Intoxication et Inhalation de Fumées

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Pathologies d'incendie

- Brûlures
- Inhalation de fumées
- Explosion
  - Blast
- Pathologies connexes
  - Hystérie
  - Sur-accident

Inhalation de fumées

- Types d'inhalations:
  - Air chaud
    - Brûlures des muqueuses
  - Suies
    - Irritation locale immédiate: œdème
    - Irritation à distance
  - Gaz à effets systémiques
    - CO : coma
    - Cyanure de K+ : instabilité hémodynamique
  - Poussières diverses si effondrement
    - Béton
    - Amiante
    - …

Inhalation de fumées

- 30% des brûlés
- Mortalité importante
  - +20% mortalité / surface brûlée
  - Inhalation sans brûlure
    - Mortalité 3-11%
  - Inhalation + brûlure:
    - 30-90% décès
- Prédispose au développement de pneumonies
  - Mortalité + 40%

Inhalation de fumées

- Aussi chez professionnels
  - Implications en médecine du travail
  - Problèmes respi chez pompiers
    - Général: OR:1,2 à 1,4 / 25 feus / 1 an
    - Si 1 accident: OR: 1,7-3,0
  - 2001/9/11 NYFD
    - Pas fumés d'incendies franches
    - Effondrement: béton, amiante,…

Air Chaud

- Dégagement important de chaleur
- Brûle surtout VAS
  - Perte de chaleur dans VA.
  - Exception: vapeur d'eau
- Clinique:
  - Souvent associé à brûlures au visage
  - Détresse respiratoire aigue
  - Œdème glottique
- Traitement:
  - Intubation rapide
  - Traitement supportif (ventilation mécanique)

Daegu, 2003/02/18

At 9:53 AM on February 18, 2003, a fire occurred at a subway station in Daegu, a large city in the Republic of Korea. This fire caused 192 deaths and 148 injuries. Two subway trains were completely immolated. A host of synthetic materials had been used in the construction of the subway, including finishing reinforced products (polyester, glass fibers, carbonated calcium,

BURNS 33 (2007) 200–208

Table 1 – Characteristics of fire victims admitted

n	96
Mean age, years (S.E.)	35.2 (2.56)
Sex	
Male, *n* (%)	43 (45)
Female, *n* (%)	53 (55)
History of smoking	
Nonsmoker, *n* (%)	83 (86)
Smoker, *n* (%)	13 (14)
Exposure duration, min, range	5–20
Mean COHb, % (S.E.)[a]	9.1 (1.34)
Presenting clinical features, *n* (%)[b]	
Sore throat	78 (89)
Hoarseness	51 (58)
Cough	85 (97)
Dyspnea	82 (93)
Chest pain	28 (32)
Sooty sputum	75 (85)
Wheezing	39 (44)
Stridor	15 (17)

Definition of abbreviation: COHb, carboxyhemogloin. (a and b) measured in 86 and 88 victims, respectively.

Buenos Aires, 2004/12/30

On 30 December 2004, a flare burst into an overcrowded rock club in Buenos Aires. Locked exit doors trapped participants in smoke and flames. The fire killed 194 and injured over 700 people, causing Argentina's worst disaster in the past 60 years.

Table 1 – Data from the victims (n = 13) under mechanical ventilation maintained in the intensive care unit (ICU)

Characteristic	Mode (min–max)	Mean ± S.D.
Age (years)	21 (15–29)	22.5 ± 3.9
APACHE II	27 (7–35)	22.0 ± 8.9
MV (days)	6 (1–46)	11.5 ± 13.0
ICU (days)	31 (1–58)	15.9 ± 16.6
Hospital (days)	1 (1–62)	21.9 ± 16.9
Mortality		2/13

S.D., standard deviation; APACHE, acute physiology, age and chronic health evaluation; MV, mechanical ventilation.

Table 2 – Groups of patients graded according to depth of mucosal damage estimated by fibre-optic bronchoscopy on admission, in line with Chou's classification [7]

Grade	Number of patients	Findings
G0	0	Negative (no mucosal damage)
Gb	0	Positive (mucosal damage) confirmed by biopsy
G1	7	Mild oedema + hyperaemia, with or without carbon soot
G2	1	Severe oedema + hyperaemia, with or without carbon soot
G3	4	Ulceration, necrosis, no cough reflex or bronchial secretions

Suies / fumées

- Souvent sous estimé
  - Histoire de l'incendie
    - Lieu clos,
    - Plastics,..
  - Présence de suies
    - Nez / visage / bouche
  - Tableau clinique:
    - asthme, wheezing, hypoxie
    - Rare à l'admission
    - Mauvais pronostic

Suies

- Substances irritantes
  - Charbon => couleur noire
  - Dégradation des plastics, des parquets laminés (formaldehyde,…)
- Clinique:
  - En général peu de symptômes au début
  - ARDS tardif (5-10 jours)
- Rx thorax
  - Peu contributive à admission
  - Médico-légal : apparition d'anomalies
- Bronchoscopie

