Fire-related death: An unusual histopathologic clue of forensic relevance

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Abstract. Fire-related deaths are issues for forensic pathologists particularly in ascertaining if death occurred before or during fire. The authors highlight a unique bronchiolar epithelial cytological clue (nuclear heat-induced elongation) determined by active inhalation of hot gases and fumes, not yet described in the literature at distal small airways level.

Key words: Fire-related death, viability, light microscopy, bronchiolar epithelium.

INTRODUCTION

Fire-related deaths are always challenging for the medical examiner because not frequently judicial autopsy are performed on extensively burned bodies.

One and perhaps the most important critical task for the medical examiner in fire-related deaths is to ascertain if the deceased was burned alive or already dead.

Usually, the two most employed findings to solve the forensic problem arise from lung light microscopy and cadaveric blood toxicological analysis.

In our routine, we generally look for the presence of "soot" inside bronchioles and alveoli after extensive lung tissue sampling (at least one sample of tissue from each pulmonary lobe).

A rapid survey of lung parenchima with light microscopy after H&E suffices.

This constitutes a reliable light microscopy morphological evidence of active inhalation of combustion fumes immediately before death.

An abnormally elevated carboxyhemoglobin (FHbCO) percentage in cadaveric blood, is the second data recorded.

FHbCO is easily determined by subjecting a small quantity (less than 1 ml) of cardiac blood to an oximeter readly available in our "emergency departement" (Maeda et al., 1996 and Brehmer and Iten, 2003).

If the value obtained is high enough (far above 10%) it offers an "intra autopsy" proof of active respiration (ventilation plus diffusion) of smoke produced by the fire. In this report our aim is to highlight an unusual "light microscopy" clue that can help in assessing that the decedant was breathing (alive) during fire.

CASE REPORT

A caucasian man, aged 85, was found dead in a wood shack, almost completely burned by fire. He used to store some tanks of fuel for his agriculture machines inside the shack.

The body was found almost already carbonized by fire especially at limbs level with the exception of the dorsal and lumbar regions.

According to topography of the most or least burned body areas, the fire origin was situated in front of the foot of the decedent.

The fire fighters believed that the fire origin was to be referred to the ignition of the tanks stored, an intense blaze developing immediately after.

The physician of the decedent excludes noted illnesses. He confirmed that his patient was a heavy cigarette smoker.

A complete autopsy was performed.

The hearth was structurally normal but a critical focal DIV stenosis was noted and the stenotic coronary tract sampled for routine “light microscopy”.

A full sampling was performed for forensic histopathological study of the case, comprehensive of a transversal section of the ventricles and a fragment from the deep parenchyma of each lung lobe to avoid any external heat parenchimal distorsion.

The “intra autopsy” oxymetric hemoglobin analysis of post-mortem cardiac blood yielded a FHbCO value of 40% which inform the law enforcement agents that the deceased was alive during burning.

The forensic histopathologic examination, conducted in the usual manner (light microscopy of tissue micro sections H&E stained) confirm severe coronary stenosis and the occlusion of the vessel by recent thrombus.

Extensive myocardial “contraction band” necrosis definitely allowed to ascertain acute cardiac ischemic attack due to the sudden thrombotic occlusion of the stenotic middle tract DIV.

Soot was easily found in bronchioles and in alveolar spaces.

The case was classified as fire-related death caused by accidental ignition of fuel stored in tanks due to an ischemic cardiac attack suffered during smoking a cigarette near fuel tanks. The deceased was judged “alive during burning”.

RESULTS

A careful examination of lung parenchyma with light microscope allowed to note well preserved respiratory epithelium of membranous bronchioles, an unusual finding in autopsy material due to post-mortem alteration.

The well preserved bronchiolar epithelium shows a noticeable cytoabnormality, regarding the nuclear shape. All nuclei (ciliated or basal cells) appear to be elongated centripetally, sometimes appearing stretched or assuming a “worm shape” (figure 1).

