Activity of superoxide dismutase and its cofactors in maternal venous blood and umbilical cord blood of newborns

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Introduction

Superoxide dismutase (SOD) is a key enzyme of the body's antioxidant barrier of the body. SOD catalyses the dismutation reactions of anion radicals superoxide (O2●-) to hydrogen peroxide and molecular oxygen, thereby protecting cells from the action of O2●-, but also indirectly prevents the formation of the hydroxyl radical (●OH) in a reaction catalysed by transition metal ions, i.e. zinc, copper, manganese.

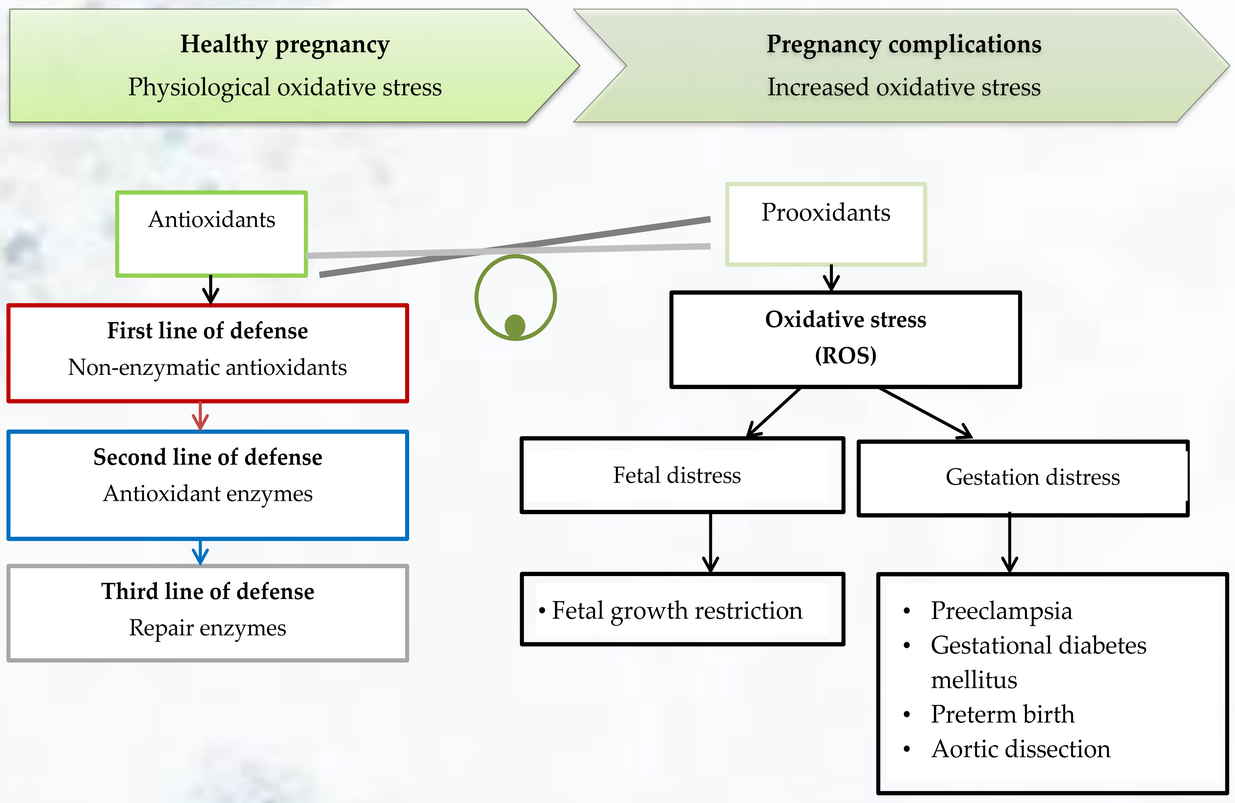

Figure 1. Clinical effects of oxidative stress imbalance during pregnancy [1].

- **Manganese (Mn)** is an activator of glycosyltransferase and other manganese-dependent enzymes such as arginase, phosphatase, choline esterase, and pyruvate carboxylase. One of the most critical functions of manganese is its participation in antioxidant processes as SOD cofactor [2, 3].
- **Zinc (Zn)** is part of the cytoplasmic superoxide dismutase and metallothionein's (proteins rich in cysteine residues that protect against free radicals). Being in the composition of the copper-zinc superoxide dismutase (Zn/CuSOD) participates in removing peroxynitrite formed in the reaction of superoxide anion with nitrogen oxide [4, 5].
- **Copper (Cu)** is an integral part of the vital Cu/Zn-SOD antioxidant enzyme, and its deficiency lowers the activity of this enzyme. Copper deficiency affects the rate of catalase and Mn-SOD synthesis, which limits the body's ability to eliminate ROS and leads to oxidative stress [6]. Copper has the ability to oxidase iron [7]. It participates in the synthesis of haemoglobin, which, although not an enzymatic protein, may exhibit catalase activity [8] and peroxidase [9].

