Legal Medicine 11 (2009) 4–9

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Injuries due to sharp trauma detected by post-mortem multislice computed tomography (MSCT): A feasibility study

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ARTICLE INFO

Article history:
Received 15 April 2008
Received in revised form 2 July 2008
Accepted 8 July 2008
Available online 23 August 2008

Keywords:
Virtopsy
Sharp trauma
Forensic imaging
Post-mortem imaging
MSCT

ABSTRACT

Modern cross-sectional imaging techniques are being increasingly implemented in forensic pathology.

In order to assess the practicability of such a method, namely post-mortem multislice computed tomography (MSCT) in cases of fatal cut and stab injuries, 12 corpses underwent such an examination prior to forensic autopsy.

The questions regarding detection of foreign bodies, wound channels, skeletal and organ injuries, as well as the cause of death were addressed at MSCT and autopsy. The results of the two techniques revealed that post-mortem MSCT a useful tool in the assessment of such injuries.

1. Introduction

Fatal injuries due to sharp trauma are common in everyday forensic practice, be it in a homicidal, a suicidal, or in an accidental setting. The main common denominator of the injury-inflicting objects in sharp trauma is that they can pierce and slice the human body and thus cause internal damage. Death due to this harming of the body's integrity is manifold; exsanguination by injury of blood vessels is the most frequently encountered form. However, death due to air embolism, haemopericardium, etc. are also encountered regularly.

In the assessment of sharp trauma, issues such as the wound morphology, which may help to determine the type of weapon involved, the number and location of the injuries, the wound channel, the injuries inflicted to the soft tissues and the skeleton, as well as the cause of death should always be addressed in order to evaluate a possible third party involvement and to undertake an incident reconstruction.

In traditional examination techniques, stab wound directions are examined by painstakingly dissecting layer by layer of the surrounding tissue. This method is excessively time-consuming and can harm previously intact structures in the immediate vicinity of the wound channel, thus complicating the differentiation between perimortal and post-mortal injury. Another method for detecting a stab wound direction consists of inserting a probe or otherwise comparable object into the wound. This method is generally regarded as being obsolete, as, besides the possibility of damaging intact structures, there is a great risk of displacing potentially crucial traces into the wound depth. Gas embolism, an often encountered and vital sign in stabbing, is difficult to detect upon opening the body.

These problems may be countered by the non-invasive method of post-mortem imaging. The conventional approach involving X-rays is sufficient to detect foreign bodies, gross osseous lesions and gas, but reduces a three-dimensional corpse to a two-dimensional image, thus complicating reconstructive attempts.

In the past decade, post-mortem radiology has grown from a simple autopsy-assisting X-ray to a veritable forensic field of its own. With the advance of medical technologies such as computed tomography (CT) introduced by Hounsfield and Cormack in the early seventies, new possibilities became available for forensic pathologists. A first CT scan was performed on a victim of a gunshot injury to the head as early as 1977 [1] and authors such as Brogdon [2], Vogel [3] and Donchin et al. [4] have mentioned the usefulness of radiology in forensic medicine.

With the invention of spiral computer tomographs, two-dimensional reconstructions of radiological images in every possible plane or even three-dimensional reconstructions are possible. These multislice computed tomographs (MSCT), which have become everyday clinical standard, have been implemented in forensic pathology by different groups with promising results [5–9], also regarding sharp trauma [10,11] and disaster victim identification [12].

In order to assess the practicability of post-mortem MSCT in assessing the main forensic questions in cases of sharp trauma,

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doi:10.1016/j.legalmed.2008.07.001

namely the amount and location of these injuries, the depth, the injuries inflicted to organs and skeletal structures, the wound channel and the cause of death, we performed MSCT prior to forensic autopsy on 12 corpses.

2. Materials and methods

Twelve bodies of persons who died due to sharp trauma which were delivered to our institute were included in this study. Apart from one case, which showed slight signs of putrefaction after a post-mortem interval of roughly one week in a forest under cold ambient conditions, no signs of decay were seen. The male:female sex ratio was 7:5. The average age was 42 years.

An overview of the case circumstances is shown in Table 1.

The corpses were wrapped in artefact-free body bags (Rudolf Egli AG, Bern, Switzerland). MSCT scanning was executed on a Somatom Emotion 6 scanner (Siemens Medical Solutions, D-91301 Forchheim, Germany) with 4×1.25 mm collimation. The reconstruction interval was 0.7 mm. This scanning procedure took approximately 10 min.