ARDS

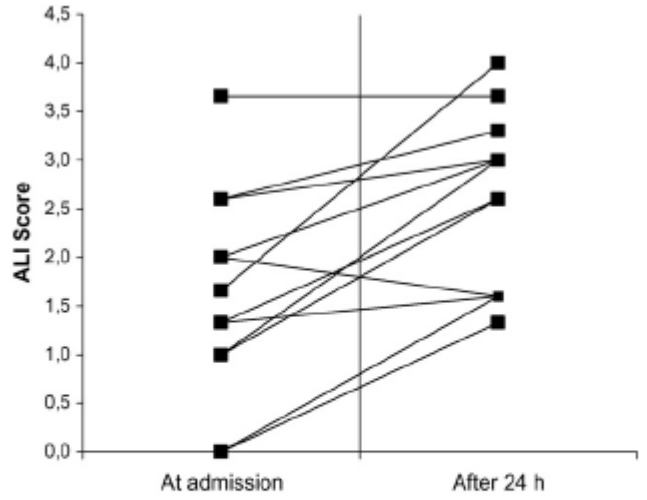

Fig. 3 – Worsening of acute lung injury (ALI) after 24 h. Initial normal oxygenation or chest radiograph can lead to underestimation of the level of injury (ALI = 1.6 ± 1.1 vs. 2.6 ± 0.9, $p = 0.020$).

BURNS 34 (2008) 533–538

Suies

(A) Bronchial soot

(B) Bronchial cast

Suies

- CPK admission
  - Facteur gravité
  - Rhabdomyolyse associée
  - Mauvais pronostic

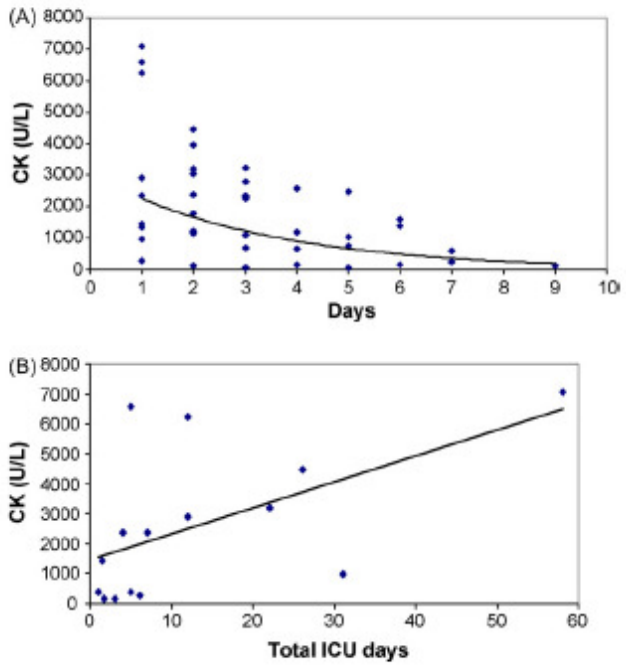

Fig. 2 – (A) Exponential decrease of creatine kinase among survivors, reaching normal levels by the 3rd day, $n = 38$, $r = 0.45$, $p < 0.004$. (B) Initial creatine kinase levels in all 15 victims admitted to the intensive care unit plotted against length of stay in the unit shows a significant linear relationship, $r = 0.54$, $p = 0.03$.

Suies

- Descend d'autant plus bas que de petit diamètre
  - > 10µm : VAS
  - 10 > 3 µm: arbre bronchique
  - 3 > 0,5 µm: alvéoles
  - < 0,5 µm : reste dans les gaz, expirées. .
- Surveillance rapprochée
- Intubation si dégradation respiratoire
  - Traitement supportif
  - Mauvais pronostic
  - Lésions -sténoses

Daegu, 2003/02/18

Table 2 – Outcome and late structural complications

	Patients without EI ($n = 79$) n (%)	Patients with EI ($n = 17$) n (%)	Total ($n = 96$) n (%)
Outcome			
Survival	79 (100)	13 (76)	92 (96)
Death	0 (0)	4 (24)	4 (4)
Complications			
Vocal cord stenosis	0 (0)	5 (29)	5 (5)
Tracheal stenosis	0 (0)	1 (6)	1 (1)

Definition of abbreviation: EI, endotracheal intubation.

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Suies

- Autres traitements
  - Maintenir oxygénation
    - SaO2 > 90%, + humidification
  - N-acetylcystéine +/- héparine en aérosols
    - Fluidifiant
    - Fibrinolytique: caillots
  - Bronchodilatateurs
  - Bronchoscopie thérapeutique
    - Nettoie les vois es aériennes
  - Dépistage et traitement des pneumonies
    - Expectorations
    - Antibiothérapie
  - Mobilisation précoce / kiné respi.

Efficacité des corticoïdes

Table 4 – Relationship between the use of steroid and the changes of pulmonary functions in patients without endotracheal intubation

Parameter	Non-steroid-treated ($n = 22$)	Steroid-treated ($n = 19$)	p-value
Age, years	32.9 ± 3.27	38.4 ± 4.62	0.248
Sex (M/F)	15/7	12/7	0.735
Nonsmoker/smoker	22/0	16/3	0.091
FVC, % pred.			
Initial	84.4 ± 3.08	77.1 ± 4.45	0.175
3 months later	95.0 ± 3.36**	92.6 ± 3.95*	0.640
Change of FVC	10.6 ± 2.50	15.5 ± 6.48	0.471
FEV_1, % pred.			
Initial	83.5 ± 4.16	82.7 ± 5.42	0.910
3 months later	98.4 ± 3.49**	99.5 ± 4.19*	0.835
Change of FEV_1	14.9 ± 3.16	16.8 ± 6.48	0.785
FEV_1/FVC, %			
Initial	79.5 ± 1.56	83.8 ± 2.02	0.097
3 months later	85.9 ± 1.92	85.3 ± 1.45	0.786
Change of FEV_1/FVC	6.4 ± 2.05	1.5 ± 2.06	0.097
$FEF_{25-75\%}$, % pred.			
Initial	71.5 ± 5.79	78.1 ± 7.36	0.476
3 months later	92.9 ± 4.66**	99.8 ± 7.40*	0.417
Change of FEF_{25-75}	21.5 ± 6.29	23.5 ± 8.63	0.846

*$p < 0.05$, **$p < 0.01$ vs. the initial value for each group. Data are mean ± S.E. or n.