Material and method

- Study group: 199 mother-child pairs;
- Criteria for inclusion: full-term (low-risk) pregnancy, between 37-41 weeks of gestation;
- Exclusion criteria: mother's diseases, including diabetes, hypertension, heart disease, kidney disease, multiple pregnancies, fetal developmental defects, anaemia in the mother or fetus, and smoking;
- Biological Material: the mother's venous blood and the newborn's umbilical cord blood;
- Examined: Superoxide Dismutase (SOD) and Analysis of Selected Cofactors of the Oxidation-Reduction Reactions: zinc, copper and manganese;
- Bioethics commission: Institutional Review Board at the University of Rzeszow (protocol code No. 3/03/2015, date 25 March 2015;
- The probability level was considered statistically significant when the p-value was less than 0.05.

Results

Table 1. Clinical parameters of mothers and newborns

Clinical data of mothers			
	$\bar{x}$ ± SD	median	min - max
Age	30.32 ± 5.44	30	26 - 34
Completed week of gestation	39.29 ± 0.95	39	39 - 40
Anthropometric parameters of newborns			
	$\bar{x}$ ± SD	mediana	min - max
Birth weight (g)	3454.46 ± 463.21	3490.00	2160.00 – 4830.00
Body length (cm)	55.39 ± 2.60	56	48 - 63
Head circuit (cm)	34.26 ± 1.66	34	26.00 – 39.00
Apgar score (points)			
at 1 minute	9.80 ± 0.81	10	5 - 10

Table 2. Parameters of oxidative stress in the mother's venous blood and the newborn's umbilical cord blood.

Parameters	**Mother's venous blood**			**Umbilical cord blood**			
	$\bar{x}$ ± SD	median	min -max	$\bar{x}$ ± SD	median	min -max	p
SOD [U/ml]	204.82 ± 38.67	210.18	144.37-277.70	194.80 ± 18.61	195.14	132.24-281.41	0.014
Mn [µmol/L]	0.11 ± 0.26	0.06	0.01-2.86	0.10 ± 0.17	0.07	0.00-1.81	0.338
Cu [µmol/L]	32.66 ± 8.01	31.85	5.00-77.40	6.87 ± 4.26	6.50	0.50-33.40	0.000
Zn [µmol/L]	11.92 ± 8.28	10.80	0.01-58.50	14.41 ± 12.98	12.30	0.01-143.90	0.020

$\bar{x}$ -arithmetic mean; Me-median; SD-standard deviation; p-level of probability for the Mann-Whitney U test; p <0.05

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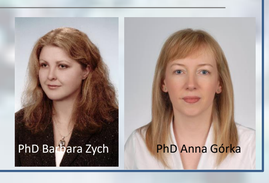

Conclusion

The study showed that superoxide dismutase activity was higher in the venous blood of mothers than in the neonatal group (p = 0.014). With regard to the superoxide dismutase cofactors assessed in maternal venous blood, copper and manganese concentrations were higher and zinc concentrations were lower compared to neonatal cord blood. For copper (p = 0.000) and zinc (p = 0.020), this difference proved to be statistically significant, indicating the presence of competition between the elements. Although this situation occurs during low-risk births, waiting too long to deliver after the due date will favour an increase in zinc concentration and a decrease in copper concentration in the neonate's body by lowering the activity of superoxide dismutase.

References

1. Zych B, Górka A, Myszka A, Błoniarz D, Siekierzyńska A, Błaż W. Status of Oxidative Stress during Low-Risk Labour: Preliminary Data. Int J Environ Res Public Health. 2022 Dec 22;20(1):157; 2. Aschner, J.L.; Aschner, M. Nutritional aspects of manganese homeostasis. Mol. Asp. Med. 2005, 26, 353–362; 3. Michaelis, V.; Aengenheister, L.; Tuchtenhagen, M.; Rinklebe, J.; Ebert, F.; Schwerdtle, T.; Buerki-Thurnherr, T.; Bornhorst, J. Differences and Interactions in Placental Manganese and Iron Transfer across an In Vitro Model of Human Villous Trophoblasts. Int. J. Mol. Sci. 2022, 23, 3296; 4. Agarwal, A.; Aponte-Mellado, A.; Premkumar, B.J.; Shaman, A.; Gupta, S. The effects of oxidative stress on female reproduction: A review. Reprod. Biol. Endocrinol. 2012, 29, 10–49; 5. Willekens, J.; Runnels, L.W. Impact of Zinc Transport Mechanisms on Embryonic and Brain Development. Nutrients **2022**, 14, 2526; 6. Bocca, B.; Ciccarelli, S.; Agostino, R.; Alimonti, A. Trace elements, oxidative status and antioxidant capacity as biomarkers in very low birth weight infants. Environ. Res. 2017, 156, 705–713; 7. Linder, M.C. Ceruloplasmin and other copper binding components of blood plasma and their functions: An update. Metallomics 2016, 8, 887–905; 8. Nishi, H.; Inagi, R.; Kato, H.; Tanemoto, M.; Kojima, I.; Son, D.; Fujita, T.; Nangaku, M. Hemoglobin is expressed by mesangial cells and reduces oxidant stress. J. Am. Soc. Nephrol. 2008, 19, 1500–1508; 9. Kapralov, A.; Vlasova, I.I.; Feng, W.; Maeda, A.; Walson, K.; Tyurin, V.A.; Huang, Z.; Aneja, R.K.; Carcillo, J.; Bayir, H.; et al. Peroxidase activity of hemoglobin-haptoglobin complexes: Covalent aggregation and oxidative stress in plasma and macrophages. J. Biol. Chem. 2009, 284, 30395–30407.