Importance of Multi-Slice Computed Tomography for Autopsy: Single Center Experience

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Abstract

Virtopsy applications are widely-used minimally invasive autopsy techniques which are assistive techniques to increase the efficacy of the autopsy. The aim of this study was to show whether or not Multi-Slice Computed Tomography (MSCT) could be an alternative autopsy method or used in place of autopsy in some cases. In this study, evaluation was made of 20 forensic cases with MSCT applied pre-autopsy followed by conventional autopsy at Sivas Cumhuriyet University Hospital between 08.11.2006 and 30.09.2007. The cases were 17 male and three female in an age range of four months to 69 years. The cause of death was stated for all except one case, which was in an advanced stage of decomposition. The findings of the MSCT taken before the autopsy were compared with the conventional autopsy findings and the place of virtopsy in forensic cases was discussed. When it is considered that autopsy is necessary in some cases, it can be said that for some, MCST is superior to autopsy, so in some cases it could be an alternative or a supplementary method. Examination made with radiological imaging, as an independent, objective non-invasive observer means that data related to the corpse can be retrieved from digital storage and provides the opportunity for re-examination years after the organ remains have decomposed or been discarded.

Key Words: Multi-slice computed tomography, virtopsy, autopsy, cause of death, forensic medicine

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Introduction

Developments in computer technology in several branches such as genetics, toxicology and radiology have contributed to the development of forensic medicine. The use of cross-sectional imaging such as CT and MR in radiology has been beneficial in autopsy practice. With virtopsy, examination can be made of the human body or an anatomical region as interactive research in real time without opening or damaging the body [1,2]. As a combination of ‘virtual’ and ‘autopsy’, ‘Virtopsy’ has the meaning of the neutral examination of evidence and the physical characteristics of an event to be taken as evidence [2-4].

Three-dimensional images of the human body can be created with this non-invasive method. Virtual endoscopy can be applied within luminal structures and at the same time, cross-sectional images can be taken of internal structures. Thus the general aim of virtopsy is to define the cause of death and the mechanism of death, to evaluate whether or not lesions were life-threatening and to develop forensic reconstruction with the obtained findings [3]. Imaging methods are of undisputed benefit in identification and investigating the cause of death in events such as natural disasters and accidents with multiple deaths for reasons such as the necessity of storing bodies until autopsy and acceptance of religious and other social factors of medical autopsy [5]. In addition when images are not available for the case, the event may be considered in different dimensions [6].

Some radiological findings determined in radiological examinations can not be determined as anatomic findings or are not as easily determined as in radiological examinations. Good identification of these findings renders virtopsy unrivalled in this field and it has become indispensable. This prospective study aimed to show whether MSCT could be an alternative autopsy method or whether it could be used instead of autopsy in some cases because of the properties of MSCT. In the study it was aimed to investigate the findings only determined radiologically in virtopsies made with MSCT.

Material and Method

This was a case series study comprising 20 cases admitted for forensic autopsy at Cumhuriyet University Hospital between 8th November 2006 and 30th September 2007. MSCT images were taken at mean 12hours after death (range, 2-24 hrs). At a maximum of 20 mins after taking

MSCT images, autopsies were started on the bodies in the Forensic Morgue of the hospital. In 1 case, the body was exhumed for autopsy 21 days after MSCT imaging.

MSCT (Philips Brilliance 16 slice CT, Holland) imaging was made without contrast dye. All examinations were made with the body in a supine position and using the parameters of 1-3mm slice thickness, 2.4mm table movement, 55mA, 120kV and gantry rotation time of 0.5secs. The time taken for the MSCT imaging, including preparation, was approximately 10 mins.

Depending on the status of the body, the head, neck, chest and abdomen were scanned with MSCT. The images were transferred to a workstation (Philips Extended Brilliance Workspace Release 2.1.2) for post-processing procedures and detailed evaluations were applied at separate times by two specialist radiologists. In conflicting situations, evaluation was made by a third, independent specialist radiologist. The findings obtained by the two radiologists were included for evaluation. Any findings with three different opinions were excluded from the study.

The autopsies were performed according to the appropriate regulations, by opening the head, neck, chest and abdomen, if allowed by the status of the body. Different forensic medicine and pathology specialists performed the autopsies. Blood, urine and tissue samples taken during the autopsy underwent toxicology and histopathology examinations.

