Post Mortem Computed Tomography as an important tool in establishing a cause of death in fire fatalities

Anne Marie Andersen*, Lene Warner Thorup Boel

Department of Forensic Medicine, Aarhus University, Brendstrupgaardsvej 100, 8200 Aarhus N, Denmark,

*AMA@forens.au.dk

INTRODUCTION

In the forensic assessment of a severely burned body the question of whether the victim was still alive when exposed to the fire, as well as establishing the cause of death, is of crucial importance. The examination of a burned body is often a challenge due to postmortem consumption by the fire, and the external findings are often inconclusive. Consequently the internal findings are all the more important. The most important internal signs of vitality are soot deposits in the respiratory tract, the esophagus and the stomach as well as elevated CO-Hb values in the blood. In toxicological investigations of cause of death, CO-Hb concentrations above 50 % are considered lethal. In some cases where the bodies are severely charred, it can be difficult to obtain a suitable specimen for CO-Hb testing.

Post Mortem Computed Tomography (PMCT) has shown to be a valuable tool facilitating conventional autopsy also in fire fatalities [1-5]. In 2008 The Institute of Forensic Medicine in Aarhus obtained a Siemens Somatom Definition 64 slices CT-scanner and a full body scan before medico-legal autopsy is now a routine examination. Three routine scanings are performed: head, torso and extremities. Here we present two cases of fire fatalities where PMCT proved to be an important factor in establishing the cause of death.

CASE REPORTS

Case 1 (figs. 1a-c): In a completely burned-out car, parked in a wood, an unidentified, charred body was found on the driver's seat. The license plate was relatively intact, and the owner of the car was registered to be a 45-year-old woman. The woman's husband gave information to the police that she had been mentally unstable lately. Some years ago she had been hospitalized due to mental health problems, and she had once tried to commit suicide. The morning on the day on which the body was found the woman had taken their 14-year-old daughter to school, and nobody had seen her since.

The external examination revealed a severely burned and charred female body with loss of soft tissue, thermal amputation of the distal extremities and partial thermal destruction of the cranium. The conventional autopsy revealed that all internal organs were affected by the heat with shrinking and charring. The organs, muscles and the blood had a cherry-red color. In the pharynx, respiratory tract and the esophagus great amounts of soot deposits were found. Remnants of blood was found in the heart and aorta, but it had changed into a thick, modeling wax-like texture, and was not

suitable for CO-Hb testing. The corpse was identified by the forensic dentist to be the suspected victim.

Before autopsy, the routine PMCT was performed. The head scanning was performed with a tube voltage of 140 kv and 500 mAs; a beam collimation of 1 mm and pitch 0,75, the torso scanning with tube voltage of 120 kv and 300 mAs; a beam collimation of 1,5 mm and pitch 0,5, and the extremity scanning with tube voltage of 120 kv and 200 mAs; a beam collimation of 1 mm and pitch 0,85. Images were analyzed by a deputy chief pathologist and afterwards by a specialist in radiology.

The radiological examination revealed artifacts due to charring and shrinking and challenged the evaluation of the CT images. However, it was possible to localize an area in the ascending aorta, where a small air bubble appeared, and we interpreted this as if the vessel was still containing fluid blood. No blood was clearly visible in the heart chambers. This information was given to the forensic pathologist before the autopsy, thereby enabling her to optimize the anatomical location for aspiration of blood. After opening of the chest, but before the evisceration and guided by the CT images, the syringe was placed in ascending aorta. An ample amount of blood was aspirated and analyzed to establish the CO-Hb level as well as the blood was used for alcohol and drug analysis.

Additionally the radiological investigation showed a pelvic fracture on the left side (caused by heat), and fragmented bones in the arms, legs, chest and skull.

Toxicological analysis revealed that her carbon monoxide level was 57 % saturation. Additionally it showed that she had a concentration of morphine at 0,55 mg/kg in the blood, which was considered consistent with lethal intoxication. No alcohol was detected in the blood. CO-Hb was measured by a spectrophotometric method as described by Pannell et al. [6]. Qualitative and quantitative analysis for ethanol in urine and blood was performed using headspace dual column gas chromatography and flame ionization detection (HS-GC-FID) with t-butanol as internal standard. Qualitative screening for buprenorphine, amphetamines, opioids, benzodiazepines, cocaine, and benzoylecgonine in blood was performed by LC - time of flight mass spectrometry (LC-TOF MS). Qualitative and quantitative analysis for acidic and neutral compounds in blood was performed using protein precipitation and LC and tandem mass spectrometry (MS-MS). Quantitative analysis of other compounds in blood was performed using SPE or liquid-liquid extraction with GC-MS or LC-MS-MS separation and detection.

Histological examination revealed soot deposits in the lower respiratory tract, thus confirming the diagnosis. The cause of death was established to

be carbon monoxide poisoning in combination with morphine intoxication. The manner of death was believed to be suicide. The car was sent to technical analyses, but it was not possible to determine how the car was set on fire, as it was completely destroyed by the fire.

Case 2 (figs. 2a-b): At a parking place in a natural resort a heavily burning car was found. The on-site commander from the fire brigade concluded that the fire had started in the cabin. When the fire had been put out, a severely burned and charred man's body was found on the driver's seat. Again the license plate was relatively undamaged, and the owner of the car was registered to be a 55-year-old retired school teacher. The man's wife had told the police that her husband had been suffering from depression, and he was currently receiving medical treatment for his disease. Information of which medication he was prescribed was not available. He had been hospitalized at the psychiatric hospital and had previously tried to commit suicide by taking an overdose of pills. The wife had noted that a 5 liter petrol can was missing from the garage, but apparently none of her husband's medication was missing.

