Interrelationships between maternal and fetal mineral status: A new perspective

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Introduction

Deficient mineral status of the developing fetus has been associated with potential risk for abortion and stillbirth. However, the relationship between maternal and fetal hepatic mineral concentrations is not simply a linear association and there are increasing concerns over mineral toxicity in the fetus or neonatal calf. The objective of this study is to utilize paired maternal and fetal liver mineral concentrations using a calculated ratio of fetal-to-maternal and maternal-to-fetal hepatic mineral concentrations to identify maternal-fetal relationships in hepatic mineral concentrations.

Materials and Methods

Paired maternal and fetal liver samples were collected from an abattoir on five different occasions over a 9-month period. Cows were identified as either dairy or beef breeds based on appearance. Crown-to-rump measurement and gender were recorded for all harvested fetuses. Maternal and fetal liver mineral concentrations were determined by inductively coupled plasma spectroscopy (ICP/MS) methods. Mineral concentrations (μg/g) were determined on a wet weight (WW) basis and converted to DW basis using determined liver dry matter content. Measured minerals included calcium (Ca), cobalt (Co), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn). Paired maternal-fetal liver mineral concentrations (DW) were used to calculate the fetal-maternal mineral concentration ratio (FMR) and maternal-fetal mineral concentration ratio (MFR). Mineral data were assessed for normality and transformed as necessary. Analysis of variance (ANOVA) models evaluated the potential of breed, gestational age (GA), gender and sampling time influence on FMR and MFR. Linear and nonlinear regression modeling was used to relate FMR or MFR to respective fetal or maternal liver mineral concentrations.

Results

A total of 185 paired maternal-fetal liver samples were available with 11 twin fetuses. Mean (±SD) fetal age was 6.4±1.5 mo (range: 3.7-9.4 mo). Mean (±SD) FMR values were >1 indicating fetal concentrating ability for Ca (1.69±0.64), Cu (3.01±6.91), Fe (4.93±4.50), Mg (1.33±0.23), Se (1.71±1.25) and Zn (4.50±2.72), whereas FMR was <1 for Mn (0.76±0.30), Mo (0.21±0.12) and Co (0.38±0.33). Mean MFR were reverse values from FMR relative being > or <1, except for Cu (1.19±0.87). Fetal-maternal ratio and MFR were influenced (P<0.0002) by GA for Mg, Ca, Mn, Fe and Mo when adjusting for breed and sampling period, gender was not significant. In general, FMR declined and MFR increased with GA, though these were not always linear relationships. Both Mn and Mo showed increasing FMR and declining MFR with GA.

Relationship between FMR and maternal liver mineral concentration was fitted with a power function where at low maternal mineral concentrations there was a high FMR and low FMR with high maternal liver mineral. Minerals Cu (r^2=0.94), Co (r^2=0.89), Se (r^2=0.42), Fe (r^2=0.24), Zn (r^2=0.57) and Ca (r^2=0.53) all showed (P<0.0001) this response. A strong linear relationship (P<0.0001) between MFR and maternal Cu (r^2=0.76) or Co (r^2=0.89) liver concentration. There was a quadratic relationship (P<0.0001)between maternal (r^2=0.39) and fetal (r^2=0.56) liver Mg concentrations and Mg-FMR. Maternal-fetal Mg ratio was linearly associated with maternal (r^2=0.37, P<0.0001) and quadratically with fetal (r^2=0.60, P<0.0001) liver Mg concentration. Both Mn and Mo showed similar relationships between fetal liver mineral concentration and FMR and MFR. Fetal Mo (r^2=0.83; r^2=0.77) and Mn (r^2=0.51; r^2=0.69) concentrations were associated linearly (P<0.0001) with FMR and nonlinearly (P<0.0001) with MFR, respectively. Additionally, Fe (r^2=0.74), Zn (r^2=0.60) and Ca (r^2=0.53) showed (P<0.0001) a lower fetal liver mineral concentration with higher MFR, but this relationship was not observed with Cu, Co or Se.

Significance

The power response observed with many of the minerals suggests a high maternal to fetal transfer at low maternal mineral concentration but a more limited transfer as maternal mineral content increase; possibly a protective mechanism.