Dietary eicosapentaenoic acid (EPA) to produce antileukemic cyclopentenone prostaglandin J₃?

We read with great interest the article by Hedge et al., reporting that Δ¹₂-prostaglandin (PG) J₃ (Δ¹²-PGJ₃) has antileukemic activity in mice. Anti-inflammatory and antineoplastic activity has also been reported for 15-deoxy-Δ¹₂,1⁴-prostaglandin J₂ (15d-PGJ₂). We...

Figure 1. Excretion of 15d-PGJ₂ in human urine and its in vitro conjugation with glutathione, L-cysteine and N-acetylcysteine. (A) Reaction of 30μM 15d-PGJ₂ with each 1110μM glutathione (GSH), L-cysteine (Cys) or N-acetylcysteine (NAC) in 100mM phosphate buffer (pH 7.4) resulted in formation of the corresponding conjugates and concomitant decrease of 15d-PGJ₂ as measured by high-performance liquid chromatography (HPLC). Retention time was 12.7, 3.6, 2.8 and 1.2 minutes for 15d-PGJ₂ and the 15d-PGJ₂-NAC, 15d-PGJ₂-Cys, and 15d-PGJ₂-GSH conjugates, respectively. Reaction of 15d-PGJ₂ with Cys was accompanied by a shift of the maximum wavelength from 318 nm to 312 nm and an increase in absorbance at 230 nm. (B,C) The HPLC fractions of the above mentioned conjugates were collected and subjected to catalytical hydrogenation/desulfurization as described elsewhere for the cysteinyl leukotriene E₄. The precursor ion at m/z 397 [M-PFB]⁻ was subjected to collision-induced dissociation (CID) to generate GC-tandem MS (GC-MS/MS) spectra (C). Expectedly, virtually identical GC-MS and GC-MS/MS mass spectra were obtained from all thiol (RSH) conjugates of 15d-PGJ₂. Inserts in panels B and C indicate schematically part of the analytical procedure used and the proposed structures for the ions obtained. (D) Excretion of 15d-PGJ₂ and the isoprostane 15(S)-8-iso-PGF₂α (iso-PGF₂α) was measured in fresh spot urine samples of 12 healthy volunteers (4 females) by GC-MS/MS using 2H₄-15d-PGJ₂ and 2H₄-15(S)-8-iso-PGF₂α as internal standards. 15(S)-8-iso-PGF₂α was extracted from urine (1 mL) by immunoaffinity column chromatography. 15d-PGJ₂ was extracted from acidified (pH 4.5) urine samples by solid-phase extraction and purified by isocratic reverse phase HPLC. In the urine samples no 15d-PGJ₂ was detectable. 15(S)-8-iso-PGF₂α was measured because it is considered a COX-independent metabolite, analogous to 15d-PGJ₂ and 15d-PGJ₃.
agree with Hedge et al\(^1\) that one of the most important questions is whether sufficient quantities of \(\Delta^{12}\)-PGJ\(_3\) are formed in vivo to exert any biologic activity. Here, we comment on this eminently crucial issue from pharmacologic and nutrition perspectives.

PGJ\(_1\) and PGJ\(_2\) are the dehydrated products of PGD\(_1\) and PGD\(_2\) formed in vivo from eicosapentaenoic acid (EPA) and arachidonic acid (ARA), respectively, by the catalytic action of cyclooxygenase (COX). PGJ\(_1\) and PGJ\(_2\) are further dehydrated and isomerized to produce \(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\) and 5d-PGJ\(_2\), respectively. Common feature of \(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\) is the highly reactive cyclopentenone ring, which is readily attacked by low- and high-molecular-mass thiols to form thioethers (Figure 1). Thiolation of \(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\) is likely to reduce both availability and bioactivity of \(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\). So far, there are no data about excretion of \(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\). We (Figure 1) and others\(^3\) found only pM-concentrations of 15d-PGJ\(_1\) in human urine, while PGJ\(_1\) metabolites including 15d-PGJ\(_1\) were below the detection limit of our method (30 pM) in urine. This may suggest that basal PGJ\(_1\) biosynthesis from EPA is several fold lower than PGJ\(_1\) from ARA. Dietary EPA has been shown to increase formation of prostaglandin I\(_3\) (PGI\(_3\)) and thromboxane A\(_2\) (TXA\(_2\)), but even at very high doses, did not increase PGI\(_3\) and TXA\(_2\) synthesis to a degree comparable with that of PGJ\(_1\) and TXA\(_2\) from ARA.\(^4\)

\(\Delta^{12}\)-PGJ\(_1\) and 15d-PGJ\(_1\) are considered potentially useful therapeutic agents for the treatment of cancer.\(^1,2\) Dietary EPA supplementation is unlikely to produce nM-concentrations of \(\Delta^{12}\)-PGJ\(_1\) required for antileukemic activity, but topical administration of considerable amounts of synthetic \(\Delta^{12}\)-PGJ\(_1\) would be required.

**Response:**

**Endogenous levels of D12-PGJ3 derived from eicosapentaenoic acid**

In response to the comment by Tsikas and Stichtenoth,\(^1\) we would like to provide clarification for their views and address the questions. First, while it is correct that the reactivity of the 2 electrophilic centers could make these classes of compounds less bioavailable, our data clearly demonstrate that intraperitoneal administration of D12-PGJ3 completely eradicates leukemia stem cells in the bone marrow and spleen. This suggests that the formation of Michael adducts does not affect their antileukemic activity nor systemic bioavailability. Second, it is not surprising to find that the pM concentrations of 2- and 3-series CyPGs (of the J class) in the urine. Our studies show (see Figure 1 in Hegde et al\(^5\)) that macrophages cultured with 50\(\mu\)M EPA for a week, produce D12-PGJ3 in the cell culture media in quantities (nM) sufficient to target leukemia stem cells. The authors show very low levels (pM) of these metabolites in urine. However they did not measure levels in the serum and it would be difficult to infer serum concentrations from these measurements. Moreover, it is not surprising that given the low rate of conversion, the level of D12-PGJ3 from ARA-derived EPA is likely to be in the pM range as described. In the future, quantitation of these metabolites in the serum will be necessary to provide a true measure of their concentration, particularly in EPA-supplemented individuals. Unpublished studies from our laboratory confirm the metabolism of dietary EPA generates D12-PGJ3 at concentrations in the serum high enough to induce apoptosis in leukemia stem cells in vitro. A manuscript with these results is being currently prepared for submission.

**References**


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