Corticosteroid therapy is contraindicated in the case of fire victims with combined surface burns and inhalation injuries, as it does not appear to generate any significant benefits with regard to complications and mortality [14,15]. However, the role

Suies

- Complications tardives
  - Sténoses trachéales
    - Sous glottique
    - Ballon du tube
    - Traitement chirurgical

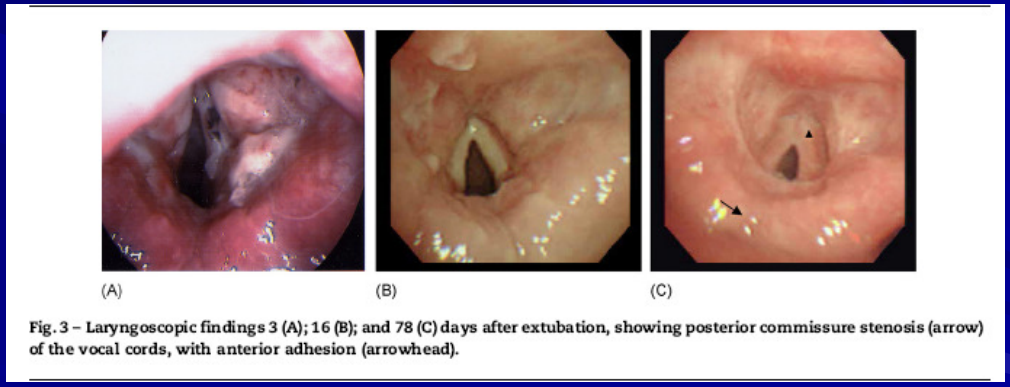


Fig. 3 – Laryngoscopic findings 3 (A); 16 (B); and 78 (C) days after extubation, showing posterior commissure stenosis (arrow) of the vocal cords, with anterior adhesion (arrowhead).

  - Déficit pulmonaire chronique
    - Rare, résolution rapide (mois)
    - Suivi par EFR

Toxicité Systémique

- Deux toxiques principaux
  - CO
  - Cyanure
- Toxicité métabolique (systémique)
  - Mitochondries
- Mortalité précoce
  - Morts sur place
  - Dans la 1ère heure de l'incendie.

Toxicité Systémique

- Diagnostic présomptif
  - Lieux clos
  - Suies
  - Altérations neurologiques
  - Instabilité hémodynamique
  - Arrêt cardiaque

CO

- Combustion normale des gaz
  - CO_2
- Incendie en milieu clos : CO
  - Manque d'O_2
- Problème:
  - Affinité pour Hb > 200 X O_2
  - Se fixe à Hb au lieu de l'O_2 (compétiteur)
    - Plus de transport d'O_2
    - Ischémie des tissus
    - Shift de la courbe de dissociation Hb vers la G.
  - Pas relâché au niveau des tissus
    - Reste longtemps