The external examination revealed the body of a man, severely charred and carbonized. Enclosing the body, remnants from the burned car and from the man's clothes and shoes were found. The cranium was burned and fractured with brain tissue exposed. The torso and abdomen were severely burned and destroyed, and the internal organs were exposed and partly carbonized. The arms were seen in pugilistic attitude, and the hands were destroyed. The legs were burned and the bones were exposed. On the back and buttocks areas with intact skin were found, but no cherry-red livores could be demonstrated for certain. The conventional autopsy revealed a heat haematoma in the skull, and in the respiratory tract soot deposits were seen. In the aorta arteriosclerosis of moderate degree was found. The corpse was identified by the forensic dentist to be the suspected victim.

As in the first case, a PMCT was performed before autopsy, the scan parameters were the same as in case one. The data were in this case analyzed by a deputy chief pathologist and an experienced forensic laboratory technician trained in analyzing CT-images. Again the radiological investigation revealed a small air bubble, this time in the aorta arch, which had to be tantamount to the fact that this vessel was still containing fluid

blood suitable for analysis. Furthermore, it showed the crushed skull, burned brain tissue and arteriosclerosis in aorta. No old or new fractures in the legs, arms or pelvis were seen. The toxicological analysis established the CO-Hb level to be 30 % saturation, which was considered to be consistent with serious or lethal intoxication. Furthermore it showed a concentration of venlafaxine in the blood at 0,19 mg/kg, O-desmethylenlafaxine at 0,53 mg/kg (decomposition product in venlafaxine), Mirtazapine at 0,14 mg/kg and Oxazepam at 0,13 mg/kg, all of which were considered to be

Figure 1b. 3D image of the deceased.

Figure 1c. CT scanning of the heart and ascending aorta. The arrow indicates where the sample was taken.

Figure 1a. The deceased as she was found in the remains of the car.

consistent with level of treatment. No alcohol was detected. Histological examination revealed soot deposits in the respiratory tract. The cause of death was determined to be carbon monoxide poisoning in combination with combustion.

DISCUSSION

Over the recent years, imaging methods have gained increasing ground in the context of forensic post-mortems, where PMCT prior to the postmortem in particular has proved useful. Using PMCT, important information supplementary to the traditional postmortem is obtained and in addition, PMCT provides insight into areas not routinely investigated during the postmortem, for example the facial skeleton, cervical spine, arms and legs [1,3].

In cases of charred bodies CT scanning has also proven to be a valuable tool in the forensic documentation and examination [2,4,5]. CT examination has made it possible to document heat related injuries such as epidural haematoma, fractures and gas embolism to the heart and liver. CT scanning is obviously not suitable for discovering soot aspiration or an elevated carbon monoxide concentration in the blood, which are the two most important vital signs [4,7]. Soot aspiration must be looked for during autopsy and toxicological analyses must establish an elevated CO-Hb, if present. It must be kept in mind though, that if the body has been greatly destroyed by the fire, the presence of soot is uncertain, as it may be due to passive deposition [7]. Therefore, it is of critical importance to be able to collect a suitable sample of blood from all cases of burned bodies.

Recently postmortem minimally invasive image-guided percutaneous biopsy has also become more of interest to the professionals. In the Virtopsy® project in Switzerland the main goal is the development of minimally invasive techniques for postmortem examination of the body and a postmortem minimally invasive biopsy is a necessity for definitive diagnosis within the concept of image-guided postmortem virtual autopsy [3,8]. The research group has developed a technique for postmortem minimally invasive angiography, injecting contrast medium into the entire vascular system with the aid of a modified heart and lung machine. PMCT scanning is then performed in order to represent the body's vascular system in 3D, thereby enabling any vascular defects, abnormalities and sources of bleeding to be located before the conventional postmortem autopsy, where it can be difficult to visualize the vessels [9,10]. To avoid artifacts, sample collections for toxicological analysis (cerebrospinal liquid, vitreous humor, peripheral and cardiac blood, bile and urine) are done before the contrast agent is injected. During a native scan, radiopaque markers are placed in areas on which biopsy will be performed and the sample collections can be done [11]. In another study the research group has demonstrated, how a small collection of subcutaneous liquid, suspected to be infectious in nature, in an extremity can be collected under CT guidance [12]. In a study from Bern, a CT data-based navigation system for guiding the biopsy needle has even been constructed [8].

When death has occurred the components of blood are separated by gravity, which leads to typical fluid levels in blood-filled cavities, such as the major vessels and cardiac cavities [13]. This can often be observed on PMCT images, even though MRI is superior for this purpose. In our two cases the bodies were so severely charred, so there was not enough blood was left to create any fluid level. Instead we noticed in both cases a small air bubble in the aorta, which as expected showed to represent small

Figure 2a. The deceased as he was found in his car.

Figure 2b. CT scanning of the aortic arch. The arrow indicates where the sample was taken.

areas still containing fluid blood. We collected the blood samples during autopsy, guided by the CT image, since we have not yet implemented methods for proper CT guided biopsies as described above. In cases like the two described, we believe, that this approach is desirable as it is quick, easy and does not put the forensic pathologist in any risk for radiation

exposure. We have demonstrated in two cases, how CT scanning images can act as a guide for selecting an anatomical location during autopsy for aspiration of blood suitable for analysis. In both cases an elevated CO-Hb concentration was found in the blood, thereby assisting in determining both the cause and manner of death.

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