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○アブストラクトデータ

Significance of fingernail and toenail mercury concentrations as biomarkers for prenatal methylmercury exposure

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Objective: To investigate the appropriateness of mercury (Hg) concentrations in fingernails and toenails at parturition for detecting prenatal exposure to methylmercury (MeHg).

Methods: Total Hg concentrations were measured in 54 paired samples of fingernails, toenails, maternal blood, and maternal hair (1cm incremental segments from the scalp toward the tip) collected at 4th weeks of (early) pregnancy, and the same specimens and cord blood collected at parturition.

Results: Strong correlations were observed between Hg concentrations in fingernails and toenails at early pregnancy ($r=0.923$, $p<0.01$) and at parturition ($r=0.895$, $p<0.01$). At early pregnancy, Hg concentrations in fingernails and toenails showed the strongest correlations with those in hair 3–4 cm from the scalp. Mercury concentrations in fingernails and toenails at parturition represented strong correlations with those in cord blood ($r=0.803$, $p<0.01$ for fingernails and $r=0.792$, $p<0.01$ for toenails, respectively). At parturition, Hg concentrations in fingernails had the highest correlation with those in hair 0–1 cm from the scalp ($r=0.918$, $p<0.01$), and Hg concentrations in toenails showed the highest correlation with those in hair at 2–3 cm from the scalp ($r=0.872$, $p<0.01$). In addition, the correlation coefficients of Hg concentrations between nails and hair segments at parturition were equally high among hair at 0-1, 1-2, and 2-3 cm from the scalp.

Discussion: This is the first comprehensive study investigating the appropriateness of using Hg concentrations in fingernails and toenails as biomarkers for maternal and fetal MeHg exposure at parturition, compared with those at early pregnancy. Mercury in fingernails and toenails at early pregnancy reflected the maternal Hg body burden level approximately 5 months retroactively. At parturition, Hg levels in fingernails and toenails also showed strong correlations with those in cord blood. In addition, Hg levels in fingernails and toenails at parturition reflected MeHg levels throughout third-trimester of gestation. These results suggest that fingernails and toenails at parturition are useful biomarkers for prenatal MeHg exposure for mothers and fetuses, especially during the third-trimester of gestation.

○アブストラクトデータ

胎児のメチル水銀曝露指標としての手足爪の水銀濃度の意義

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目的：手足の爪の水銀濃度の胎児のメチル水銀曝露指標としての意義について研究を行う。

方法：妊娠初期と出産期に集められた、母体血、手足爪、母親の毛髪及び臍帯血と、毛髪の束（頭皮部から先端に向けて1 cm刻みに切断）の総水銀濃度を測定した。

結果：手足の爪は妊娠初期 ($r=0.923$, $p<0.01$) と出産期 ($r=0.895$, $p<0.01$) で有意な強い相関を示した。妊娠初期において手足爪は、頭皮から3-4 cmの毛髪 ($r=0.818$ and $r=0.747$, $p<0.01$) とそれぞれ最も強い相関係数を示した。出産期における臍帯血水銀濃度は手足爪中水銀濃度と強い相関を示した ($r=0.803$, $p<0.01$ 足爪との相関; $r=0.792$, $p<0.01$ 手爪との相関係数)。出産時の手爪は、頭皮から0-1 cmの毛髪と ($r=0.918$, $p<0.01$)、足爪は頭皮から2-3 cmの毛髪と ($r=0.872$, $p<0.01$) 最も強い相関係数を示した。更に、出産期の手足爪水銀濃度は、頭皮から0-1, 1-2, 2-3 cmの毛髪と同様に強い相関係数を示した。

考察：我々の結果は、これは妊娠初期と出産期における母親と胎児のメチル水銀曝露量評価に関するバイオマーカーとしての手足爪中水銀濃度の意義に関する最初の包括的研究である。妊娠初期における手足双方の爪中水銀濃度は約5か月遡ってのメチル水銀曝露量を反映していた。出産時に、手足双方の爪は臍帯血中水銀濃度と強い相関を示した。加えて、出産時における手足双方の爪中水銀濃度が、母親と胎児の妊娠後期1/3を通してのメチル水銀負荷量を反映した。これらの結果は、出産時の手足爪は母親や胎児の出産前、特に妊娠後期1/3におけるメチル水銀負荷量を知るのに有用であることを示す。