CO

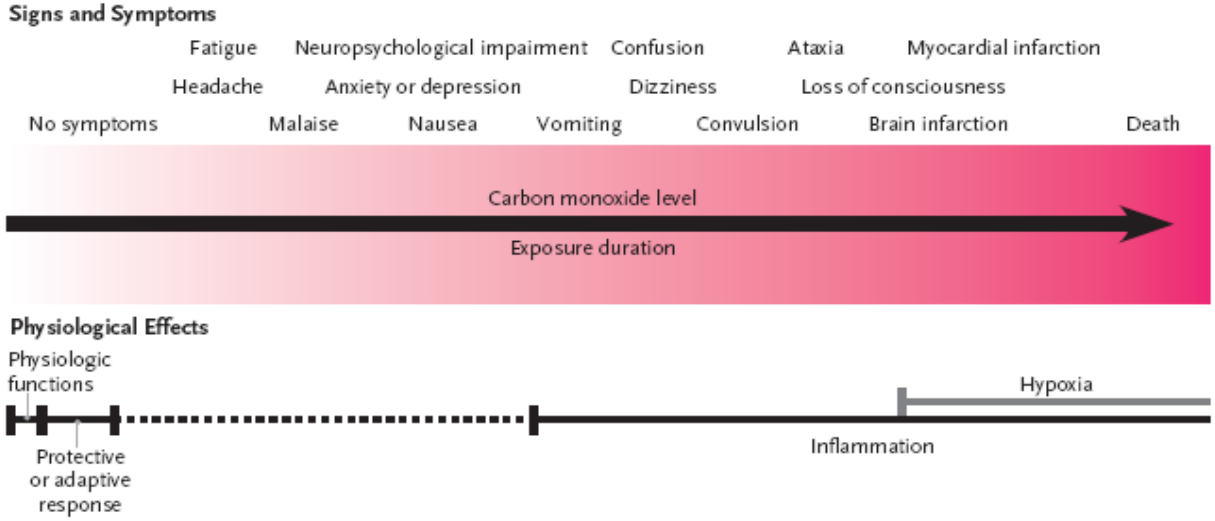
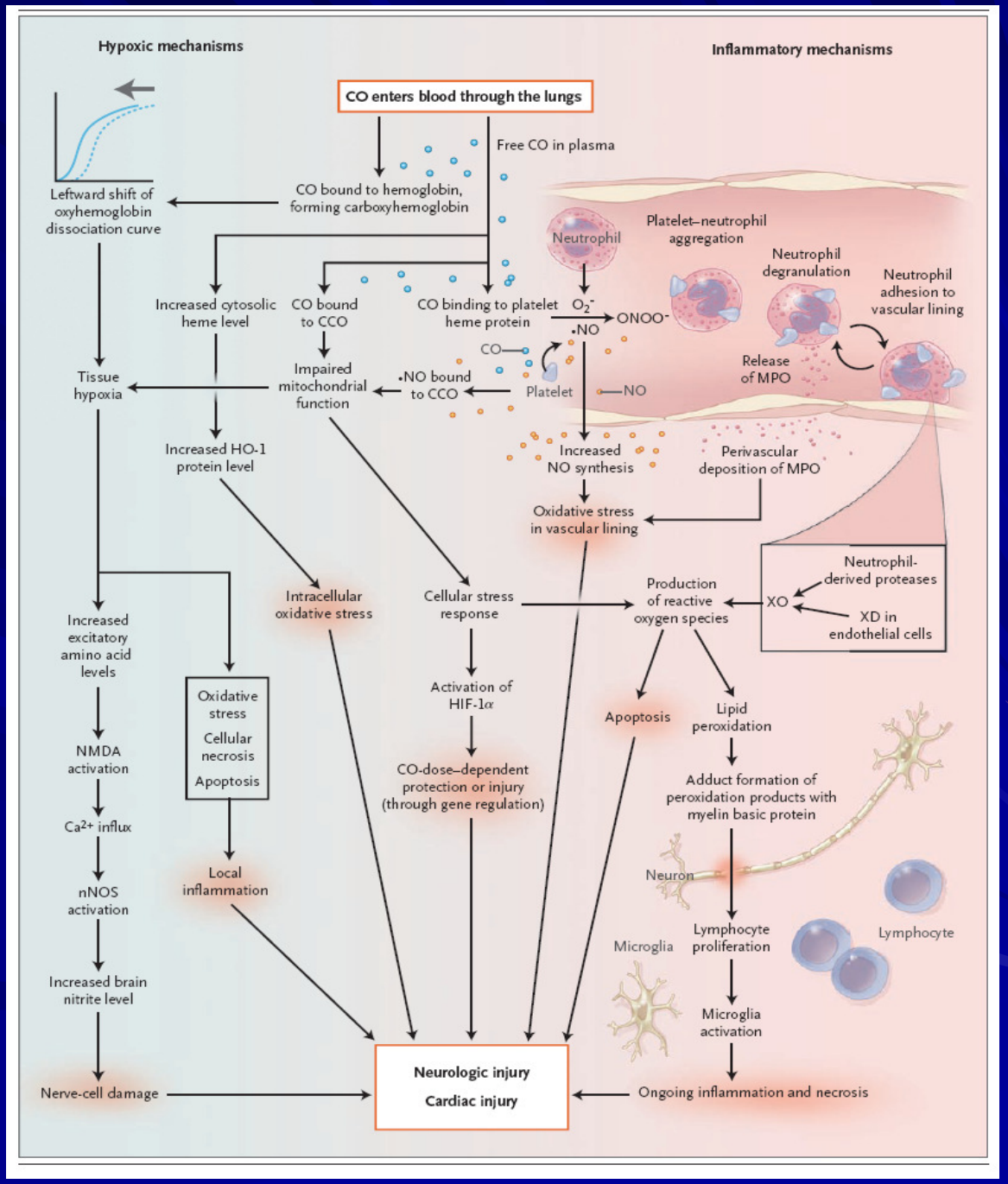


Figure 1. Spectrum of Symptoms and Effects of Exposure to Carbon Monoxide, According to the Level and Duration of Exposure.

In all humans, small amounts of carbon monoxide are present and are important for multiple physiologic functions, including neurotransmission. Exogenous exposure to amounts of carbon monoxide above physiologic levels can result in a protective or adaptive response, but exposure to even higher levels results in toxic effects. Toxic exposures can cause inflammation, followed by hypoxia, although there is uncertainty regarding the range of carbon monoxide exposures above which inflammation occurs (as indicated by the dashed line). The signs and symptoms of poisoning are highly variable, depending on the acuity and duration of the exposure.

N ENGL J MED 360;12 NEJM.ORG MARCH 19, 2009

CO



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CO

- Clinique: dépend du taux sanguin
  - < 3% chez non fumeur
  - < 10 % : fumeur
  - 10-20 %: nausées, vomissements, céphalées, vertiges.
  - 20-50%: symptômes neurologiques majeurs:
    - Coma
    - Convulsions
  - > 50 %: décès.

