

Thyroid stunning - Effect of absorbed dose, dose rate and type of radiation

Charlotta Lundh

Department of Radiation Physics, Göteborg University, Sweden

ABSTRACT

At radioiodine treatment of thyroid disease the outcome of the therapy may be negatively influenced by a phenomenon called *thyroid stunning*. Thyroid stunning implicates that the thyroid is not accumulating as much iodine as predicted, owing to radiation induced effects from the radioiodine administered for dose-planning. The stunning phenomenon has been investigated in an *in vitro* model mimicking the thyroid follicle epithelium with an apical and a basal compartment corresponding to the follicular lumen and the extrafollicular space, respectively. These are some of the first *in vitro* studies performed to enhance the knowledge on the mechanisms that cause stunning. An *in vivo* study was also performed to elucidate if thyroid stunning could be identified in hyperthyroid patients receiving 0.5 MBq ^{131}I for dose-planning.

The absorbed dose affects thyroid stunning with a statistically significant reduction in iodide transport at absorbed doses ≥ 0.15 Gy from ^{131}I *in vitro*. The stunning effect increased with increased absorbed dose. The iodide transport obtained varies with time after irradiation, corresponding to the time interval between dose-planning and therapy in patients. Immediately after irradiation and within the first day, no stunning and sometimes increased iodide transport was found *in vitro*. The effect was shown to be reversible, and within a week the iodide transport was sometimes back to the control level. The maximum stunning effect *in vitro* was found between 3-5 days after irradiation.

Higher dose rate gives more stunning. Also the type of irradiation will influence the iodide transport. All radionuclides studied caused stunning, however, to various extent. ^{131}I caused least stunning per unit absorbed dose. ^{123}I and $^{99\text{m}}\text{Tc}$ irradiation reduced the iodide transport about twice as much as ^{131}I . The most pronounced stunning effect was seen after irradiation with the alpha-particle emitter ^{211}At , which also showed recovery after 7 days. The reduction in iodide transport was correlated to down-regulated NIS mRNA expression.

Stunning was found in hyperthyroid patients after diagnostic absorbed doses of 0.07-0.27 Gy. Increased diagnostic absorbed dose was statistically significantly correlated to reduction in effective half-life and reduction in absorbed dose delivered per unit activity administered.

The *in vitro* studies demonstrate that the reduced iodide transport partly can be explained by a decreased NIS expression (involving the basal membrane of the thyrocyte). Furthermore, the *in vivo* data reveal that the stunning effect is connected to a decreased retention of the iodine in the thyroid tissue (involving the apical membrane of the thyrocyte). These findings are important steps in finding the cellular mechanisms that are involved in the stunning effect in the thyroid cell. Such knowledge might be needed to better understand when stunning is of importance clinically, and how to avoid negative effects at treatment of thyroid diseases.

Key words: Thyroid stunning, ^{211}At , ^{131}I , ^{123}I , $^{99\text{m}}\text{Tc}$, ^{131}I therapy, NIS, dosimetry, hyperthyroidism