In this study, evaluation was made by comparison of the MSCT findings with the findings obtained from judicial records, autopsy and postmortem reported findings and hospital records.

Results

The cases were 17 males and three females with a mean age at death of 33 years (range, four months-69 years). The cause of death was determined as traffic accident in five (25%) cases, a fall from height in three (15%), hanging in three (15%), gunshot wounds in two (10%), physical assault in one (5%), pneumonia in one (5%), pneumonia +hypertensive heart disease + brain oedema in one (5%), drowning in one (5%), poisoning in one (5%) and poisoning + hypothermia in one (5%). Cause of death could not be determined in one (5%) case because of decomposition despite autopsy and postmortem examinaton after exhumation.

While the manner of death was determined as natural causes in two (10%) cases, unnatural causes were determined in 17 (85%) cases and in one (5%) case the cause of death was undetermined. Of the unnatural causes cases, 11 (64%) were accident, four (24%) were suicide and two (12%) were murder.

The cases were examined in order according to the type of event. Definitive cause of death was determined from the autopsy result and the postmortem MSCT findings.

CASE 1 (gun shot wounds): Widespread free fluid was observed inside the abdomen (bleeding), *free air in the abdomen and liver vascular line,* a foreign body 3cm in diameter in the intestine and right cecal region of the abdomen (plug) (Figure 1), many foreign bodies of metal density in the abdominal right upper and lower quadrants (pieces of shot). A fragmented fracture of the right iliac wing was observed, *and widespread free air in the abdomen.* Defects were seen in the abdominal anterior wall in the right inguinal region (3.5cm) and in the suprapubic region (3cm).

Cause of death: internal and external haemorrhage which developed as a result of organ damage associated with hunting rifle injuries.

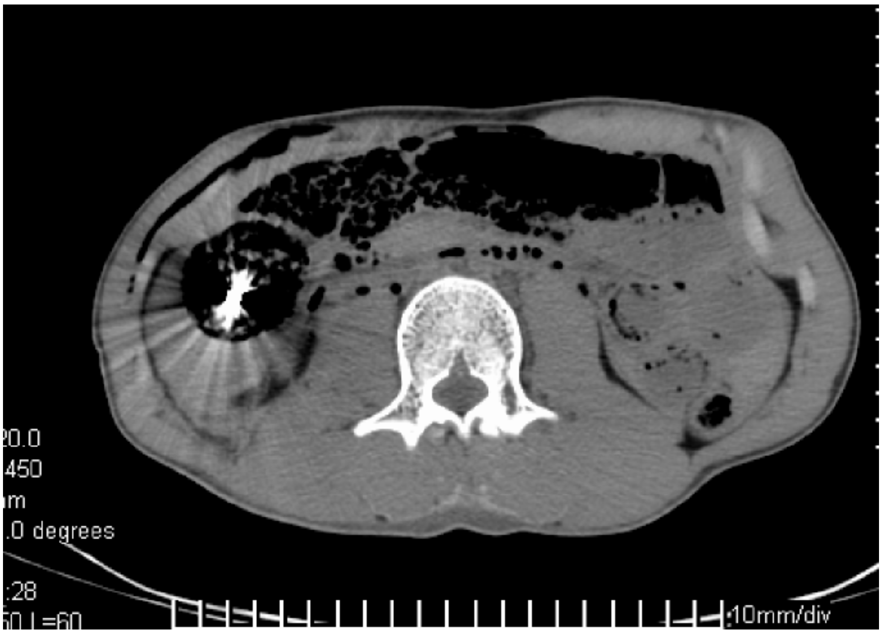

Figure 1. A three-cm foreign body demonstrating a density of a metal in the lumen of the caecum.

CASE 2 (gunshot wounds): *Appearance of minimal collapse and thrombosis at the upper levels of the abdominal aorta and collapse was observed at the lower levels.*

Cause of death: External bleeding was determined to have developed associated with major vessel damage as a result of a firearms injury.