Table I. Carboxyhaemoglobin (COHb) levels and corresponding symptomatology

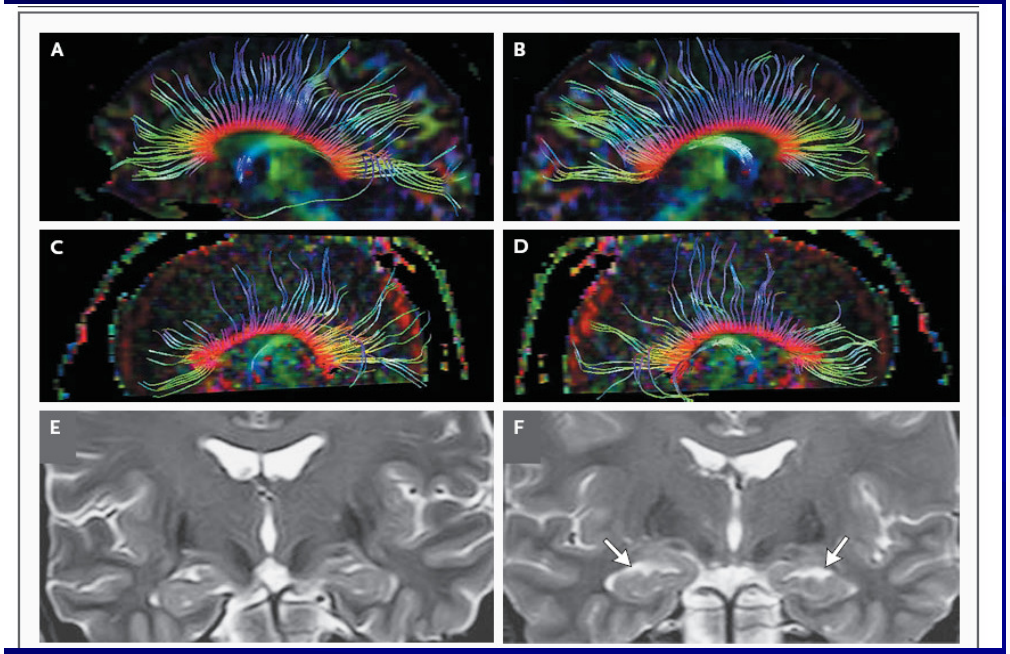
COHb (%)	Symptoms
10	Asymptomatic or may have headaches
20	Dizziness, nausea and syncope
30	Visual disturbances
40	Confusion and syncope
50	Seizures and coma
60	Cardio-pulmonary dysfunction and death

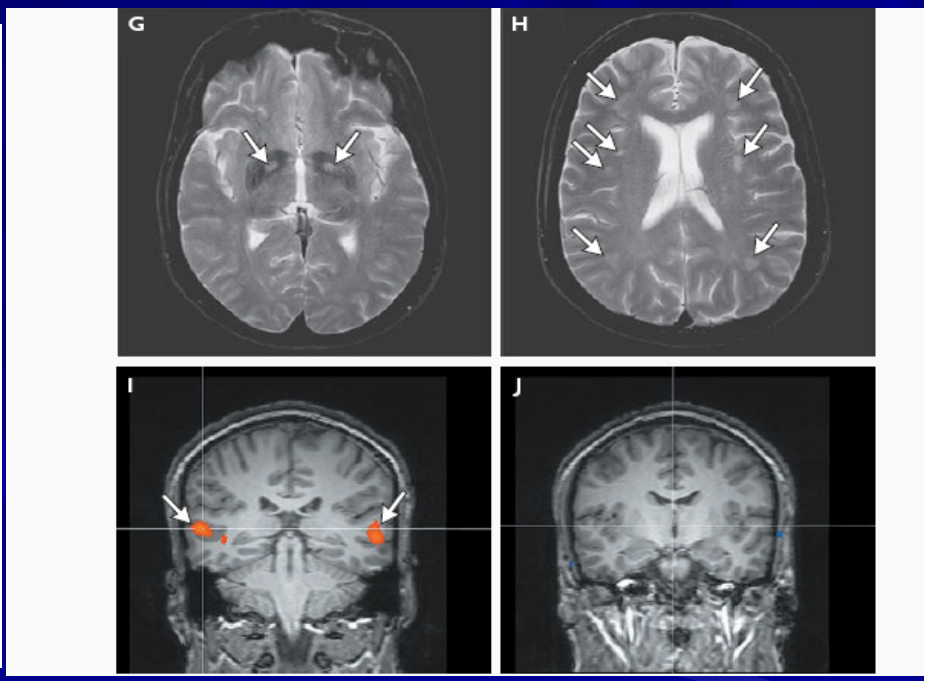
Rorison and McPherson 1992.

CO

- Danger majeur pour
  - Enfants
  - Femmes enceintes (mortalité fœtale > 50%).
- Séquelles neurologiques à long terme : +-50 %
  - moins fréquentes si traitement hyperbare (+- 25%) ?
  - Réévaluation à 30 jours: testing neuro.
- Autres organes touchés:
  - Cœur: ECG, troponine: infarctus myocardique, angor

Lésions neurologiques





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CO

- Traitement:
  - Oxygène
    - ½ vie air ambiant: 5 h
    - ½ vie sous O2 100% NRM: 80-90 minutes
    - ½ vie sous O2 hyperbare (caisson > 2 atm): 20 minutes
  - Première chose à faire: O2 100% immédiat

CO

- Traitement:
  - Indications de caisson hyperbare:
    - > 25% CO
    - Femmes enceintes, enfants
    - Symptômes neurologiques majeurs (convulsions, coma,…)
    - Souffrance cardiaque
    - Acidose sévère

