Firefighter Down!
Special Consideration for the Resuscitation of the Downed Firefighter

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Who Are These Guys?

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Conflicts of Interest Disclosure

Christopher Watford  
- None

Michael Herbert  
- Employed by Advanced Circulatory as a clinical educator.
- Advanced Circulatory is the manufacturer of the ResQPOD and ResQGARD.
- Advanced Circulatory has had no financial or editorial input into this presentation or its contents.
Disclaimer

- This presentation and our opinions do not reflect the views or opinions of our employers.

- We’re not speaking for them, we’re speaking for us.
Why Listen to Us?

- We are not the experts.
- We encourage you to question our assumptions.
- We encourage you to question our assertions.
- We would like you to ask for our references.
- We would like your feedback on our proposed solution to a problem.
Objectives

- Understand the epidemiology of Firefighter fatalities
- Define physiological changes during stress
- Define physiological changes during firefighting
- Define risks during firefighting
- Understand pathophysiology of HCN exposure
- Define barriers to treatment during Firefighter resuscitation
- Understand treatment goals during Firefighter resuscitation
Dedication.
Epidemiology

CDC/NIOSH Fire Fighter Fatality Investigation and Prevention Program

“Each year an average of 100 fire fighters die in the line of duty. To address this continuing national occupational fatality problem, NIOSH conducts independent investigations of fire fighter line of duty deaths. This web page provides access to NIOSH investigation reports and other fire fighter safety resources.”

http://www.cdc.gov/niosh/fire
Fatality Etiologies

Medical: 1105 (44%)
- Heart Attack: 957
- CVA: 59
- Heat Exhaustion: 9
- Other Medical: 80

Trauma: 1384 (56%)
- Crushed: 390
- MVC: 345
- Struck by Vehicle: 148
- Asphyxiation: 218
- Burns: 118
- Electrocution: 22
- Drowning: 19
- Other Trauma: 108
Trauma Fatalities

- Collapsing structures most common traumatic etiology
- Motor vehicle collisions second most common
  - Being struck by a vehicle also common!
- Asphyxiation likely if trapped or lost
Trauma Fatalities (en route)

- Rollovers very common
  - Too fast, high center of gravity, inexperience, weather

- Intersection collisions common
  - Too fast, driving without due regard

- Overuse of lights and sirens?
Trauma Fatalities (on scene)

- Working an MVC is one of the most dangerous jobs a firefighter or EMS provider will do.
- Spend more time blocking the scene
- Backers are even more important on busy fire scenes
  - Numerous fatalities from apparatus repositioning

Watford, Heribert - Firefighter Reasssessment - EMT Today 2014
Trauma Fatalities (overhaul)

- Structure collapse during overhaul is a real concern
- Toxic gasses during overhaul too
- Electrocution rare, but happens
Medical Fatalities

- Heart Attacks are the number one cause of line of duty deaths in fire fighters.
- Autopsies of firefighters include findings such as: cardiomegaly, hypertrophy, severe CAD, etc.
- Heat exhaustion fairly common during training events
- Heat exhaustion coupled with cardiovascular risks is a dangerous mix!
Focus on the prevalence of cardiomyopathy and cardiomegaly in those <35!

http://millhillavecommand.blogspot.com/2014/02/sudden-cardiac-death-among-firefighters.html
Medical Fatalities (cont.)

- CVA's are comparatively rare
- Cardiomyopathies and channelopathies should be considered in younger firefighters who collapse
- Do you know what medical problems your crew has?
  - Comorbid factors may play a large role in FF fatalities
- Certain Cancers are now recognized as resulting from Line of Duty incidents!

Watford, Heribert - Firefighter Resuscitation - EM Today 2014
Physiological Effects of Firefighting
Physiological Effects of Firefighting

Effect of live-fire training drills on firefighters' platelet number

A randomized controlled trial of aspirin and exertional heat

Psychophysiological responses of firefighters to emergencies: A review

Fabri

Effect of strenuous live-fire fire fighting drills on hematological, blood chemistry and psychological measures

Clotting and fibrinolytic changes after firefighting activities

Denise L. Smith, Gavin P. Horn, Steven J. Petruzzello, George Fahey, Jeffrey Woods
The Stress of Firefighting

- Firefighters:
  - perform strenuous physical work
  - while wearing heavy personal protective equipment (PPE)
  - often in hot environments and under physiologically stressful conditions

Watford, Heribert - Firefighter Reasssessment: IDM Today 2014
The Stress of Firefighting