CASE 3 (hypothermia+poisoning): Hypodense areas of parenchymal focal oedema with 20-30 HU (Hounsfield Unit) density were determined in both frontal regions (Figure 2). *The parenchyma of both lungs had the appeaance of frosted glass (bleeding)and heterogenity was seen in the intraocular fluid in both bulbus oculi (hypothermia finding). In the heterogenous appearance of the eyeball, areas of 25 HU density and other areas of -30 to -40 HUwere measured (Figure 3).*

Cause of death: The combined effect of hypothermia with alcohol and drug intoxication (substance agent, amitriptyline).

Figure 2. Hypodense area in both frontal regions (parenchymal focal edema).

Figure 3. Bilateral heterogeneity in intraocular fluid.

CASE 4 (poisoning): Oedema was observed in the brain parenchyma and more evidently as a consolidation area in the lower lobes in the parenchyma of both lungs, widespread frosted glass appearance and pleural effusion 1cm in thickness on the right.

Cause of death: Drug intoxication (amitriptyline).

CASE 5 (hanging): *Minimal oedema was seen in the brain.* In the Volume Rendering (VR) examination made with the postmortem MSCT data, rope marks were observed on the neck. A

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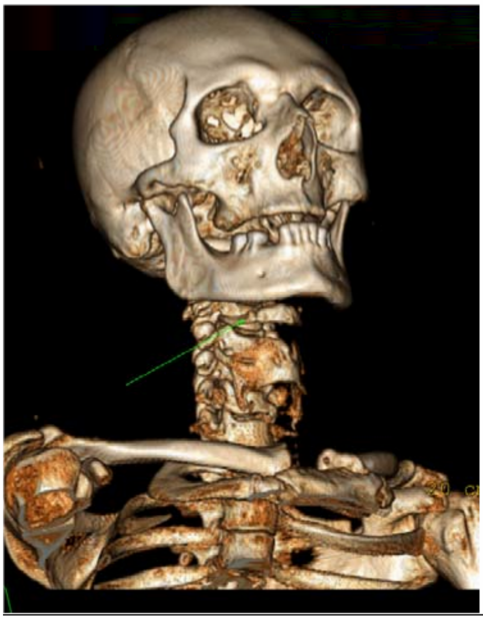
fracture line was seen in the right cornus of the hyoid bone (Figure 4) and the left cornus was observed to be normal (Figure 5). Hyperdense areas (parenchymal bleeding) were seen in both thyroid glands and parenchymal bleeding was seen in the left parotid (Figure 6).

Cause of death: Mechanical asphyxiation associated with hanging.



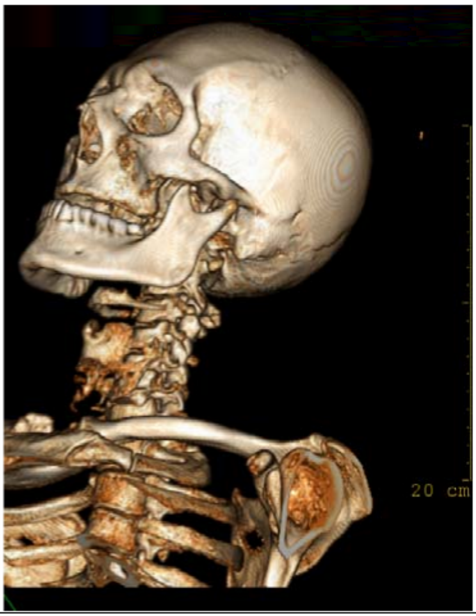


Figure 4. Fracture of the right horn of the hyoid bone.	**Figure 5.** Natural appearance of the left horn of the hyoid bone.

Figure 6. Soft tissue formation in the left maxillary sinus, and parenchymal bleeding in the left parotid gland.

CASE 6 (hanging): *Frosted glass appearance in the lower lobes of both lungs* (bleeding) and rope marks were seen on the neck. No pathology was determined in the bones and cartilage structures of the neck, or in the spinal cord.

Cause of death: Mechanical asphyxiation associated with hanging.

CASE 7 (hanging): *Frosted glass appearance in the lower lobes of both lungs* (bleeding) and rope marks were seen on the neck. No pathology was determined in the bones and cartilage structures of the neck, or in the spinal cord.

Cause of death: Mechanical asphyxiation associated with hanging.