○発表データ

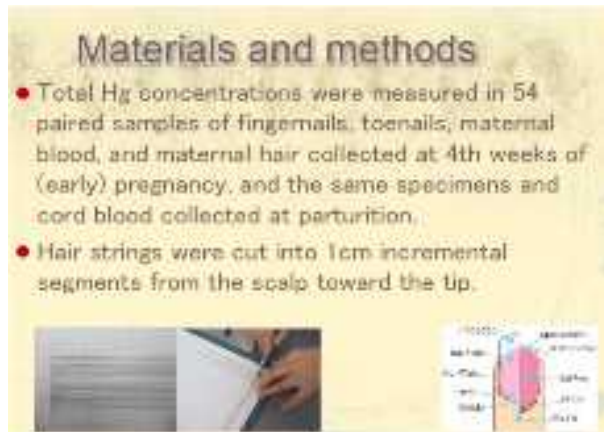
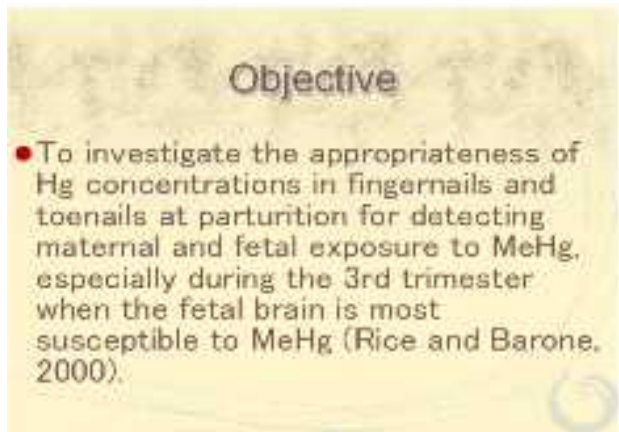
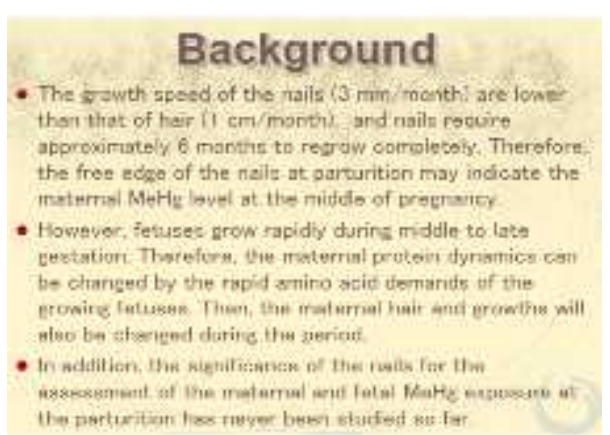
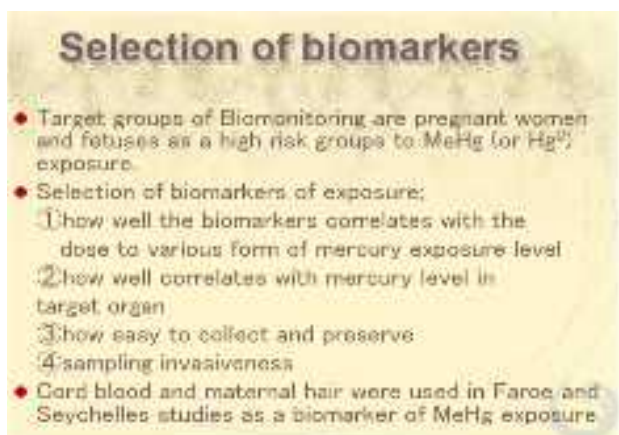


Table 1. Geometric (25-75 percentile) of Hg concentrations (ng/g) in maternal and cord blood, fingernail and toenails and in sequential hair at early gestation and parturition.

	At early gestation	At parturition
Maternal blood	1.90 (1.28-2.94)	2.30 (1.25-4.90)**
Cord blood		7.34 (4.65-12.05)**
Fingernail	5.71 (4.02-7.91)	3.94 (3.78-4.02)*
Toenail	4.62 (3.28-6.54)	4.72 (3.25-6.67)**
Hair length (cm)		
0-1	1.68 (1.41-1.95)	1.84 (1.60-2.06)
1-2	1.76 (1.58-1.97)	1.77 (1.62-1.93)
2-3	1.86 (1.62-2.12)	1.82 (1.66-2.01)
3-4	1.94 (1.67-2.21)	1.87 (1.67-2.11)
4-5	1.74 (1.60-1.88)	1.74 (1.61-1.87)
5-6	1.71 (1.57-1.85)	1.71 (1.62-1.81)
6-7	1.64 (1.44-1.84)	1.64 (1.50-1.80)
7-8	1.41 (1.24-1.58)	1.47 (1.33-1.62)
8-9	1.23 (1.02-1.44)	1.23 (1.02-1.44)

The differences in Hg concentrations between paired samples were demonstrated by paired t-test using log₁₀ transformed data and/or the chi-square test. Hg concentrations in cord blood, organ- and toenails at parturition were significantly (* p < 0.05, ** p < 0.01) lower than those at early gestation. Hg concentrations in cord blood was significantly (** p < 0.01) higher than those in maternal blood at parturition.



