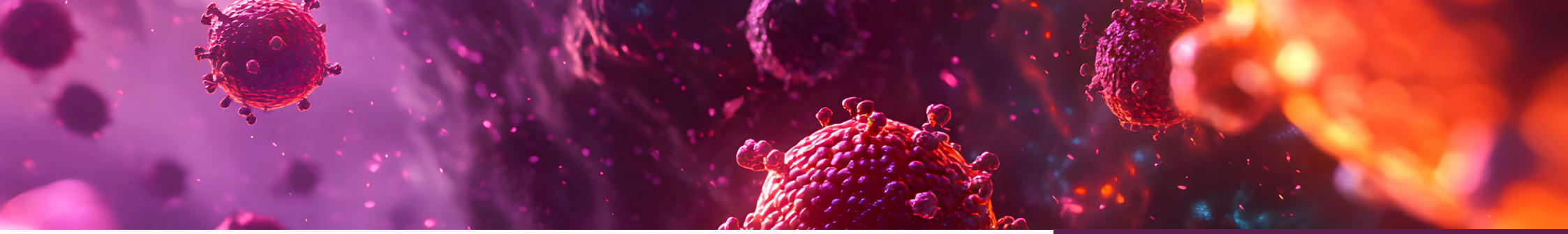


Figure 13: Predominance of lymphocytes with KEB = -23.3 in CSF in the case of intensive inflammation with oxidative burst of macrophages in the CNS induced by intracellular bacteria *Listeria monocytogenes* in the CNS.



Extending Cytological-Energy Applications

By combining cytological and energy analyses, the KEB method offers a more precise understanding of inflammation across various organ systems (Figures 14–16).

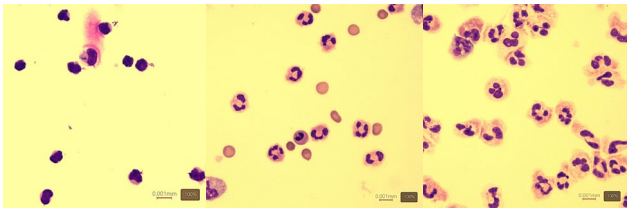


Figure 14: Predominance of lymphocytes with KEB = -30.2 in intraocular fluid in the case of intensive inflammation with oxidative burst of macrophages in eye induced by intracellular parasitic protozoan *Toxoplasma gondii*

Figure 15: Predominance of neutrophils with KEB = 34.2 in pleural effusion in the case of non-purulent reaction in the pleural cavity of patient with heart failure

Figure 16: Predominance of neutrophils with KEB = -855.5 in synovial fluid in the case of purulent inflammation in the knee joint induced by extracellular bacteria *Streptococcus dysgalactiae*

Following successful application in CSF analysis, Dr. Kelbich expanded his collaboration with medical specialists to explore other extravascular body fluids. These included pleural, pericardial, and abdominal effusions, as well as intraocular fluid, peritoneal dialysate, amniotic fluid, synovial fluid, and others. The results were highly promising, demonstrating that cytological-energy analysis has significant potential for broader applications across multiple medical fields.

Towards More Precise Diagnostics

Dr. Kelbich's approach integrates cytological and metabolic profiling, providing a comprehensive framework for diagnosing inflammatory conditions across various organ systems. By quantifying the type and intensity of immune responses, Cytological-Energy Analysis enables:

- More precise differentiation between types of local inflammation.
- Enhanced monitoring of disease progression.
- More targeted treatment strategies, leading to improved patient outcomes.

This method seamlessly combines scientific knowledge with practical application, offering deeper insights into localized bodily processes. It represents a promising tool to advance the diagnosis and treatment of a wide range of conditions, ultimately benefiting patients worldwide.

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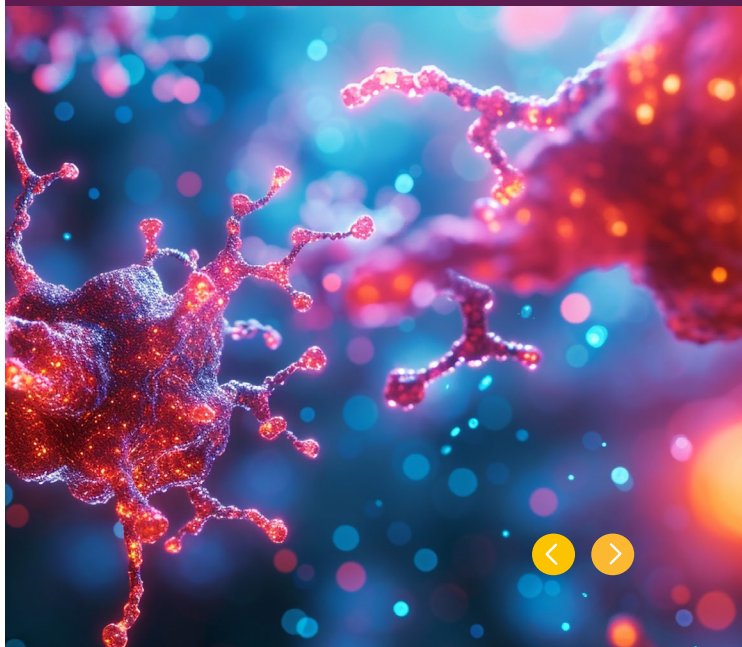

MEET THE RESEARCHER

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Dr Petr Kelbich serves as the head of the Department of Biomedicine and Laboratory Diagnostics at Jan Evangelista Purkyně University and Masaryk Hospital in Ústí nad Labem, Czech Republic. His primary research focuses on the analysis of cerebrospinal fluid and other extravascular body fluids to enhance the diagnosis of central nervous system disorders and diseases affecting other organ systems. He developed an accessible diagnostic procedure aimed at refining diagnostic accuracy across various medical fields. Dr. Kelbich presented his work to the global scientific community about a decade ago and has since contributed to the field through peer-reviewed publications and conference presentations, sharing advancements in diagnostic methodologies.

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https://fzs.ujep.cz/cs/ustav-biomediciny-a-laboratorni-diagnostiky

FUNDING

Internal Grants of the Krajská zdravotní, a.s. in Ústí nad Labem, Czech Republic: IGA-KZ-2021-1-1, IGA-KZ-2021-1-2, IGA-KZ-2020-1-7, IGA-KZ-2019-1-7, IGA-KZ-2019-1-9, IGA-KZ-2017-1-5, and KZ-2016-1-9

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