CASE 8 (blunt trauma): Swelling and oedema were seen on the right parietal, the left occipito-temporal and frontal regions of the scalp. A linear fracture was observed in the right parietal bone, epidural haematoma in the right occipito-parietal region, intraparenchymal haematoma in the right fronto-parietal region and widespread subarachnoid bleeding in the brain. *A widespread frosted glass appearance (bleeding) was seen in the posterior of the lower lobe within the parenchyma* in both lungs.

Cause of death: Skull fracture together with brain haemorrhage and destruction of brain tissue due to blunt trauma to the head

CASE 9 (fall from height): Oedema and bleeding were determined in the left frontal and left parietal regions of the scalp. Fragmented fractures with scattered displacement were seen in the left parietal bone, left frontal bone, left zygomatic arc, left orbital rim, right parietal bone and right occipital bone. *Oedema and widespread pneumocephaly was determined in the brain parenchyma*, widespread hyperdense areas secondary to bleeding, fractures in all the bones forming the base of the skull, fragmented fractures in the nasal bone and bleeding in the paranasal sinuses. Extensive parenchymal bleeding was seen in the brain, *and foci of pneumocephaly localised in the inferior brain stem at the foramen magnum level.*

Subcutaneous emphysema and bleeding in the soft tissue was observed at all levels starting from the neck and extending to the chest anterior wall and air-fluid levelling (bleeding) in the trachea and main bronchi. *Air was determined in the heart cavities, effusion(bleeding)reaching a thickness of 4cm in the right haemothorax and pneumothorax reaching a thickness of 2cm on the right and 3cm on the left.* Parenchymal collapse (parenchymal bleeding) was seen in both lungs, *frosted glass appearance* and widespread air cysts.

A displaced fragmented fracture was determined in the left scapula, fractures in ribs 1-5 on the right and in ribs 1 and 3-5 on the left, and extensive displaced fractures in the transverse and spinous processes at the level of the thoracic and lumbar vertebrae. *Air was observed along the vascular trace of the liver and there was widespread gas distension in the intestines.* A displaced fragmented fracture in the left iliac wing was determined, a fracture in the right ischium arm and a fragmented fracture on the sacral surface of the right sacro-iliac joint. A fragmented fracture was observed in the left patella and free air, bone fragments and *air in the left popliteal fossa* in the patella-femoral space.

Cause of death: Internal bleeding and internal organ damage which developed together with skull and rib fractures due to general body trauma.

CASE 10 (fall from height): Fractures were observed in ribs 3-7 on the right and ribs 5 and 6 on the left, pleural effusion (haemothorax) at a thickness of 3cm on the left and *deviation to the left of the trachea.* Consolidation areas (bleeding) in the mid and lower lobes of the right lung and in the lower lobe of the left lung. *The left main bronchus was dilated compared to the right, an amount of free air was observed in the left atrium, the right anterior mediastinum and the chest wall.* Compound fragmented fractures were determined in the proximal third of the right tibia and fibula.

Cause of death: Internal bleeding and *fat embolism* resulting from internal organ damage which developed due to general body trauma.

CASE 11 (fall from height): In the brain, bleeding was determined inside the 4th ventricle, superior to the cerebral peduncle and in the posterior of the 3rd ventricle. Fractures were seen in the right clavicle, in the corpus sternum and in the vertebral corpus and posterior elements of C7, T1 and T7-8. Many rib fractures were determined on the right side and in the first rib at the right sternoclavicular level. Haematoma and air were observed in the right chest wall, atheromatous plaque in the aorta, *air in the right ventricle, right atrium and vena cava inferior, pneumohaemothorax on the right* and haemothorax on the left.

Cause of death: Internal bleeding with concomitant internal organ damage, multiple rib fractures and vertebral fractures due to a fall from height.

CASE 12 (Pnemonia+Hypertensive Heart Disease+Brain Oedema): *Oedema was observed in the right hemisphere of the brain* (acute/subacute infarct), right lateral ventricle with compressed appearance and a shift to the left in the midline structures of the brain. *An extensive consolidation area and a scattered appearance of frosted glass (pneumonia)was determined in the lower lobes of both lungs*, more evidently on the right.

