MP26-The impact of ambient pollutants on the reproductive health on a population of infertile male

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Abstract

Objective
The present retrospective study investigates the effect of environmental pollutants on male reproductive health.
Methods
Male patients with primary infertility (n = 282) from a single center (National Taiwan University Hospital, Taipei, Taiwan), between January 2016 and December 2017, were identified. Patients were physically examined for the presence of varicocele, and the volume of both testicles. Semen quality was measured in terms of total sperm count (millions), sperm concentration (millions/ml), and the percentage of motile sperm cells and the sperm cells with normal morphology. Data on the concentration of sulfur dioxide (SO_2) (ppb, parts per billion), ozone (O_3) (ppb), nitrogen monoxide (NO) and nitrogen dioxide (NO_2) (ppb), and particulate matters 2.5 (PM2.5) concentrations (μg/m3), measured on daily and hourly basis, were acquired from the Environmental Protection Administration Executive Yuan, Taiwan. Individual exposure to pollutants was estimated based on the reported residential address of patients. Statistical analysis indicated the impact of each pollutant on the testicular volume and semen parameters.
Results:
Mean ± SD of age was 36.7 ± 7.3 years. Except for PM2.5, the mean concentration of all the particulate matters were within the reference value. NO_2 and SO_2 exposure were negatively associated with the sperm concentration and motility, and testicular volume, respectively.
Conclusion:
NO_2 and SO_2 exposure were negatively associated with the sperm concentration and motility, and testicular volume, respectively, in a population of infertile male.

Objective

Recently, the effects of environmental toxicants, such as particulate matters of size 2.5 μm (PM2.5), nitrogen oxides, sulfur oxides, and carbon monoxide, on human reproductive health has gained increasing attention.
In addition to altered fertility rates, studies had disclosed association between ambient pollutants and male reproductive system and sperm quality on a animal model.
However, limited studies have investigated the direct effects of environmental chemical particles, including sulfur oxides, nitro oxides, and ozone, on semen quality and the male reproductive system. We focused on the association between environmental pollutants and male reproductive health.

Methods

We analyzed data of male patients diagnosed with primary infertility from a single center (National Taiwan University Hospital, Taipei, Taiwan) from January 2016 to December 2017. Primary infertility was defined as the WHO definition.
Semen analysis
Patients were asked to practice abstinence for 3–5 days before semen collection. Each man was provided with a wide-mouth plastic container. The semen sample was collected through masturbation and was sent to the laboratory at our institute for analysis. Concentration, total count, motility and normal morphology were recorded.
Ambient pollutant data and analysis
Data were acquired from the Environmental Protection Administration Executive Yuan, Taiwan. Air pollutants inclusive of Sulfur dioxide (SO_2) , Ozone (O_3) , and Nitrogen oxides (NO_x), including nitrogen monoxide (NO) and nitrogen dioxide (NO_2), and particulate matters 2.5 (PM2.5) concentrations.
Statistical analysis
Linear regression was applied to indicate the effect of each unit of pollutant on the testicular volume and semen parameter. Smoking and medical comorbidity, including obesity and the status of varicocele, were adjusted in the multivariate regression model. We set the significance level at $p < 0.05$. All data analyses were performed using SPSS version 17 (SPSS Inc., Chicago, IL, USA).

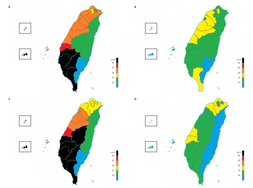

Figure 1. Distributions of PM 2.5 concentration in a: Jan 2016; b: Jul 2016; c: Jan 2017; d: Jul 2017

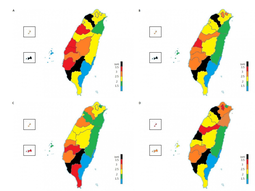

Figure 2. Distributions of SO_2 in concentration a: Jan 2016; b: Jul 2016; c: Jan 2017; d: Jul 2017

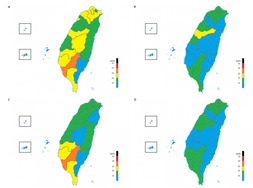

Figure 3. Distributions of NO_x concentration in a: Jan 2016; b: Jul 2016; c: Jan 2017; d: Jul 2017