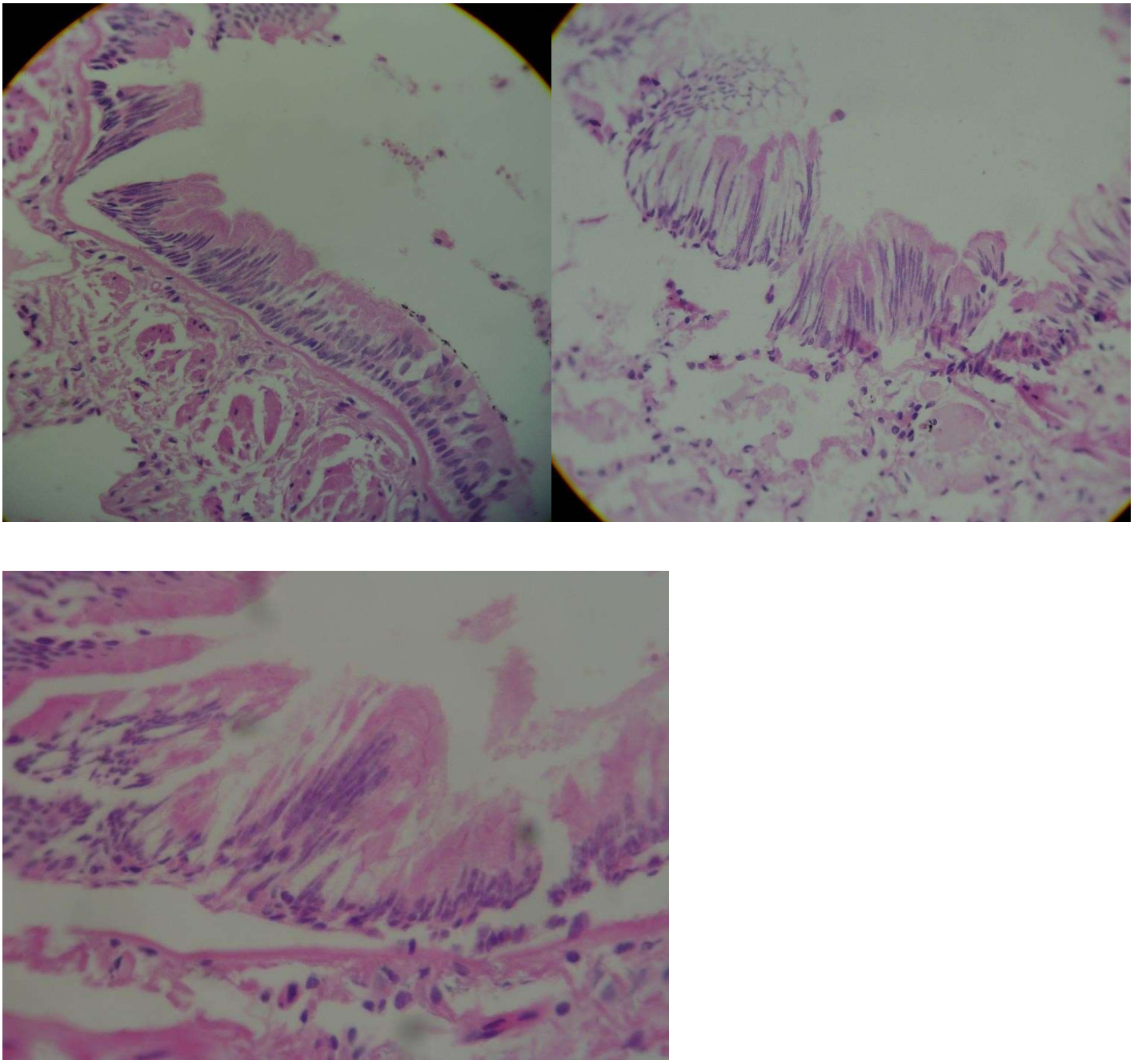


Figure 1. Abnormally elongated (“worm shaped”) nuclear shape of bronchiolar epithelial cells. Note the normal

The elongation of nuclear shape confers an unusual image of “nuclear crowding” in the respiratory epithelium when an oblique section of bronchiole is examined (figure 2).

nuclear shape of the connective tissue cells sourrounding bronchiole. H&E, x400.

