

Modulation of intracellular calcium and proliferative activity of invertebrate and vertebrate cells by ethylene

ABSTRACT

The results presented in this paper indicate that ethylene, previously known to act as a mediator (hormone) in plants only, deserves also attention as a potential signaling molecule in higher vertebrates. Further studies are necessary to clarify the specificity and physiological significance of the effects induced by ethylene in mammalian cells.

INTRODUCTION

Background Ethylene is the chemically simplest plant hormone. This compound plays an important regulatory role in plant growth, development, and senescence; it is involved in a variety of stress responses in plants (for a review, see). In the last years, much progress has been made in the isolation and characterisation of the genes and proteins participating in the ethylene signal transduction pathway in plants (for a review, see). Calcium and protein phosphorylation/dephosphorylation processes may be involved in the transduction of the ethylene signal. Ethylene is also among the mediators of programmed cell death in plants. Recently we demonstrated for the first time that besides plants, certain animal cells, namely cells from a marine sponge (*Suberites domuncula*), sensitively react to ethylene. This gas is present, at a concentration of up to 100 pM, in seawater, where it can be produced from dissolved organic carbon by photochemical (especially ultraviolet light-induced) reactions. We showed that primmorphs of *S. domuncula*, consisting of aggregates of dissociated sponge cells that are able to proliferate, respond to ethylene with an increase in $[Ca^{2+}]_i$ and a reduction of apoptosis induced by starvation. In addition, in *S. domuncula* primmorphs an upregulation of the expression of two genes occurs following ethylene exposure, one of these genes, termed SDERR, is related to the ethylene-responsive plant gene HEVER. The other gene encodes the Ca^{2+} /calmodulin-dependent protein kinase II. The SDERR cDNA has been isolated and characterized. The sponges (Porifera) are considered to form the first or one of the first metazoan phyla that diverged from the common ancestor of all Metazoa, the Urmetazoa. They are provided with the same protein constituents known from higher animals, including molecules involved in cell recognition and signal transduction pathways (for a review, see). Therefore, we asked if besides sponges, cells from higher vertebrates respond to ethylene. Here we demonstrate that various mammalian cell lines react to ethylene, generated by ethephon (or ethylene gas), with an upregulation of $[Ca^{2+}]_i$ level and an increased expression of the cell cycle-associated antigen Ki-67, used as a marker of cell proliferation.

CONCLUSION

Conclusions Measurements of intracellular calcium level ($[Ca^{2+}]_i$) in various mammalian cell lines (mouse NIH-3T3 and human HeLa and SaOS-2 cells) revealed that ethylene, produced by ethephon, caused a significant upregulation of $[Ca^{2+}]_i$ in these cells. A similar effect was found in cells kept under pressure after exposure to ethylene gas. These data support previous findings showing an upregulation of $[Ca^{2+}]_i$, as well as an increased expression of an ethylene-responsive gene, SDERR, in invertebrate cells (primmorphs of the marine sponge *S. domuncula*). These results indicate that ethylene is not only an important mediator of many biological processes in plants but may also have some modulatory effects

on intracellular signaling pathways in animals.