Table 3. Correlations among Hg concentrations (ng/g) in maternal and cord blood, fingernail and toe nails, and segmental hair at parturition.

24 samples	Correlation coefficients			
	Maternal blood	Cord blood	Fingernail	Toenail
Maternal blood	1			
Cord blood	0.838	1		
Fingernail	0.697	0.793	1	
Toenail	0.484	0.724	0.842	1
Hair length (cm)				
0-1	0.804	0.692	0.878	0.885
1-2	0.770	0.876	0.875	0.877
2-3	0.719	0.846	0.875	0.877
3-4	0.827	0.759	0.845	0.825
4-5	0.752	0.779	0.769	0.794
5-6	0.888	0.738	0.798	0.781
6-7	0.617	0.659	0.662	0.729
7-8	0.608	0.628	0.631	0.717
8-9	0.474	0.494	0.515	0.692

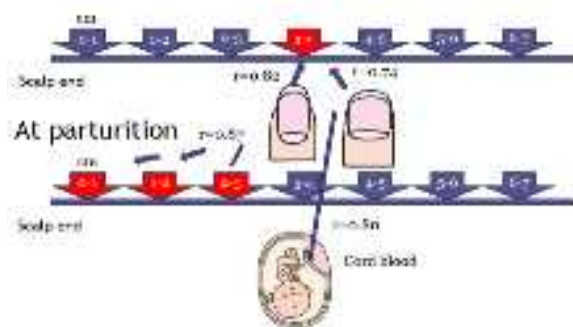
Correlation coefficients were calculated using logarithmically transformed Hg concentrations.

All the correlation coefficients were statistically significant ($p < 0.01$).

At early pregnancy

- Hg concentrations in fingernails and toenails showed the strongest correlations with those in hair segment 3-4 cm from the scalp ($r=0.818$ and $r=0.747$, $p<0.01$, respectively) among the 1 cm incremental hair segments.

At early gestation



Conclusion

- This is the first comprehensive study investigating the appropriateness of using Hg concentrations in fingernails and toenails as biomarkers for maternal and fetal MeHg exposure at parturition, compared with those at early pregnancy.
- Both fingernails and toenails collected at parturition can be used as biomarkers for maternal and fetal MeHg exposure, throughout the 3rd trimester of pregnancy.

Table 4. Correlations among Hg concentrations (ng/g) in maternal blood, fingernail and toe nails and segmental hair at early gestation.

24 samples	Correlation coefficients		
	Maternal blood	Fingernail	Toenail
Maternal blood	1		
Fingernail	0.793	1	
Toenail	0.707	0.833	1
Hair length (cm)			
0-1	0.664	0.787	0.773
1-2	0.689	0.784	0.744
2-3	0.630	0.780	0.790
3-4	0.633	0.646	0.744
4-5	0.699	0.732	0.733
5-6	0.729	0.806	0.755
6-7	0.648	0.779	0.768
7-8	0.438	0.636	0.588
8-9	0.468	0.692	0.633

Correlation coefficients were calculated using logarithmically transformed Hg concentrations.

All the correlation coefficients were statistically significant ($p < 0.01$).

At parturition

- Hg concentrations in fingernails ($r=0.80$, $p<0.01$) and toenails ($r=0.79$, $p<0.01$) showed strong correlations with those in cord blood.
- The correlation coefficients of Hg concentrations between nails and hair segments at parturition were equally high ($r=0.87$) among hair at 0-1, 1-2, 3-4 and 2-3 cm from the scalp.
- The migration of the peak correlation coefficient, between Hg concentrations in nails and hair segments 3-4 cm from the scalp at early pregnancy to the hair segments at 0-1, 1-2, 3-4 cm from the scalp at parturition, can be explained
- either by a decrease in the hair growth rate at late gestation (Pecoraro et al., 1971), or an increase in the growth rate of finger nails from mid to late gestation (Hewitt and Hilman, 1986).