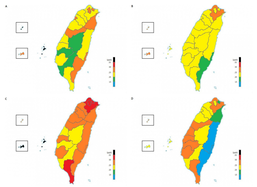

Figure 4. Distributions of ozone concentration in a: Jan 2016; b: Jul 2016; c: Jan 2017; d: Jul 2017

Table 1. Demographics of study population (n=282)

Variables	Mean ± SD	Range
Age	36.7 ± 7.3 years	19–69 years
BMI	24.6 ± 4.2 kg/m^2	17.3–36 years
Right testis	14.18 ± 2.7 ml	6–20 ml
Left testis	14.30 ± 2.4 ml	5–20 ml
Sperm count	41.9 ± 56.6 mln	0.25–280
Sperm concentration	34.1 ± 38.8 mln/ml	0.1–420
Sperm motility	30.5% ± 16%	0–75
Normal form	23.6% ± 9.2%	0–80
	N	**Percentage (%)**
Smoker	65	23
Varicocele	64	22
Residency		
Northern Taiwan	265	93
Central Taiwan	7	3
Southern Taiwan	7	3
Other	3	1

Table 1. Demographics of the study population

	Exp (B)[b] (95% confidence interval)	p value
Sperm count		
PM2.5	0.896 (−16.113 to 40.225)	0.382
SO_2	−0.891 (−169.427 to 68.260)	0.384
NOx	−1.136 (−12.614 to 3.738)	0.270
O_3	−0.196 (−18.947 to 15.698)	0.846
Sperm concentration		
PM2.5	0.109 (−13.821 to 15.340)	0.914
SO_2	−1.302 (−99.796 to 23.235)	0.208
NOx	−2.174 (−8.627 to −0.164)	0.043*
O_3	−1.749 (−16.458 to 1.475)	0.096
Sperm motility		
PM2.5	−0.303 (−7.508 to 5.608)	0.765
SO_2	0.049 (−27.026 to 28.308)	0.962
NOx	−2.321 (−4.014 to −0.207)	0.032*
O_3	−1.248 (−6.437 to 1.624)	0.227
Sperm normal form		
PM2.5	1.248 (−3.566 to 13.322)	0.234
SO_2	−0.617 (−46.216 to 25.681)	0.548
NOx	1.400 (−1.147 to 5.369)	0.185
O_3	0.992 (−4.546 to 12.267)	0.339

*P < .05.

Table 2. Multivariable linear regression by using a sperm parameter for exposure to ambient

	Exp (B)[b] (95% confidence interval)	p value
Right testicle		
PM2.5	−0.472 (−0.956 to 0.607)	0.643
SO_2	−3.101 (−8.279 to −1.575)	0.006**
NOx	−0.967 (−0.376 to 0.140)	0.347
O_3	−1.337 (−1.007 to 0.226)	0.199
Left testicle		
PM2.5	0.472 (−0.956 to 0.607)	0.643
SO_2	−3.101 (−8.279 to −1.575)	0.006**
NOx	−0.967 (−0.376 to 0.140)	0.347
O_3	−1.337 (−1.007 to 0.226)	0.199

*P < .05, **p<.01

Table 3. Multivariable linear regression by testicular volume for exposure of ambient pollutant

Results

Sperm parameter
The mean values of the total sperm count, concentration, and normal form were higher than the cut-off values according to WHO standards. However, the percentage of the progressively motile spermatozoa was low.
Zoom out to 100% (for 24x48), 150% (for 36x72), or 200% (for 48x96) to preview what this will look like on your printed poster.
Ambient pollution
The average levels of PM2.5, O3, SO2, and NOx were 18.0 μg/m3 (range = 10.9–27.2 μg/m3), 27.3 ppb(parts per billion) (range = 21.0–40.6 ppb), 2.9 ppb (range = 1.7–5.6 ppb), and 29.0 (range = 3.7–91.9 ppb), respectively. According to WHO air quality guidelines, the recommended annual mean for PM2.5, O3, SO2, and NO2 were 10 μg/m3, 100 ppb, 20 ppb, and 40 ppb, respectively. Except for PM2.5, the mean concentrations of particulate matters in Taiwan were within the reference values.
Linear Regression model
The exposed mean concentrations of nitrogen oxides in the study period were negatively associated with sperm concentration and total motility ($p < 0.05$). No statistically significant relationship was observed between exposure to other air pollutants and sperm parameters. The testicular volume was negatively associated with the exposed mean concentration of SO2 ($p < 0.01$).

