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Short Communication

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Endocrine regulation of tissue streaming: formulation of concept

Abstract

An attempt is presented for combining the concepts of tissue streaming and episodic / pulsatile hormonal secretion in larger concept, in order to explain several data presently treated in separate mode. Special attention is attracted to ontogenetic alterations of both tissue streaming and episodic/pulsatile hormonal secretion.

Keywords: tissue streaming, episodic/pulsatile hormonal secretion, ontogeny

Volume 13 Issue 3 - 2025

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Received: October 14, 2025 | **Published:** October 30, 2025

Introduction

This short communication aims at formulation of larger concept that combines together two smaller concepts separately treated in the past and developed previously by several researchers. The first of them is related historically to investigations of Gershom Zajicek in Israel, mainly during the decade of eighties of the last century, and concerns the tissue streaming.[1,2] Another one is referred to episodic / pulsatile hormonal secretion that was studied a lot by research groups of Stafford L. Lightman in UK[3] and Johannes D. Veldhuis in USA, resulting in proposal of saltatory growth,[4] but also by many others.

In our earlier theoretical endeavors we used the concept of tissue streaming for elaborating the schemes of cytodiffferones in anterior pituitary and adrenal glands.[5,6] In addition, we have already suggested that tissue self-renewal is regulated by hormonal agents in accord with homeodynamic/homeokinetic principles.[7]

Let's discuss now in details the concepts mentioned above.

Concept of tissue streaming

At first, we should outline that tissue streaming is not equal to overall tissue growth. In fact, in adult state the somatic growth does not occur any more, but tissue streaming continues. How is it possible? In this case it is important to recognize the existence of the following scheme:[8]

SC → PC → <DC → >DC → A / R

Where SC – stem cell, PC – progenitor cell, <DC – less differentiated cell, >DC – more differentiated cell, A / R – apoptosis / removal.

The critical step here is the last one in the sequence presented, i.e. apoptosis and removal (usually by means of phagocytosis), since it maintains the overall tissue size unaltered. Moreover, the scheme shown above should be understood also as the sequence of cell layers, from cambial till terminally differentiated one, and tissue streaming occurs obviously between these two layers.

However, the main question is the following: what are kinetic characteristics of tissue streaming?

Concept of episodic/pulsatile hormonal secretion

Now it is already well known that blood levels of various hormones oscillate in some sort of ultradian rhythm, but with unstable period (or frequency).[3] The main explanation of these patterns is for prevention of tissue desensitization to hormones. However, the theory of systems communication affirms that such patterns called homeodynamic or homeokinetic serve much better for information transfer. But which processes are regulated in target organs/tissues by these oscillatory signals?

Formulation of larger concept (unifying hypothesis with HPA axis as illustrative example)

As we have suggested earlier, there exists the necessity of homeodynamic / homeokinetic regulation of cellular growth and tissue streaming. It means that the following schematic description may be offered, for example, in relation to hypothalamo-pituitary-adrenal (HPA) aixs:

Hypothalamic PVN → CRF / AVP → Anterior pituitary → ACTH → Adrenal cortex → Corticosteroids →Peripheral target organs

Where; PVN – paraventricular nucleus, CRF – corticotropin-releasing factor, AVP – arginine-vasopressin, ACTH – adrenocorticotropic hormone.

It is important that not only hormonal secretion is oscillatory, but also tissue streaming should be, at least in anterior pituitary and adrenal glands, what in principle confirms the possibility of saltatory growth, but exactly which parts of cytodifferone are pulsatile, is not clear yet.

Final comments

Earlier we have shown that hypothalamic hormones, thyrotropin-releasing hormone and somatostatin, as well as dopaminergic agonist bromocriptine regulate not only prolactin secretion, but also proliferation of lactotrophs, i.e. pituitary cells producing prolactin.[9,10] The concept of homeodynamic / homeokinetic regulation of tissue streaming is in partial accord with these data.

Moreover, partially corresponding cytodifferones in anterior pituitary and adrenal cortex5,6 also may be explained better by this concept. Finally, hierarchical organization of endocrine system allows for generalization of this concept to other axes:

Hypothalamus → Anterior pituitary → Peripheral endocrine gland → Target organs / tissues

But what for ontogenetic alterations of tissue streaming and related oscillatory hormonal paterns? It is not clear yet how tissue streaming changes during development, but we can suggest that answers should be looked for in ontogenetic alterations of oscillatory hormonal levels in the blood. Some scarce data allow to propose that especially in aging the tissue streaming should occur with much lower velocity.[11] Again, ontogenetic alterations in hormonal oscillatory patterns can serve as partial explanation of these data.