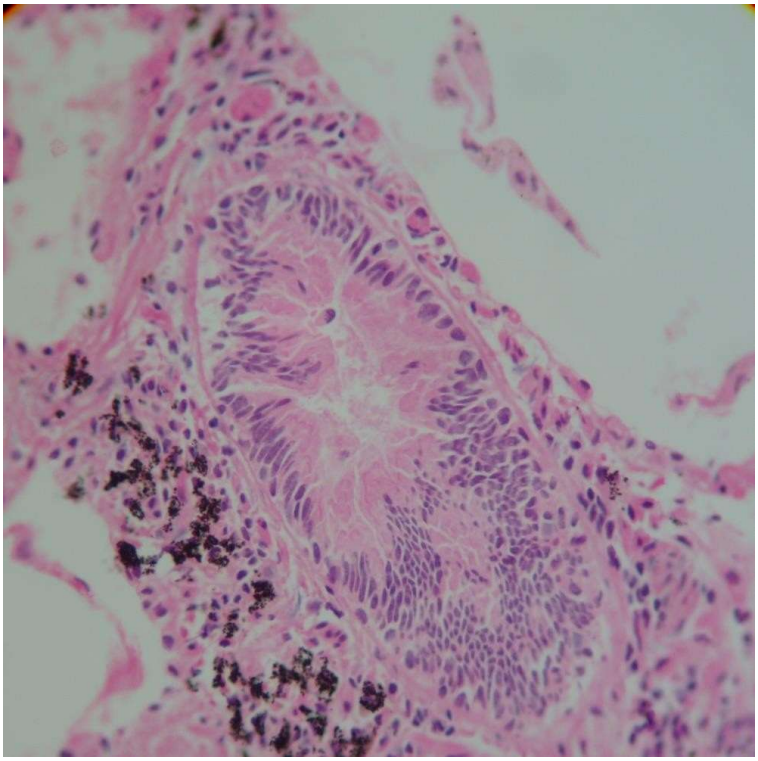
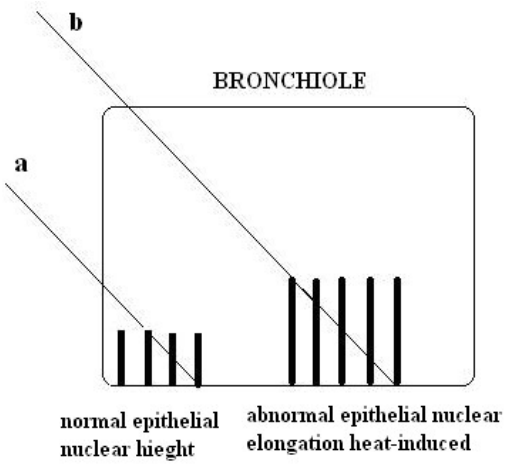


Figure 2. Epithelial nuclear crowding in oblique bronchiolar section. H&E, x250.

In case of oblique histological section of a bronchiole, the more elongated the nuclei are, the more numerous they will be sectioned by the microtome knife and the more numerous they will appear stained in the bronchiolar wall. Hence the crowding induced by heat-elongation.

The sketch below exemplifies the mechanism of nuclear crowding heat-induced.



plane a: 3 bronchiolar epithelial cell nucleus evident in the margin of oblique bronchiolar section

plane b: 5 bronchiolar epithelial cell nucleus evident in the margin of oblique bronchiolar section

In association with the nuclear stretching and crowding, one can note mucous secretion melted by heat (figure 3).