Conclusions

In conclusion, ambient pollutants are negatively associated with male reproductive health of infertile men. Exposure to nitrogen oxides was negatively associated with sperm concentration and sperm motility. Moreover, exposure to SO2 was negatively associated with the testicular volume. Furthermore, we studied changes in the physical structure, which was not investigated in previous studies. However, the strength of the result is limited by the retrospective nature of the study.

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References

1.Ruth De Celis MS, Alfredo Feria-Velasco, M.D., Ph.D., Marco Gonza´ lez-Unzaga MS, Jorge Torres-Calleja, M.D., M.Sc., and, Nives Pedro´ n Nuevo MD, Ph.D. Semen quality of workers occupationally exposed to hydrocarbons. fertility and sterility 2000;73(2):221-8.
2.Brenda Eskenazi P, Andrew J. Wyrobek, PhD, Laura Fenster, PhD,, David F. Katz P, Marianne Sadler, MPH, Jon Lee, BS, Mark Hudes, PhD,, and David M. Rempel M, MPH. A Study of the Effect of Perchloroethylene Exposure on Semen Quality in Dry Cleaning Workers American Journal of Industrial Medicine 1991;20:575-91.
3.Selevan SG, Borkovec L, Slott VL, Zudová Z, Rubes J, Evenson DP, et al. Semen quality and reproductive health of young Czech men exposed to seasonal air pollution. Environmental Health Perspectives. 2000;108(9):887-94.
4.MARILYN F. VINE RWS, JR., RICHARD B. EVERSON, and, WYROBEK AJ. HUMAN SPERM MORPHOMETRY AND SMOKING, CAFFEINE, AND ALCOHOL CONSUMPTION reproductive toxicology. 1997;11(2):179-84.
5.Boeri L, Capogrosso P, Ventimiglia E, Pederzoli F, Cazzaniga W, Chierigo F, et al. Heavy cigarette smoking and alcohol consumption are associated with impaired sperm parameters in primary infertile men. Asian J Androl. 2019;21(5):478-85.
6.de Jong AME, Menkveld R, Lens JW, Nienhuis SE, Rhemrev JPT. Effect of alcohol intake and cigarette smoking on sperm parameters and pregnancy. Andrologia. 2014;46(2):112-7.
7.Jungui J, Ramlau-Hansen CH, Bay B, Ingerslev HJ, Strandberg-Larsen K, Kesmodel US. Low-to-moderate alcohol consumption and success in fertility treatment: a Danish cohort study. Human Reproduction. 2019;34(7):1334-44.
8.Nieuwenhuijsen MJ, Basagaña X, Dadvand P, Martinez D, Cirach M, Beelen R, et al. Air pollution and human fertility rates. Environment International. 2014;70:9-14.
9.Fruton V, González-Comadrán M, Solà I, Jacquemin B, Carreras R, Checa Vizcaíno MA. Impact of air pollution on fertility: a systematic review. Gynecological Endocrinology. 2015;31(1):7-13.
10.Farhat J, Farhat SCL, Bragà ALF, Cocuzza M, Borba EF, Bonfá E, et al. Ozone decreases sperm quality in systemic lupus erythematosus patients. Revista Brasileira de Reumatologia (English Edition). 2016;56(3):212-9.
11.Meng Z, Bai W. Oxidation damage of sulfur dioxide on testicles of mice. Environmental Research. 2004;96(3):298-304.
12.Pires A, de Melo EN, Maud T, Nascimento Saldiva PH, de Siqueira Bueno HM. Pre- and postnatal exposure to ambient levels of urban particulate matter (PM2.5) affects mice spermatogenesis. Inhalation Toxicology. 2011;23(4):237-45.
13.Wei Y, Cao X-N, Tang X-L, Shen L-J, Lin T, He D-W, et al. Urban fine particulate matter (PM2.5) exposure destroys blood–testis barrier (BTB) integrity through excessive ROS-mediated autophagy. Toxicology Mechanisms and Methods. 2018;28(4):302-19.