Cyanure

- Produit de combustion < colles chimiques
  - P ex: parquets laminés, laines, PU,
  - Nécessite une températur e> 315°C
  - Libéré sous forme de HCN

Cyanure

- Bloque l'utilisation oxygène par tissus (cytochrome oxydase)
  - Passage en anaérobiose
  - Production acide lactique
    - => acidose métabolique
  - Élévation oxygène veineux
  - Pas d'amélioration par O_2
- Pas de technique de dépistage direct

Cyanure

- Clinique:
  - Présence d'au moins deux signes suivants
    - Atteinte neurologique: convulsion, confusion, comas
    - Suies dans la bouche ou expectorations
    - Acidose lactique > 8-10 mmol/L.
  - Choc
    - Dysfonction cardiaque
    - Instabilité hémodynamique
    - Hypoperfusion cérébrale: pétéchies, hémorragies
  - Mort subite

Cyanure: Symptomes

Table 1 **Common signs and Symptoms of Cyanide Poisoning**

Symptoms	Signs
• Headache • Confusion • Dyspnea • Chest tightness • Nausea	• Altered Mental Status (e.g., confusion, disorientation) • Seizures or Coma • Mydriasis • Tachypnea / Hyperpnea (early) • Bradypnea / Apnea (late) • Hypertension (early) / Hypotension (late) • Cardiovascular collapse • Vomiting • Plasma lactate concentration ≥8 mmol/L

Cyanure

- Dose toxique
  - Adulte: > 1 mg/L (39 µmol/L)
  - Dose létale:
    - Adulte: 2,6 – 3 mg/L (100-115 µmol/l)
    - +- 33- 87% des victimes décédées (méta-analyses)
- Traitement de base
  - Manœuvres de réanimation de base
    - Intubation si GCS < 8/15.
    - RCP
  - Correction acidose / maintient TA
  - Antidotes

Cyanure: Antidotes

- USA: Cyanid Antidote Kit
  - Mélange de drogues
    - Nitrites Amyle et NA
    - Thiosulfate Na
  - Mal toléré
    - Nitrites: MetHb
    - Hypotension
    - Choc
  - Dosage précis
  - Peu stable
  - Pas en extra-hospitalier.

Cyanure: Traitement

- France : Hydroxycobalamine (Cyanokit®)
  - HbCOb
  - Détoxifie le CN en Cyanocobalamine (vit B12),
    - Inactif
    - Eliminé par urines
  - Utilisé en France depuis 1996
    - Pompiers de Paris: extra-hospitalier
    - Études prospectives sans cas témoins
    - Modèle animal prometteur
  - Agit en 20 min, LCR en 30 min.

CYANIDE POISONING AND CARDIAC DISORDERS: 161 CASES

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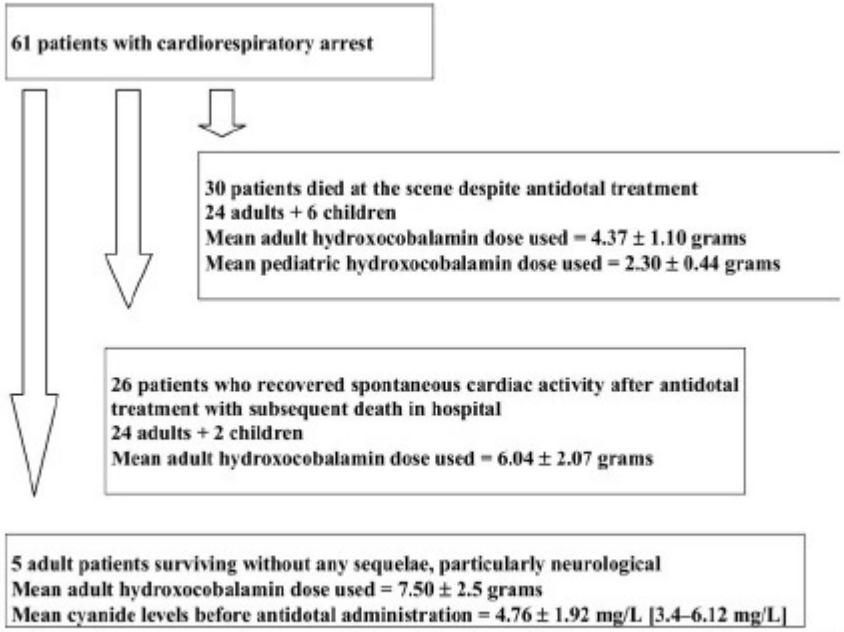

Figure 1. Outcome of patients in cardiovascular arrest after poisoning with fire smoke and treatment with hydroxocobalamin (Cyanokit®; Merck KGaA, Darmstadt, Germany [in the United States, marketed by Meridian Medical Technologies, Bristol, TN]).