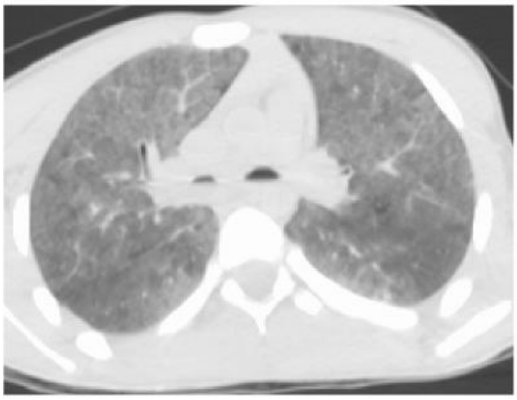
Cause of death: Respiratory failure associated with pumonary pathology (lobal pneumonia), circulatory failure associated with hypertensive heart disease and brain oedema.

CASE 13 (Pneumonia): *Minimal oedema was determined in the brain*, a consolidation area adjacent to the left lung lower lobe bronchus, and *frosted glass appearance in the parenchyma of both lungs.*

Cause of death: Respiratory failure associated with extensive pneumonic infiltration.

CASE 14 (drowning in water): *Eradication of the sulci (brain oedema) in the high convexity of the brain was determined.* Fluid was observed in the nasopharynx and trachea, especially at the carinal level. *A levelling in the fluid density was determined in the maxillary sinus, air-fluid levelling in both main bronchi* (Figure 7) and effusion reaching a thickness of 8mm in the pericardium. *Frosted glass appearance was observed in the parenchyma of both lungs* (bleeding, oedema) (Figure 8), fluid and gas in the oesophagus. The small intestine and stomach were seen to be full of fluid. Gas distension was determined in the large intestine.

Cause of death: Mechanical asphyxiation associated with drowning in water



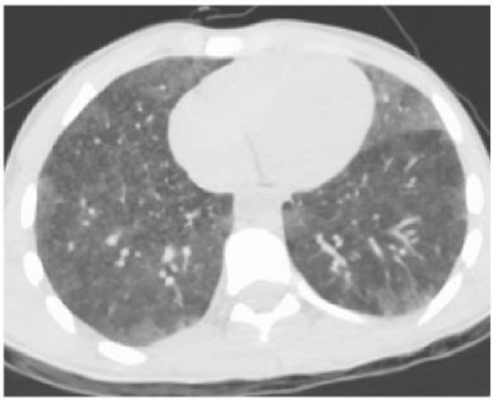


Figure 7. Air-fluid level in main bronchi.	**Figure 8.** Frosted glass appearance in lungs.

CASE 15 (decomposition): *Widespread air was observed secondary to decomposition in the brain parenchyma,* separation in all the skull sutures and it could be seen in the neck that soft tissue planes had become fluid. *Free air was determined in all the soft tissue planes in the abdomen* and thorax. The parenchymal thoracic cavity of both lungs had the appearance of collapse and the remaining thoracic cavity was observed to be full of air. Free air was seen in the chambers of the heart, irregularity in the contours of the liver and *free air, which had become cyst-like, in the parenchyma of the whole liver. Air was observed in the vertebral corpus, in the shaft of both femurs and intramedullary in the tibia and fibula.*

Cause of death: Could not be determined due to advanced decomposition

CASE 16 (traffic accident): An advanced degree of dilatation (hydrocephaly) was observed bilaterally in the brain ventricles. Adjacent to a fracture line in the left fronto-parietal bone, *pneumocephaly* and a fracture line in the zygomatic arc were observed. A fracture line was observed on the right side of the mandibular corpus and *fluid density (bleeding) in the right* *maxillary sinus and soft tissue structure.* The trachea was seen to be open as far as the carina level. *The main bronchi appeared collapsed with a surrounding consolidation area (bleeding).Extensive frosted glass appearance (bleeding) was determined in both lungs. In the right subclavicular region muscle groups, fluid (bleeding) was observed.*

Cause of death: Destruction of brain tissue together with fractures of the skull associated with general body trauma.

