Long-term effects of carbon monoxide exposure
Long-term outcome of CO exposure

- Very variable – differences between individuals
- Level of exposure
- Duration of exposure
- Chronic or acute
Long-term sequelae of CO exposure

- Sherral Devine, Shalene Kirkley, Carole Palumbo, Roberta White
- MRI and neuropsychological correlates of carbon monoxide exposure: a case report
- *Environmental Health Perspectives* 2002 110: 1051-1055

- These authors present a detailed case report of a 45 year old woman with long-term, chronic exposure to CO in the restaurant kitchen where she worked in Boston
- The study gives a very clear picture of the kind of subtle but functionally significant neuropsychological problems which can follow chronic CO exposure and several important pointers to improving care
Sherral Devine, Shalene Kirkley, Carole Palumbo, Roberta White
MRI and neuropsychological correlates of carbon monoxide exposure: a case report
*Environmental Health Perspectives* 2002 110: 1051-1055

- Probably exposed for at least a year
- Initially vague flu like symptoms
- Later couldn’t walk straight and bumping into things
- Problems with balance and some falls
- Severe, persistent headache for most of the time
- Fatigue
- Cloudy feeling
- Inability to speak clearly or produce a full sentence
- Hearing problems
- Irritability
- Facial pain
She noticed that after she had five days off her symptoms were better.

When she returned to work there was a smell of gas in the kitchen.

The gas company was called and they found that there was also faulty ventilation of the furnace and a “very high level” of CO in the kitchen.

Seen at ER about six hours later.

Normal carboxyhaemoglobin.

Nothing to find on exam.
After the furnace was fixed, she said that most of her symptoms resolved.

However, when she was seen by a neuropsychologist 17 months later she still had residual problems with reading, writing and speaking.

She would sometimes miss out a letter when she was writing a word.

She sometimes had word finding difficulties or mispronounce words.
An MRI 15 months after the furnace was fixed was initially reported as normal.

The neurologist who saw her then said her neurologic exam was normal and that he could find no evidence that she had suffered a CO-induced encephalopathy.

However, the scan was later reviewed independently by a neuroradiologist and a neuroscientist working in neuroimaging research.

They felt that there were actually subtle changes in the basal ganglia consistent with CO poisoning.
The initial neuropsychological assessment 17 months after the end of CO exposure showed performance in the superior to very superior range on most tests with a FS IQ of 132, a VIQ of 135 and a PIQ of 121. However, her performance was below expected on demanding tasks involving attention, new learning, memory retrieval. During the testing, some lapses in attention, perseveration. Susceptible to interference effects on memory tasks. Mood inventory suggested some depression.
Second neuropsychological evaluation 29 months after the end of CO exposure

- Variability with some scores better and some worse
- Still performing below expected level on more demanding memory tasks and on complex verbal reasoning tests
- Poor performance on tests involving motor co-ordination and speed
Although there was a slight degree of improvement on this second assessment, it was clear that there were persisting subtle – but functionally significant – cognitive impairments even 29 months after exposure to CO had ended.

The neuropsychological findings were interpreted as suggestive of subtle frontal lobe dysfunction of a kind seen when there is a secondary frontal lobe deficit associated with subcortical disorders involving the basal ganglia.
It was concluded that:

“The deficits observed were typical of those we have seen residually in patients with histories of chronic low level CO exposure not producing loss of consciousness.”
It is clear from this case study that:

- Routine neurological examination may be normal in people who show quite significant cognitive and neurobehavioural changes following CO exposure.

- Comprehensive formal neuropsychological evaluation is an essential part of the clinical assessment.

- Subtle changes on MRI following CO exposure may be overlooked on routine reporting of scans.
Areas of the brain affected by carbon monoxide exposure
Areas of brain involvement in carbon monoxide poisoning

- The commonest MRI changes following CO exposure include:
  - bilateral necrosis in the basal ganglia (esp globus pallidus)
  - bilateral hyperintensities in periventricular white matter which are thought to represent (reversible) demyelination

- The white matter changes may be more predictive of long-term outcome than the basal ganglia changes
Areas of brain involvement in carbon monoxide poisoning

Although the deep white matter and basal ganglia are most commonly involved, abnormalities have been reported in other brain areas, including:

- medial temporal lobe/hippocampus
- frontal, parietal and occipital lobes
- thalamus
- cerebellum
Long-term effects of carbon monoxide exposure
Long-term sequelae of CO exposure

- There is not really a specific pattern of neuropsychological deficits following CO exposure and a wide range of impairments have been reported.
- However, the majority of studies have described problems with:
  - memory
  - visuospatial function
  - executive function (frontal lobe impairment)
  - problems with speech/language and reading/writing
  - depression
Long-term sequelae of CO exposure

- A range of other problems have been reported in some individuals, including:
  - abstraction deficits with concrete thinking (frontal lobe)
  - impaired fine motor control esp. of the hands
  - impaired tactile identification of complex objects
  - impairments in attention and cognitive processing speed
  - neuropsychiatric and neurobehavioural problems (including depression, personality change, lability of mood, irritability, aggression, impaired social perception and loss of social skills)
Sequelae of CO exposure

- I’ve emphasized cognitive and neurobehavioural impairment following CO exposure.

