Short communication

Zinc protoporphyrin as an indicator of lead exposure: precision of zinc protoporphyrin measurements

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Summary. In lead-exposed workers many factors affect the relationship between the levels of lead and of zinc protoporphyrin (ZPP) in blood. When the zinc protoporphyrin level is used to assess the lead in the blood level, the analytical accuracy of the ZPP and the PbB determinations should be known. Also the variability of lead exposure over time is an important parameter of this assessment. The absolute and relative precision of ZPP measurements with two brands of ZPP meters (AVIV and ESA) were compared. The absolute precision of the ZPP measurements is not constant for the AVIV meter, but is constant for the ESA meter. The relative precision for both brands of meters decreases with increasing ZPP levels. Between the AVIV and the ESA meters, a significant difference in response, irrespective of the kind of anticoagulant used, was observed. The regression equations between PbB and ZPP levels were studied. Different factors can affect the relationship between PbB and ZPP, e.g. variability in lead exposure, the time-lag between the increase of PbB and ZPP, and the precision and accuracy of PbB and ZPP measurements.

Key words: Precision – Accuracy – Standardization – Zinc protoporphyrin – Lead in blood

Introduction

In addition to the lead in blood concentration (PbB), some biological effect parameters are used both for monitoring the state of health and/or for assessment of the health risk. Some indicators of a biological effect on the heme synthesis are the activity of the enzyme 5-aminolevulinic acid dehydratase in blood, the concentrations of 5-aminolevulinic acid and coproporphyrin in urine and of porphyrins in blood [15]. It has been shown that the concentration of porphyrins in blood offers the best predictor of the individual lead in blood level in workers
with a PbB level, which was rather constant over a period of at least six months (PbB 1–4 μmol/l) [5]. Among these porphyrins, zinc protoporphyrin (ZPP) is the most simple to determine by means of a solid state type fluorometer. The ZPP level can be measured frequently in a drop of blood, with little inconvenience to the worker and at low cost. When the estimated ZPP does not exceed a predetermined, acceptable level, determination of PbB may be omitted. Therefore, routine monitoring of ZPP in blood may be regarded as an effective tool in the prevention of overexposure to lead, both in occupational and in environmental health. However, it should be kept in mind that, when PbB levels are estimated from ZPP, an error of ±0.5 μmol/l Pb/l blood may be made by this estimation [5].

Beside this problem, standardization of the ZPP measurement is necessary to minimize the variability of the dose (PbB)-effect (ZPP) relationship. This variability is due to three errors:

— the error in the PbB determination (the precision of the PbB determination);
— the error in the ZPP determination (the precision of the ZPP determination); and
— biological variation in the relationship between PbB and ZPP.

When the precision of the PbB and/or ZPP determinations are poor, the variability of the relationship is also influenced; however, this is usually not the case [5].

The accuracy of the PbB determination can be checked by round-robin studies and the use of control samples. This aspect will not be dealt with in this study.

The object of the present study was to:

— improve the precision and the accuracy of the ZPP measurements; and
— present a critical evaluation of the relationship between PbB and ZPP levels under conditions of stable occupational exposure to lead. As criterion of stability, the analytical precision of the PbB-value was used; if the second measurement of PbB was within the range of the first PbB ± SD (standard deviation), then exposure was stated to be stable [5].

Materials and methods

Comparison of ZPP meters

ZPP was measured by using two brands of meters: the AVIV Hematofluorometer and the ESA Model 4000. Both fluorometers measure the ratio of ZPP to Hb.

AVIV meter

The AVIV meter is provided with a set of three calibration glasses, colored with Rhodamine B. The values of the glasses are given by AVIV as:

1. 2.1 ± 0.5 μg ZPP/g Hb;
2. 7.4 ± 0.5 μg ZPP/g Hb; and
3. 33.5 ± 1.0 μg ZPP/g Hb.

With each glass, 100 measurements were made with increasing ZPP levels and with random sequences.