CASE 17 (traffic accident): Fractures were seen in both clavicies and the posterior of the first ribs. *Air was observed in the spinal canal at the level of the neck. Pneumohaemothorax were observed on both sides but more on the right and air was determined between the deep fascia in the neck. Subcutaneous emphysema was observed in the right hemithorax, oedema in the lungs and air within the major vessels and the heart cavities. Fluid was seen in the trachea and main bronchi. Air was determined within the liver parenchyma and vessels.* Fractures were seen in the right pubic arm and acetabulum.

Cause of death: Internal bleeding as a result of internal organ damage associated with general body trauma.

CASE 18 (traffic accident): Displaced depressed fractures were observed in the left fronto-parieto-temporal region and adjacent *free air in the brain parenchyma* with an area of oedema and bleeding in this region of the scalp. Epidural bleeding was seen at a thickness of 2cm in the left occipital region and an appearance consistent with subarachnoid bleeding in the whole brain parenchyma.

Cause of death: Brain haemorrhage as a result of head trauma which developed associated with general body trauma.

CASE 19 (traffic accident): Fractures were determined in the right temporal bone and the base of both orbits, a fracture adjacent to the midline in the left mandible and *bleeding in all the paranasal sinuses. Oedema was observed in the brain parenchyma,* a hyperdense appearance consistent with subarachnoid bleeding in the basal cisterns and *pneumocephaly foci at the base of the brain. Free air was seen in the soft tissue planes of the neck and in the medulla spinalis.*

A fragmented fracture was determined in the right scapula and fragmented fracture lines in the transverse and posterior elements of all the cerviical vertebrae. Displaced fractures were determined in the left first rib and from the second to the sixth rib on the right side and with adjacent *extensive subcutaneous emphysema in the chest wall extending to the abdominal wall.*

A laceration was seen in the right lung parenchyma, *collapse and frosted glass appearance (bleeding) in the parenchyma of both lungs, pneumothorax and haemothorax on the right. Air-fluid levelling was observed in the oesophagus and trachea and free air in the chambers of the heart. Free air was seen along the liver vascular line* and gas distension in the intestinal loops. Fractures were determined in the transverse processes and posterior elements of the thoracolumbar vertebrae. A fragmented fracture was determined in the left acetabular roof, at the level of the right knee joint and in the tibial plateau and fibula.

Cause of death: Haemorrhage which developed as a result of lung and liver injuries and brain haemorrhage accompanied by multiple bone fractures associated with general body trauma.

CASE 20 (traffic accident): *Oedema was observed in the brain tissue and pneumocephaly in the brain parenchyma and ventricles. Free air particles were observed in both retro-orbital areas,* fragmented fractures in the base of both orbits, free air and bleeding within the left temporal muscle group. *Air-fluid levelling was determined in all the paranasal sinuses (bleeding)* and a fracture in the nasal bone. *Air particles (subcutaneous emphysema) were seen starting from the left mandibular region and continuing as far as the left thoracic soft tissue areas,* a fragmented fracture at the left clavicular-sternum junction and air-fluid levelling in the main bronchi. Fractures were seen in the left ribs 1-4.

Haemopneumothorax reaching a thickness of 6cm on the left and free air in the heart chambers were observed. On the right, a haemopneumothorax of 5cm thickness was seen. Extensive areas of contusion (frosted glass appearance) were observed in the parenchyma of both lungs, wide parenchymal air cysts and a shift to the left in mediastinal organs.

Free air was observed along the intrahepatic vascular line, within the left kidney, in the mesenteric planes and in the abdomen and gas distension in the colonic loops. A compression fracture was determined in the T2 vertebra corpus, a fracture in the right acetabular roof and fractures in the left ischium and pubis. *Free air was seen in the gluteal planes and the muscle planes adjacent to the right acetabular fracture.*

Cause of death: Internal bleeding and internal organ damage accompanied by multiple bone and skull fractures associated with general body trauma.

Discussion and Conclusion

The density of a foreign body can be measured radiologically with MSCT. The presence and localisation of foreign bodies such as a bullet, knife blade, medical implants or drugs hidden in body cavities can be accurately determined with density measurements on MSCT before opening the body. MSCT facilitates the appropriate removal of foreign bodies in an autopsy [6-12].