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Cyanure: Traitement

- France : Hydroxycobalamine (Cyanokit®)
  - Facile d'emploi
    - Disponible en flacons de 2x 2,5g (dose adulte)
    - Reconstituer dans 100 ml SP (25 mg/ml)
    - IV lent (15 minutes)
    - Adulte: Utilisation 5 à 15 g selon réponse
    - Enfants: 70 mg/kg

Cyanure: Etudes

- Borron et al (2007), Ann Emerg Med vol 49,No6: june 2007
  - Victimes d'incendie (1987-1994)
  - 69 adultes : risque d'intox CN
    - Altération conscience
    - Suies visage, nez, expectos
  - Prélèvement CN avant hydroxycobalamine
    - Confirmer intox CN/CO.
  - 5g sur place, à répéter sn (max 15 g).
  - Morts extra-hospitaliers exclus

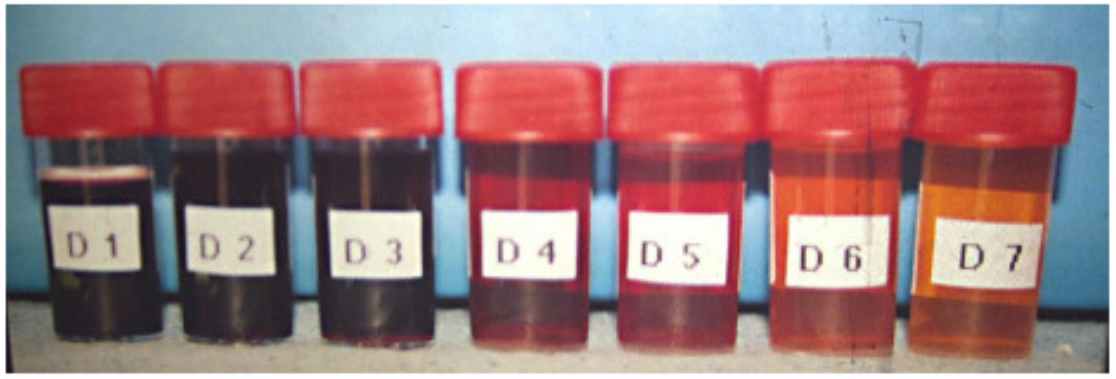
Cyanure: Etudes

Clinical Outcomes and Hemodynamic Measures	All Patients (n=69)	Cyanide Poisoning Status		Cardiorespiratory Status*	
		Present (n=42)	Absent (n=21)	Arrest Present (n=15)	Arrest Absent (n=54)
Survival rate					
Outcome, No. (%)					
Survival	50 (72)	28 (67)	18 (86)	2 (13)	48 (89)
Death	19 (28)	14 (33)	3 (14)	13 (87)	6 (11)
Decerebration, No.	13	9	2	13	0
Septic shock, No.	5	4	1	0	5
Pneumonia, No.	1	1	0	0	1
Neurologic outcomes					
Initial neurologic signs present,† No. (%)	66 (96)	41 (98)	19 (90)	15 (100)	51 (94)
Neurologic outcome, No. (%)					
Resolution	38 (58)	21 (51)	13 (68)	2 (13)	36 (71)
Neuropsychiatric sequelae	9 (14)	6 (15)	3 (16)	0 (0)	9 (18)
Death	19 (29)	14 (34)	3 (16)	13 (87)	6 (12)
Hemodynamic characteristics					
Median pulse rate, bpm (25th, 75th percentile)					
Preinfusion	98 (81, 109)	96 (79, 104)	100 (90, 115)	0 (0, 80)	100 (90, 110)
At the end of first infusion	91 (80, 105)	94 (84, 106)	89 (79, 97)	100 (81, 110)	91 (80, 100)
On arrival at the ICU	98 (80, 110)	100 (80, 100)	98 (81, 102)	104 (80, 115)	97 (80, 108)
Median systolic blood pressure, mm Hg (25th, 75th percentile)					
Preinfusion	123 (100, 140)	120 (90, 140)	130 (120, 145)	0 (0, 120)	130 (112, 145)
At the end of first infusion	140 (120, 150)	140 (120, 150)	130 (110, 150)	130 (70, 150)	140 (120, 150)
On arrival at the ICU	125 (109, 150)	125 (100, 150)	132 (115, 145)	120 (60, 150)	125 (110, 150)
Median diastolic blood pressure, mm Hg (25th, 75th percentile)					
Preinfusion	70 (60, 80)	70 (60, 80)	80 (65, 85)	0 (0, 70)	80 (70, 90)
At the end of first infusion	80 (70, 87)	80 (70, 80)	79 (60, 85)	70 (60, 80)	80 (70, 90)
On arrival at the ICU	80 (60, 100)	80 (65, 90)	90 (59, 102)	70 (47, 90)	80 (60, 100)

*Patients might have received supportive treatment (eg, catecholamines, cardiopulmonary resuscitation) that explains the presence of a pulse rate and blood pressure at the preinfusion measurements in patients in cardiac or cardiorespiratory arrest.
†Neurologic outcomes were not known for all patients.