- Firefighting results in **significant cardiovascular and thermal strain** as a result of:
  - strenuous work
  - heavy and insulating PPE
  - psychological stress
  - environmental extremes
Physiology of Stress in Firefighting

**Strenuous firefighting activities can lead to:**
- Attainment of maximal HR
- Elevated core temperature
- Dehydration
- Decreased stroke volume
- Increased arterial stiffness
- Alterations of myocardial function
Results: In the 20 minutes after arousal, no changes were seen in overall QT/RR relationship in any of the groups. However, marked T-wave morphology changes, including T-wave inversion, were observed in all the arousal events. Postural changes only accounted for a small proportion of change in T-wave morphology.
Subendocardial Viability Ratio (SEVR) provides an estimate of the arterial system’s ability to perfuse myocardial tissue (i.e., supply oxygen to the heart muscle), in order to meet the heart’s energy requirements. If SEVR decreases from baseline levels, the heart will be faced with a reduced energy reserve, potentially resulting in lower tolerance for strenuous physical activities such as fighting a fire.

Rate pressure product is a measure of the stress put on the cardiac muscle based on the number of times it needs to beat per minute (HR) and the arterial blood pressure that it is pumping against (SBP). It will be a direct indication of the energy demand of the heart and thus a good measure of the energy consumption of the heart.
Is a reduced SEVR and increased RPP related to sudden cardiac events during firefighting?
Encourage folks to push for more research through advocacy groups.
The increase in platelet number likely reflects a combination of hemoconcentration (i.e., the 5-7% decrease in plasma volume) and a release of platelets from the spleen and lymph tissue secondary to sympathetic nerve stimulation.

Platelet aggregation was enhanced following fire fighting activity (as evidenced by a shorter time to occlusion) and remained elevated following 120 minutes of recovery. The decreased closure time that persisted even after 120 minutes of recovery suggests that there is an increased risk of thrombosis at least 2 ½ hours after completion of short bouts of fire fighting activity in relatively young, healthy firefighters.

HCT: Closure Time decreases with an increase in Hct

Platelet count: Closure Time decreases with an increase in platelet count
Platelet number and function. Platelet number increased significantly immediately postfirefighting (P<0.001) and returned to baseline values 2 h postfirefighting.

When the blood was exposed to collagen and EPI, platelet closure time decreased significantly immediately postfirefighting (P<0.05) and then returned toward baseline, although it remained significantly lower than baseline at 2 h postfirefighting (P<0.05).

Platelet closure time when the blood was exposed to collagen and ADP decreased significantly after firefighting activity (P = 0.018) but was not different from baseline 2 h postfirefighting.

Reported reference ranges for closure times are:
78 - 199 seconds for the CEPI cartridge
55 - 137 seconds for the CADP cartridge

a system for analysing platelet function in which citrated whole blood is aspirated at high shear rates through disposable cartridges containing an aperture within a membrane coated with either collagen and epinephrine (CEPI) or collagen and ADP (CADP). These agonists induce platelet adhesion, activation and aggregation leading
to rapid occlusion of the aperture and cessation of blood flow termed the closure time (CT).
Several fibrinolytic factors reflected a transient increase in fibrinolysis (Table 5). t-PA activity and antigen were elevated immediately postfirefighting (P = 0.007 and P = 0.005, respectively), but there were no significant differences between prevalues and 2 h postvalues (P = 0.664 and P = 0.947, respectively). There was also a significant effect of time on PAI-1 activity. Post hoc analysis revealed that PAI-1 activity was significantly lower both immediately postfirefighting and 2 h postfirefighting than prefirefighting (P = 0.027 and P = 0.020, respectively). PAI-1 antigen did not differ significantly between pre- and immediately postfirefighting but was significantly lower 2 h postfirefighting than prefirefighting (P<0.05). When PAI-1 antigen levels were corrected for changes in plasma volume, there was no significant time effect.
TF, uncorrected for changes in plasma volume, was significantly increased immediately postfirefighting compared with 2 h postfirefighting ($P = 0.018$). However, when corrected for changes in plasma volume, TF did not vary significantly with time, suggesting that hemoconcentration was primarily responsible for this change.

FVIII increased significantly immediately postfirefighting ($P<0.001$) and remained elevated at 2 h postfirefighting ($P = 0.002$). AT-III did not change significantly over time ($P = 0.055$), although there was a strong trend for AT-III to be higher after firefighting and in the recovery period.

aPTT decreased significantly immediately postfirefighting ($P = 0.025$) and remained significantly below baseline at 2 h postfirefighting ($P = 0.032$).
Factor VIII increases post-fire fighting and remain elevated at 120 minutes into recovery, but Fibrinolytic variables that increase post-fire fighting return to near baseline levels after 120 minutes of recovery, suggesting a potentially hypercoagulable state in the hours after fire fighting.
Risks of SCA during Firefighting

- 2007 study by Kales and coworkers clearly demonstrated that the relative risk of suffering from a fatal cardiac event was 10–100 times greater following fire-suppression activities than during non-fire duties.