As IV contrast substance is not used in MSCT, there is insufficient differentiation of soft tissue from vascular structures with organs. In addition, the trajectory of a bullet on MSCT is determined with its relationship with air. However, as the bullet trajectory is associated with the ballistic properties of the bullet and the amount of air in the anatomic structures through which it has passed, bullet trajectories may show a great difference [13]. In Cases 1 and 2, organ damage associated with firearms injuries and rifle shot remnants in Case 1 could be seen with MSCT. However, it can not be said that MSCT was superior to autopsy in these cases in respect of determining the bullet trajectory.

In Case 3, the conclusion was reached that areas of focal oedema and parenchymal hypodensity in both frontal regions and heterogenity in the intraocular fluid on both sides had developed due to hypothermia.

In Case 4, oedema in the brain parenchyma was observed on MSCT. There was a widespread appearance of frosted glass and consolidation areas more evident in the lower lobes in the parenchyma of both lungs. The visualisation of the trachea lumen as fluid with black activated charcoal during the autopsy and the determination of consolidation areas in the lungs were thought to have developed due to aspiration. The formation of the widespread appearance of frosted glass can be said to have contributed to hypostasis. Therefore, with the MSCT findings alone, it would be difficult to make differential diagnoses of aspiration, pneumonia and haemorrrhage [14].

As there is a need for toxicology examinations in deaths related to poisoning, MSCT can not be said to have any superiority in this respect. In autopsy, just as it facilitates the taking of tissue samples, in image-guided biopsies with MSCT, as a minimally invasive alternative method rendering histological examinations possible, it is helpful in the determination of the cause of death [6,10,15]. However, in Cases 3 and 4 (poisoning), it was concluded that the cause of death could only be determined after toxicology examination.

In Cases 6 and 7, no patholgy was determined in the bones or cartilage structures of the neck or in the spinal cord on MSCT. The autopsy findings confirmed this. In Case 5, a fracture line was observed on the right cornus of the hyoid bone on MSCT. In addition, hyperdense areas seen in the left parotid and both thyroid glands were evaluated as haemorrhage. In cases of death by hanging, bleeding may be seen at the clavicular periosteal beginning of the sternocleidomastoid muscle. As this bleeding is seen very rarely in other causes of death, it can be said to be typical of death by hanging [16].

In Cases 9 and 11, fractures in the vertebral corpus and process were shown on MSCT which were not determined in the autopsies. Small fractures such as vertebral and rib process fractures which are easily determined with MSCT can then be checked with ease in the autopsy. The shape and form of fractures is very important in forensic medicine as they can give clues about the origin of the trauma. Three-dimensional reconstruction is useful in revealing how the fracture was formed and from which side the effect came. It is possible to gather additional information about the instrument causing the injury [7].

In Case 9, subcutaneous emphysema, bleeding in the soft tissue, air-fluid levelling (bleeding) in the trachea and main bronchi, bleeding and air cysts in the parenchyma of both lungs, pneumothorax, air in the heart cavities, widespread foci of pneumocephaly in the brain, air along the hepatic vascular line and widespread gas distension in the intestines were determined on MSCT and not shown in the autopsy. In Case 11, bilateral pneumothorax in the chest wall and air within the vena cava inferior, in the right ventricle and right atrium were determined easily with MSCT. However, in the autopsy, emphysema in the soft tissue, pneumothorax and air in the pneumomediastinum and heart were missed. The data obtained with MSCT from 3-D imaging of bone fractures prior to autopsy is an advantage as during autopsy the in-situ staus of fractures may change or be impaired. The visualisation of air embolism on CT is superior to autopsy [9].

In Case 9, fragmented fractures were determined in the left zygomatic arc, left orbital rim and nasal bones and bleeding with oedema in the frontal and left parietal regions of the scalp. As maxillofacial dissection was not generally performed in autopsy, the fractures in the maxillofacial bones and bleeding in the paranasal sinuses were not seen. Scanning of the head with MSCT is of great importance in the determination of intercranial bleeding and skull fractures in particular. In Case 11, bleeding in the 3rd and 4th ventricles of the brain, which was not shown in the autopsy was determined with MSCT.

Bolliger et al reported that rib fractures, haemothorax and extrapleural bleeding, which is rarely seen in blunt trauma, were determined with MSCT in the case of a male cadaver which had been exposed to blunt trauma in the left hemithorax. In addition, the apical cap sign, which is accepted as an indicator of aorta rupture and extrapleural bleeding in conventional radiography, was able to be determined easily with MSCT [17].

