Traffic Related Pollution: Risk Factor for the Development of Cardiovascular Diseases?

Nino Künzli
MD PhD
ICREA Research Professor
Center for Research in Environmental Epidemiology
CREAL
Barcelona, Spain
kuenzli@imim.es

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Myocardial Infarction is associated with PM$_{2.5}$ (previous 24 hrs.)


Exercise induced ST segment depressions (indicator of ischemia)

Lanki T, Environ Health Perspect, 2006

Association of cardiovascular measures with ambient PM among 9 healthy highway patrol troopers (4 shifts each)

Riediker et al., AJRCCM 2004

Odds ratios (at 2-day lag) calculated per interquartile range of particles

Significant associations of in-car PM with:
- Lymphocytes ↓
- Increased:
  - mean corpuscular volume,
  - Neutrophils,
  - CRP
- von Willebrand factor,
- Heart beat cycle length (next morning),
- Ectopic beats,
- Changes in HRV

Acute Cardiovascular Effects of Ambient Air Pollutants

Pulmonary Reflexes
Autonomic Nervous System
Automatically Conductive Repolarisation
Heart Rate Rhythm
Arrhythmia

Acute Cardiovascular Effects of Ambient Air Pollutants

Pulmonary Inflammation
Autonomic Nervous System
Automatically Conductive Repolarisation
Heart Rate Rhythm
Arrhythmia

Brooks et al. Circulation 2004
Most investigated acute cardiovascular effects of air pollution

- Increase in daily death rates
- Myocardial infarction
- Stroke
- Arrhythmia
- Change in coagulation factors
Atherosclerosis

Lusis, Nature 2000

1. Endothelial dysfunction & retention of lipids
2. Lipid accumulation and oxidation in intima
3. Monocyte & lymphocyte recruitment (inflammation)
4. Proliferation of macrophages
5. Foam cell formation
6. Fibrous plaque formation
7. Extracellular degradation
8. Rupture / Thrombosis (ACUTE EVENTS)

Is air pollution atherogenic?

Effect of instilled Ottawa PM10 in Rabbits (after 4 weeks of exposure)
Suwa et al., J Am Coll Cardiol 2002;
Goto et al. AJRCCM 2004;

- Increase in circulating polymorpho-nuclear leucocytes
- Stimulation of bone marrow release of monocytes
- Increase in macrophages containing PM10
- Higher atherosclerosis lesion scores (in coronary artery and aorta)
- More advanced lesions
- Lesions correlated with amount of PM10 uptake in alveolar macrophages

Chronic Atherogenic Effect of instilled Ottawa PM10 in Rabbits (after 4 weeks of exposure)
Suwa et al., J Am Coll Cardiol 2002

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Is air pollution atherogenic... in humans?

Measuring Atherosclerosis

Thickness of the Intima-media IMT

Diagram showing structures of a normal large artery.

Slide from E. De Groot, Amsterdam, NL

Slide showing ultrasound images of carotid arteries.

External carotid

Internal carotid

Common carotid

Carotid bulb

Carotid flow divider

Images of a cityscape with a view of mountains in the distance.
EXPOSURE SURFACE, PM2.5

Home outdoor PM2.5 is associated with CIMT
Künzli et al, Env Health Perspect 2005

Association between artery wall thickness (CIMT) and home outdoor mean PM$_{2.5}$ in women, age 60 and older
(from Künzli et al., Air Pollution and Cardiovascular Disease; Harrison Online 2005)

ONGOING IMT-STUDIES
- in children: USC Children’s Health Study (NIEHS)
- in adolescents (USC College students) (NIEHS)
- in population-based sample of adults (Spanish REGICOR study, Girona) (Spanish Ministry FIS-Grant); KORA Augsburg (A. Peters)
- others.....

Heinz Nixdorf Recall Study
(Hoffmann et al, Circulation 2007)
- Random population sample from 3 areas (Essen, Muhlheim, Bochum)
- ~4’800 subjects 45-73 yrs of age
- Baseline: 2000-2003
- Main outcome of pre-clinical state of atherosclerosis: Coronary artery calcifications (CT-scans)

Exposure assessment
- Distance between home address and median strip of major roads
  - Autobahn (red)
  - Federal highways (orange)
- Regional dispersion model (EURAD) (Memmesheimer 2003)
  - Emission data (official emission registry, scale 1 km)
  - Daily meteorology
  - Topography
- Daily surface concentrations of air pollutants (5 km grid)
- Validation with measured data from monitoring sites
- Assignment of annual average PM$_{2.5}$ (year 2002) to home address
Increasing evidence

- Ambient air pollution triggers cardiovascular events...
- .... and may contribute to atherogenesis (strong experimental evidence!)

BUT....

Is it TRAFFIC-related pollution?

- Primary emissions?
- Secondary pollutants?
- Re-suspension?
- Contribution of coarse – fine – ultrafine – nano–PM?
- Interaction of all the above?

Zhu et al, J Air Waste Manage Assoc, 2002; 52: 1032
From the Southern California Particle Centre
Is it a NANO-PM effect?

Ratio of 'Highway' to 'Urban background' concentration of different PM size fractions

Ntziachristos et al. Atmos Environ August 2007

<table>
<thead>
<tr>
<th>Size fraction (nm)</th>
<th>ratio Hwy710/urban</th>
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<tbody>
<tr>
<td>100-180</td>
<td>2.10</td>
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<tr>
<td>56-100</td>
<td>2.48</td>
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<tr>
<td>32-56</td>
<td>1.49</td>
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<tr>
<td>18-32</td>
<td>0.94</td>
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Mechanisms

- Chronic effect studies
- Integrated exposure assessment for sources and constituents
- Measurement of biologically-relevant aspects of exposure
- Assessment of exposure to PM of various size fractions, including the nano-PM scale
Traffic-related pollution:
Better knowns – …

- Very high contribution to exposure to primary and secondary pollutants
- Many pollutants (mixture)
- Many effects (mechanisms) well described for several toxicants
- Traffic-related pollution IS a health problem

Traffic-related pollution:
… – less knowns

- Contribution of specific pollutants to the orchestrated effects?
- Emissions versus re-suspension?
- Interactions between constituents?
- Health benefit of specific technological interventions / policies?
- Role of host factors (susceptibility)