14.Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HWG, Behre HM, et al. World Health Organization reference values for human semen characteristics*†. Human Reproduction Update. 2009;16(3):231-45.
15.Menkveld R. Clinical significance of the low normal sperm morphology value as proposed in the fifth edition of the WHO Laboratory Manual for the Examination and Processing of Human Semen. Asian Journal of Andrology. 2010;12(1):47-58.
16.Krzyzanowski M, Cohen A. Update of WHO air quality guidelines. Air Quality, Atmosphere & Health. 2008;1(1):7-13.
17.Zhou N, Cui Z, Yang S, Han X, Chen G, Zhou Z, et al. Air pollution and decreased semen quality: A comparative study of Chongqing urban and rural areas. Environmental Pollution. 2014;187:145-52.
18.Liu Y, Zhou Y, Ma J, Bao W, Li J, Zhou T, et al. Inverse Association between Ambient Sulfur Dioxide Exposure and Semen Quality in Wuhan, China. Environmental Science & Technology. 2017;51(21):12806-14.
19.Boggia B, Carbone, U., Farinaro, E. et al. Effects of working posture and exposure to traffic pollutants on sperm quality. Journal of Endocrinological Investigation. 2009;32(5):430-4.
20.Zhang HT, Zhang Z, Cao J, Tang WH, Zhang HL, Hong K, et al. Ambient ozone pollution is associated with decreased semen quality: longitudinal analysis of 8945 semen samples from 2015 to 2018 and during pollution-control period in Beijing, China. Asian J Androl. 2019;21(5):501-7.
21.Sokol RZ, Kraft P, Fowler IM, Mamet R, Kim E, Berhane KT. Exposure to environmental ozone alters semen quality. Environ Health Perspect. 2006;114(3):360-5.
22.Wdowiak A, Wdowiak E, Bien A, Bojar I, Iwanowicz-Palus G, Raczkiewicz D. Air pollution and semen parameters in men seeking fertility treatment for the first time. Int J Occup Med Environ Health. 2019;32(3):387-99.
23.Hansen C, Luben TJ, Sacks JD, Olshan A, Jeffay S, Strader L, et al. The Effect of Ambient Air Pollution on Sperm Quality. Environmental Health Perspectives. 2010;118(2):203-9.
24.Mirowsky JE, Dailey LA, Devlin RB. Differential expression of pro-inflammatory and oxidative stress mediators induced by nitrogen dioxide and ozone in primary human bronchial epithelial cells. Inhalation Toxicology. 2016;28(8):374-82.
25.Aitken J, Fisher H. Reactive oxygen species generation and human spermatozoa: The balance of benefit and risk. BioEssays. 1994;16(4):259-67.
26.Agarwal A, Saleh RA, Bedaiwy MA. Role of reactive oxygen species in the pathophysiology of human reproduction. Fertility and Sterility. 2003;79(4):829-43.
27.Aitken RJ, Smith TB, Jobling MS, Baker MA, De Iuliis GN. Oxidative stress and male reproductive health. Asian J Androl. 2014;16(1):31-8.
28.Wei Y, Cao X-N, Tang X-L, Shen L-J, Lin T, He D-W, et al. Urban fine particulate matter (PM2.5) exposure destroys blood–testis barrier (BTB) integrity through excessive ROS-mediated autophagy. Toxicology Mechanisms and Methods. 2017;28(4):302-19.
29.Cao XN, Shen LJ, Wu SD, Yan F, Zhou Y, Xiong G, et al. Urban fine particulate matter exposure causes male reproductive injury through destroying blood-testis barrier (BTB) integrity. Toxicol Lett. 2017;266:1-12.
30.Koskenniemi JJ, Virtanen HE, Toppari J. Testicular growth and development in puberty. Curr Opin Endocrinol Diabetes Obes. 2017;24(3):215-24.