Particularly interesting is the evidence on heterochronic parabiosis which permits to attribute aging-induced deterioration of organs and tissues to some signals transferred by the blood, probably including various hormones.[12] The theoretical concept presented here allows to explain this evidence by lowered tissue streaming under the influence of diminished oscillatory hormonal signals in aging.

Notes added in proof

We should warn the interested readers that theoretical construct presented here is preliminar one, and it requires much more sophisticated elaboration in near future. Let discuss now in brief, which questions deserve to be studied in the first place.

From all the endocrine glands, Gershom Zajicek explored only adrenal cortex.[1] What about gonads, testes and ovaries? In this case it is clear that general scheme of at least one of cytodifferones should be adjusted by inclusion of meiosis phase.

On the other hand, from all the visceral organs being targets of hormones, Zajicek studied the liver much more than others, so just recently we tried to offer a short discussion of tissue streaming in the lungs and airways, including neuroepithelial bodies and neuroendocrine cells close to the niches of stem and progenitor cells.[13] Moreover, this last addition was justified by us also by the necessity of broadening and expansion of the discipline of endocrinology as a whole.[6,14,15]

Since the general schemes of cytodifferone and tissue streaming should be detailed for many organ variants, it is clear also that separate steps in their sequences may be regulated more specifically. What about chalones and other tissue-specific bioregulators? As tissue streaming is a sort of self-renewal, then its relationship with autophagy should be explored.

We have to outline also that organ systems may include separate steps in different ways. For example, hematopoiesis occurs in bone marrow, bu the destruction of aged erythrocytes takes place in the spleen, i.e. the creation and elimination phases are separated in their locations. Moreover, some organs don't need phagocytosis. In the skin the elimination of terminally differentiated parts, including appendages (nails, hair) occurs largely by mechanical mode. Similar elimination type appears to occur in gastro-intestinal tract, since its lumen may be considered as external part of the body, therefore enterocytes simply are eliminated from the tips of intestinal crypts, joining the food bolus.

Another important topic to be discussed is the generation of pulsatile hormonal secretion, starting from hypothalamic neurons. Earlier we tried to explain the enhancement of pulsatile release of gonadotropins in puberty by altered interaction of two hypothalamic pulse generators with close, but different frequences.[16] What about tissue streaming in hypothalamus and other brain parts? Unfortunately, at present the neurogenesis is better understood only in hippocampus and some other cerebral compartments like cerebellum.

Even in endocrine system there are poorly studied aspects. For example, regulation of calcium and glucose levels in blood appears to be out of traditional scheme of endocrine axes, such as HPA, and for these regulatory loops tissue streaming should be conceptualized separately.

Finally, not only neural, but also immunological part of bioregulatory supersystem should be involved in discussion of tissue streaming. Earlier we have offered a different explanation of glucocorticoid-induced apoptosis of thymocytes by means of launching an idea for the necessity of readjusting the major part of immune system to changing antigenic spectrum of the whole body that should occur each day, during the peak phase of circadian glucocorticoid rhythm.[17] Obviously, cytodifferones of white blood cells must obey this peculiarity of tissue streaming, especially as referred to the levels of hormone-like interleukins and other cytokines.

Conclusion

A lot of not so simple questions ought to attract the attention of various researchers, including the following in the first place:

a) Which parts of cytodifferones may be pulsatile like hormonal bioregulator?

b) What alterations can be expected in tissue streaming after drastic changes in pulsatile hormonal secretion (for example, after surgical removal of endocrine gland)?

c) And the most interesting one: when in ontogeny the tissue streaming and pulsatile hormonal secretion appear in combined interaction and what are their alterations, besides the functional decline in aging?

So the author of this short essay considers it only as preliminary invitation to collaborative work, independently of geographical places where these scientists are working and residing.

Acknowledgement

The author is very grateful to anonymous reviewer for some suggestions that unfortunately, could be fulfilled only partially. Surely, the contributions of other researchers are urgently necessary.

Conflict of interest

The autor declares that conflicts of interest do not exist.

Funding

None.

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Citation: Goudochnikov VI. Endocrine regulation of tissue streaming: formulation of concept. *Endocrinol Metab Int J*. 2025;13(3):80–82.
DOI: 10.15406/emij.2025.13.00375