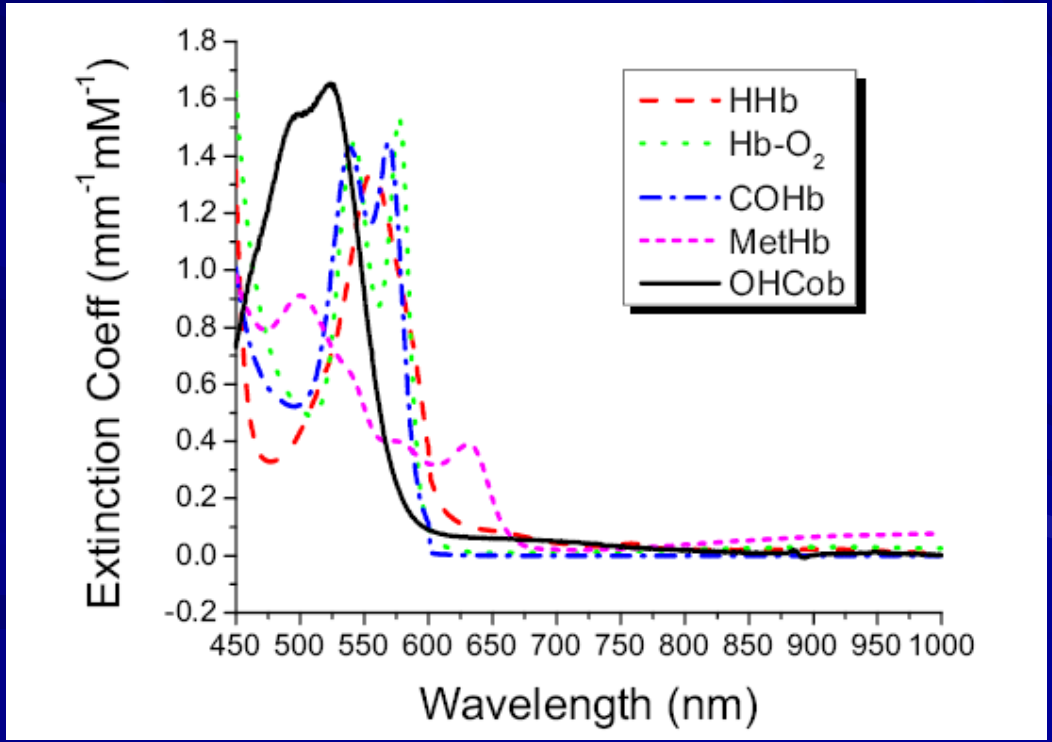
Cyanure: Etudes

- Borron et al (2007), Ann Emerg Med vol 49,No6: june 2007
  - Effets secondaires
    - Coloration peau et muqueuse (rose/rouge)
    - Coloration des urines
    - Hypertension modérée
    - Erythème



Cyanure: Etudes

- Interfère avec mesure du CO, MetHb et (augmentée).



Cyanure: modèle animal

- Borron et al (2006), *Clinical Toxicology, 44: 5-15, 2006*

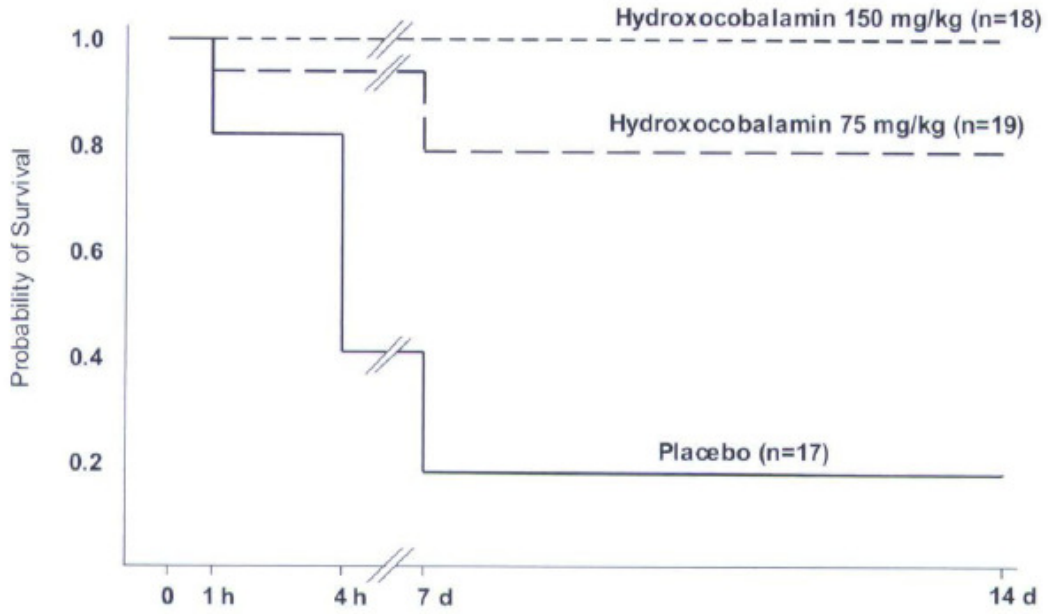


FIG. 2. Probability of survival in beagle dogs treated with hydroxocobalamin 75 mg/kg or 150 mg/kg or saline vehicle for acute cyanide poisoning.

Cyanure: Etudes

- France: Haouach et al
  - 41 enfants avec inhalation fumées (moy. 5 ans)
    - Mortalité 44% (27% sur place, 17% hôpital)
    - 70 % des vivants: tableau neurologique (CN-CO)
  - Hydroxycobalamine:
    - Mortalité 4% si pas en arrêt à la prise en charge
    - Mortalité 94% si en arrêt à la prise en charge

Conclusions

- Intoxication par fumées fréquentes
- Conséquences graves (morbi-mortalité)
- Toxiques systémiques: CO et CN
- Traitement pré-hospitalier indispensable si
  - Suies
  - Altération conscience, répercussions hémodynamiques
  - Décès?
- CO: O_2 100 % NRM
- CN: Hydroxycobalamine
  - 70 mg/kg (enfant)
  - 5 g (adulte) à répéter si nécessaire

Références

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