

Short Review on the Protection by Ouabain of *E Coli* Toxins

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Introduction

The most common form of hemolytic uremic syndrome (HUS) in children is associated with intestinal *E Coli* infection and the effect of its shiga toxin (*Stx*) on different types of cells. Diarrhea associated HUS is endemic in Argentina with the highest incidence rate in the world [1].

Once the systemic lesion is caused, management of the disease is symptomatic. So far, the only possibility to avoid the development of the lesions is by preventing either the infection or the deleterious action of the toxins.

Studies trying to obtain this goal have included the development of vaccines or antibodies against the bacteriae or the toxins [2], and the inhibition of the generation of the toxin receptor (globotriosilceramide-GB3) [3,4].

Stx was the first toxin associated with HUS, described by Karmali et al. [5].

Paton and his group [6] described another toxin-*subtilase AB* in 2004. It has a different receptor (glycans) and induces proteolytic cleavage of an Endoplasmic Reticulum chaperone leading to cellular apoptosis like *St* does [7].

The authors of this paper have shown in studies *in vitro* that exposure of human glomerular endothelial cells [HGEC] [8] and proximal tubule epithelial cells (HK-2) [9] to both *Stx2* and *SubAB* had decreased viability due to the induction of apoptosis. *Stx2* has been shown to increase the expression of the pro-apoptotic factor Bax [10] and *SubAB* to induce a pathway depending of the pro-apoptotic proteins Bax/Bak [11]

Aperia and her group [12] in 2013 showed that the exposure of rat proximal tubular cells to *Stx2* produced massive apoptosis with up regulation of the apoptotic factor Bax, increased cleaved caspase-3, and down regulation of the survival factor Bcl-xL. Co-incubation with ouabain (OUA) prevented all these effects. Moreover, they also showed that OUA reverse the imbalance between the two factors in mice treated with *Stx2*.

In this paper the authors performed studies *in vitro* with HGEC and HK-2 and with a mice model *in vivo*

1. Firstly, they established non-cytotoxic concentrations of OUA in the cell cultures by developing cell viability assays. Concentrations above 30 nM were cytotoxic for both cell lines.

2. Then, they pre-incubated the cells with OUA for 24 h and then added either *Stx2* or *SubAB* in the presence of OUA for another 48 h.

Inhibition of viability caused by both toxins was significantly lower in the cells treated with OUA. The maximum protective effect was obtained with OUA 20 nM.

3. They also studied morphologic alterations and cell detachment induced by both toxins.

These induced edema, elongated shape, and detachment in the two cell lines and OUA prevented these morphological alterations. Changes can be observed in the paper by Amaral et al. [13].

4. In order to determine the possible mechanism of OUA protection, they determined apoptotic activity in both types of cells in the presence of both toxins. They found that the groups in which OUA was added had a significant decrease in the percentage of apoptotic and necrotic cells. Only the necrosis generated in HGEC by *SubAB* was not decreased.

5. Finally the authors also measured cell proliferation by cell count and IP-labeling and flow cytometry. Both toxins decreased cell proliferation and OUA prevented this effect.

6. Since OUA concentrations above the physiological range could affect the function of Na/K ATPase, the group evaluated this by measuring electrical current across HGEC and HK-2 monolayers. At the concentrations used in the experiments OUA did not modified the measurements, showing that the protective effect was not due to alterations on the function of the Na/K ATPase.

The results show that:

1. OUA at low concentration prevents the cytotoxic effect of *Stx2* and *SubAB* on cultures of renal glomerular and tubular cells.

2. OUA also prevents morphologic alterations.

3. This protection is achieved by a decrease in the apoptotic and necrotic activity of both toxins.

4. The effect is not produced by interfering with the activity of the Na/K ATPase.

The laboratory is progressing with further experiments in animals, trying to replicate Aperia's results.

We believe that these results and the actual evidences make it possible to proceed to the translation into human use.

The only drawback is that, in the experiments, OUA was added prior to the contact with the toxins.

In the clinic, the patients present diarrhea when first seen, and, supposedly, the toxin is already getting to its targets.

Conclusion

Nowadays, there is a PCR technique to rapidly determine the presence of Shiga toxin in the stools of a child with diarrhea. This may allow the rapid addition of OUA, hopefully before the microangiopathic lesion has been produced.

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