The corpses underwent autopsy by board-certified forensic pathologists after scanning.

Using a Leonardo workstation (syngo CT software, Siemens Medical Solutions, D-91301 Forchheim, Germany), two- and three-dimensional (2D and 3D) reconstructions were calculated and assessed retrospectively by two persons, of which one was a radiologist or a forensic pathologist experienced in post-mortem imaging. The duration of the interpretation of the images varied between about half an hour to over an hour, depending on the complexity of the findings.

In each case, the following questions were addressed:

- Detection of foreign bodies.
- Wound channel.
- Organ and skeletal injuries.
- Cause of death.

As the question regarding the wound morphology is best answered by external examination, we refrained from addressing this topic.

The wound channel through the body was examined regarding the presence of gas or blood in the soft tissues and/or distinct injuries to cartilage or bones.

Foreign bodies were sought for by screening the body with scout images and subsequent 2D and 3D reconstructions.

Internal injuries were either seen as a direct lesion within an organ or bone, or were assumed to be present in an organ lying on the wound track even if injuries to the organ itself were not visible.

The determination of the cause of death was performed based on the internal injuries sustained (e.g. severe cerebral trauma with cerebral oedema or cardiac injury). The finding of a collapsed superior vena cava, main pulmonary artery, or right pulmonary artery was seen as being highly indicative of a fatal haemorrhage, according to Aghayev et al. [13]. Gas within the right cardiac chambers and in the vascular system without cardiopulmonary resuscitation attempts implied a gas (air) embolism as the most likely cause of death [14].

The results of each of the above questions obtained by post-mortem MSCT were compared to the results obtained by conventional autopsies performed by board-certified forensic pathologists. Neither the persons assessing the radiological images nor the persons performing the autopsy had information on the findings of the other group.

3. Results

3.1. Detection of foreign bodies

Neither MSCT nor autopsy could detect injury related foreign bodies in the examined cases.

3.2. Wound channel (Figs. 1 and 2)

Of the total of 101 wound channels seen in all 12 cases at autopsy, 71 (70.3%) were detected by MSCT (Table 2). Of these, superficial lesions were seen by MSCT in only 2 of a total of 22 (9%) superficial injuries. Of the total of 79 deep wounds seen at autopsy, MSCT was able to depict 69 (87.3%). In all cases in which deep stab wounds were missed, the involved stab wounds were closely grouped.

3.3. Organ and skeletal injuries (Figs. 3 and 4)

As shown in Table 3, MSCT missed an injury to the pericardium in one case (case 6), one injury to the stomach (case 7), one to the liver (case 1) and one lesion to the brachial artery (case 3). In one case (case 9), MSCT displayed an injury to cervical vessels, but could not precisely discriminate which vessels were injured. However, MSCT sufficed in detecting lesions to the lungs, the heart, the brain, the spleen and the skeleton.

Table 1
Brief description of the cases included in this study

Case no.	Age/sex	Injuries	Circumstances	CPR	PMI
1	26/f	Multiple stab wounds to trunk and head	Homicide	No	9
2	83/m	Stab wound to chest	Suicide	No	10
3	30/m	Stab wounds to chest and arm	Homicide	No	15
4	32/m	Stab wounds to chest	Suicide	No	~168*
5	15/m	Stab wound to chest	Suicide	Yes	11
6	23/f	Stab wounds to chest, cuts to neck	Suicide	No	16
7	51/m	Stab wounds to head, chest and abdomen	Homicide	Yes	5
8	41/f	Multiple stab wounds to chest	Homicide	No	48
9	76/m	Incised wound to neck	Suicide	Yes	10
10	40/m	Deep stab wound to back	Homicide	Yes	13
11	26/f	Multiple stab wounds to head, neck and thorax	Homicide	Yes	5
12	61/f	Multiple stab wounds to thorax, neck and upper extremities	Homicide	No	14

CPR stands for cardiopulmonary resuscitation, PMI for post-mortem interval, i.e. time between death and CT scanning in hours. The PMI given was the average of the time since death according to police and medical investigations. The asterisk in case 4 designates that the PMI here (about one week) is only a rough estimate of this corpse found in a cold forest with slight signs of putrefaction.