Watford, Harbert. Firefighter Resuscitation. IDE Today 2014
Summary

- Studies suggest there is an increased risk of thrombosis due to a procoagulatory state, hours after firefighting.
- In effect an increased vulnerability to myocardial infarction after fighting fire.
How do we address this?

- NIOSH and NFPA stress **Prevention** and **Detection** as the key!
- Reduce **modifiable** risk factors
  - Fitness and Nutrition Programs
  - Smoking Cessation Programs
- Screening and Detection
  - **Annual Physicals**
  - Assessment of **Cardiovascular Risks**

NFPA 1582.
Chemical Exposures during Firefighting
Let’s concentrate on the “toxic twins”…

“I’m not talking about Steven Tyler and lead guitarist Joe Perry of Aerosmith.”

<wait for audience to laugh, or not>
Toxic Twins

Hydrogen Cyanide  Carbon Monoxide
Cyanide

- Extremely poisonous, colorless chemical, with faint almond smell.
- 24 times more toxic than CO
- Synergistic toxicity with CO
- IDLH – 50ppm
- NIOSH REL – 5ppm
- OSHA PEL – 10ppm
Pathophysiology of Cyanide

- Histotoxic hypoxia
  - Inability of cells to take up or utilize oxygen from the bloodstream
  - Despite physiologically normal delivery of oxygen to such cells.

- Inhibits cytochrome C-oxidase
Relate personal anecdotes of headache after fire fighting. Often ignored!

How many trapped/lost LODD’s were due to “loss of judgment”? Could CN/CO exposure be the causal factor?
Cyanide Poisoning

- Cyanide exposure:
  - Expected in those exposed to smoke in closed-space fires
  - Important cause of incapacitation and death in smoke-inhalation victims
  - Cyanide can act independently of, and perhaps synergistically with, carbon monoxide to cause morbidity and mortality ("Toxic Twins")
Columbia Fire Department Study

- Eight month study monitoring CO and HCN at fires.
- Found extremely high HCN levels at calls
- Found no correlation between CO and HCN production

Used with permission from Capt. Steve Jones - Burlington Fire Dept
Food for thought...

- Air monitoring of these firefighters at this moment found HCN levels to be:

38 ppm

Used with permission from Capt. Steve Jones – Burlington Fire Dept.
5 g infused over 15 minutes (15 mL/min) for the loading dose. A second 5 g infusion over 15 minutes – 2 hours may be indicated.

The definitive answer on Cyanokit in downed firefighters is not known. Best available evidence says you should consider it, if you have a strong suspicion of cyanide exposure. Just giving it to give it may not be safe.

Have discussion between key stakeholders (fire, EMS, hospital) as to the best approach to managing suspected CN exposures: EMS carrying on all units, supervisor units only, hospital only?
Special Considerations during Resuscitation
Reference Houston Southwestern Inn LODD report.

Determining the Etiology

- RIT has just rescued a downed firefighter.
  - Does not appear to be breathing.
- Is it trauma?
  - Blunt? Penetrating?
  - Asphyxiation?
- Is it medical?
- Does it matter initially?
Getting them out of their gear!

- Extrication.
  - We’re at an impasse until we get these guys out of their turnout gear.

- Their gear is going to be hot, wet, maybe even contaminated.

- Their gear is in the way of what we need to be doing: Chest Compressions!
HHIFR Video: https://www.youtube.com/watch?v=dfTP6fDP_dl
Video URL TBD.

Coming soon: http://www.fd-cpr.org
Treatment order: CPR, H’s & T’s.

Use likely etiology to prioritize H’s & T’s treatments.
Your Plan?

- What is your plan for:
  - EMS response to structure fires?
  - Rehab?
  - RIT?
  - Downed firefighters?
  - Cyanide exposure?
FD-CPR References

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- **Leland Volunteer Fire/Rescue Department**
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- **FD-CPR**
  - http://www.fd-cpr.com (Coming Soon!)
  - http://www.facebook.com/fd-cpr (Coming Soon!)
References

- NIOSH Fire Fighter Fatality Investigation and Prevention Program.
  - http://www.cdc.gov/niosh/fire/


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