- But there may be a range of other residual problems including:
  - headache
  - apathy
  - akinetic mutism
  - urinary incontinence
  - gait ataxia
Effects of CO exposure

- extrapyramidal problems due to basal ganglia damage (Parkinsonism, chorea, dystonia)
- impaired co-ordination
- visual impairment
- sensorineural hearing loss
- peripheral neuropathy
- cardiac problems
Delayed encephalopathy following CO exposure

- CO exposure is unusual in that about 1/3 people who seem to be well initially go on to develop a delayed encephalopathy up to 5-6 weeks later.
- This seems to be related to white matter changes on MRI, which may reflect demyelination as well as axonal damage/degeneration and gliosis.
- The white matter changes may lead to functional disconnection of areas of cerebral cortex and disruption of neural networks.
- These structural changes correlate quite well with the degree of neuropsychological impairment.
Long-term outcome following CO exposure

- While many people will make a complete or very good recovery following CO exposure, a significant number will be left with residual long-term effects – ranging from severe to quite subtle.
- It is important to remember that even “mild” disturbances in executive function, memory, personality, social perception and mood may actually have devastating consequences for reintegration within the family and return to employment.
- This is very clear from work in other areas of acquired brain injury – especially head injury.
HOW COULD SPECIALIST CARE FOR PEOPLE WITH CO EXPOSURE BE IMPROVED?
AIMS OF SPECIALIST CLINIC FOR PEOPLE WHO HAVE HAD CO EXPOSURE

- Although existing neurorehabilitation services may care for people with severe neurological or behavioural changes following major CO exposure, there is still very limited specialist support for people with milder persisting problems – particularly following chronic, lower level exposure.

- A case could be made for seeking to develop a specialist clinic to help this group of people.
AIMS OF SPECIALIST CLINIC FOR PEOPLE WHO HAVE HAD CO EXPOSURE

- To build up clinical expertise and develop better understanding of the long-term natural history in larger and more varied groups of patients.

- Improve understanding of the profiles of chronic CO exposure in individual people.

- Basis for research which will feedback into clinical care.

- Many of existing studies involve rather small numbers of patients and relate to very specific issues assessed on a single occasion.
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- Memory impairment, speech and language difficulties and other cognitive problems:

- Memory impairments may be quite severe and disrupt readjustment to normal daily life.

- Some patients will have specific dysphasic problems.

- There may be more global cognitive problems.
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- **Neuropsychiatric problems:**
  - May be subtle or severe
  - Mood disorder
  - Anxiety
  - Irritability
  - Personality change
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- Impairments of social interaction:

- social apraxia – although the changes may be subtle, they may be hugely disruptive of interpersonal and family relationships and may completely prevent return to previous work setting.

- Clear from work on head injury that people without obvious signs of deficit (such as limb weakness etc.), but with cognitive and neurobehavioural changes may have major problems with readjustment.
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- OTHER DISABILITIES:
  - Motor deficits
  - Movement disorder
  - More global neurological impairments
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- To deal with these complex difficulties within the same clinic will need involvement of multidisciplinary team:
  - Neurologist
  - Specialist in neurological rehabilitation
  - Toxicologist
  - Neuropsychiatrist
  - Neuropsychologist
  - Speech and language therapist
  - Occupational therapist
  - Physiotherapist
  - Clinical Nurse Specialist
  - Social Worker
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

- Need to be able to deal with the various dimensions of difficulty under the umbrella of a single clinic.

- Need continuity in who is seeing the patients for long-term working relationships to develop.
REQUIREMENTS FOR SPECIALIST CO EXPOSURE CLINIC

■ JOINT CLINIC CONCEPT:

NEUROLOGIST/NEUROREHABILITATION SPECIALIST/TOXICOLOGIST
NEUROPSYCHIATRIST/NEUROPSYCHOLOGIST

CO NURSE
SPECIALIST

SPEECH & LANGUAGE THERAPY, PHYSIO, OT
SOCIAL WORK
A SPECIALIST CLINIC TO SUPPORT PEOPLE FOLLOWING CO EXPOSURE – A HOPE FOR THE FUTURE?

- At this stage, a specialist service of this kind remains a hope for the future rather than a current reality.

- However, specialist clinics for other long-term neurological conditions - such as epilepsy, multiple sclerosis and movement disorders - are well-established and work effectively.

- It would worth considering whether a similar specialist service could be developed to support people following CO exposure and how this might be achieved.
www.COvictim.org

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