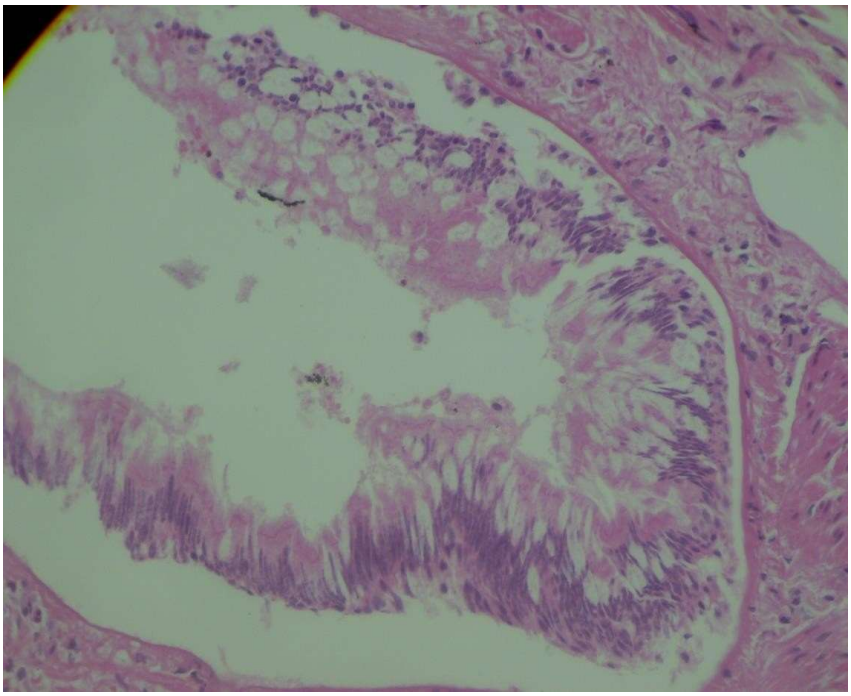


Figure 3. Epithelial nuclear crowding, elongation and mucous melting in oblique bronchiolar section. H&E, x250.

DISCUSSION

In fire-related deaths, the viability of the burning person is based on lasting respiratory activity.

If the respiratory activity was working, the decedent inevitably inhaled combustion fumes.

Fumes are usually constituted of particulate matter (soot) that deposits at bronchiolar and alveolar level. Soot can travel so far away only in case of vigorous efficient breathing (Peranantham et al., 2014).

Sometimes, for example in case of blaze, soot is not the only forensic relevant constituent of combustion fumes that contain also “hot gases”.

Hot gases, when present, must be inhaled, together with soot, till bronchioles and alveoli and if inhaled vigorously they have to determine “heat damage” at bronchiolar epithelial level (Dries and Endorf, 2003; Cox et al., 2015).

The abnormal elongation of the epithelial cell nucleus is the known forensic histopathological hallmark of the cellular heat shock, for example “electrical mark” (U¨zun ed al.,2008).

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The role of thumb is that major axis of nuclear elongation follow heat transfer direction from hotter site to cooler one.

So if a burning person retains efficient respiratory activity and inhaled hot fumes, the bronchiolar epithelium inevitably suffers a heat shock.

Consequently, the light microscopy hallmark must be an abnormal elongation of the epithelial nuclei oriented radially from the center of the bronchiolar lumen containing hot gases.

This is what was microscopically found in the forensic case reported above.

To avoid a light microscopy false positive due to “external heating cellular distortion” of the lung, connective cells and alveolar pneumocytes in tissue around the bronchioles must show usual nuclear morphology.

This heat shock of respiratory epithelium is already described in the bronchial (second and third order) where passive diffusion of warm gases could be still possible (Brinkmann and Püschel, 1978;

Foerster, 1933; Dettmeyer, 2011). The same finding at bronchiolar level is incompatible with passive diffusion, instead requires active inhalation of hot gases.

Probably this “light microscopy” nuclear alteration at bronchiolar level is not yet subjected to reporting because of the fragility of the bronchiolar epithelium that almost always tend to desquamate into the lumen impeding a clear nuclear shape evaluation in light microscopy.

CONCLUSIONS

The author thinks that an earnest handling of the autopsy lung specimens and a careful search for this “light microscopy” nuclear clue at bronchiolar level could aid the forensic pathologist in the interpretation of fire related death in regard of assessment of the viability of the deceased during fire.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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