In Case 12, brain oedema and lobular pneumonia which were determined as a result of autopsy and histopathological examinations, were determined with MSCT. A shift to the left from the midline in the brain and compression of the right ventricle were identified with MSCT. An extensive area of consolidation and the frosted glass appearance determined in the lungs with MSCT were evaluated as pneumonia [18].

In Case 13, the frosted glass appearance on MSCT together with the autopsy and postmortem findings were evaluated as pneumonia. It is difficult to determine the cause of death as pneumonia based on the MSCT findings alone. Rather than making a definitive differentiation with only MSCT findings, the clinical history of the deceased should also be considered [14].

In Case 14, brain oedema, levelling in the fluid density in the maxillary sinus and fluid in the trachea, the nasopharynx, particularly at the carinal level and in both main bronchi were determined on MSCT. A widespread appearance of frosted glass (bleeding, oedema) was determined in the parenchyma of both lungs and effusion in the pericardium. The small intestine and stomach were seen to be full of fluid, gas distension was seen in the large intestine and fluid and gas in the oesophagus. Excessive hyperemia and bleeding which form in the skull sinus mucosa with the effect of increasing pressure, and fluid which would be able to be determined in the cavity between the ear and eustachian tube shows that the person was alive while in the water with forced inspiration and is a highly valuable but rarely encountered finding. Areas of bleeding may be found as far as the tendons of the scalene, pectoral and sternocleidomastoid muscles as a result of forced respiration movements [19].

Aghayev et al [20] investigated the postmortem MSCT and MRI findings of blunt trauma and drowning associated with a fatal ferry accident. In addition to findings associated with blunt trauma, findings such as fluid in the stomach and duodenum and excessive swelling in the lungs were seen. All the raiological findings were confirmed with autopsy. In Case 14, fluid in the paranasal sinuses (fluid density levelling in the maxillary sinus) which was impossible or very difficult to see in the autopsy were shown with MSCT together with findings such as excessive swelling in the lungs and fluid filling the stomach and duodenum.

In autopsies of deaths associated with decompression in diving accidents, air bubbles within the blood vessels disappear when the dura matter is opened. This makes it difficult to determine the presence and extent of air embolism. In diving accidents, imaging of the body with CT before autopsy is important so as not to overlook significant findings in the autopsy [2,21].

In Case 15, free air in all the soft tissue could be seen in the thorax and abdomen on MSCT. The cyst-like free air in the liver parenchyma and heart chambers observed on MSCT was identified as associated with decomposition gases. In the process of decomposition, accumulated gas is seen in the body cavities and in solid organs in a sponge-like form or with a ‘Swiss cheese’ appearance. As gas accumulation associated with decomposition is diffuse and very widespread, it is useful to make differentiation from air embolism [2,22].

The brain and cerebellum lost consistency and became the consistency of mud, so when the skull was opened in autopsy the brain and cerebellum tissue was seen to flow. Therefore, MSCT showed the brain and cerebellum tissue in its anatomic place before the integrity was impaired. This imaging method is important in respect of defining lesions located within the skull.

In Case 18, the findings determined on MSCT of scalp oedema, displaced depressed fractures in the fronto-parieto-temporal region, epidural and subdural bleeding, scatttered consolidation in the parenchyma of both lungs becoming frosted glass in appearance (bleeding, aspiration) were confirmed by the autopsy findings.

Fractures in the facial bones in Case 16, fractures in the pelvis in Case 17 and fractures in the vertebrae, pelvis and extremity in Case 19, which were not determined in the autopsy were easily visualised in detail on MSCT. Parenchymal damage in the brain and cerebellum following head trauma and infarcts or bleeding could be easily seen with MSCT because of the different density values. With bone window examinations in MSCT, determination of cranial, temporal, facial, spinal, pelvic, shoulder and acetbular fractures, alignment of fragments and change in location can be evaluated [8].

It is extremely clear that bone injuries have an important place in forensic medicine examinations. In cases where the whole body is scanned with MSCT, fractures, fracture distribution and dislocations can be seen easily in three dimensions and can be presented in a blood-free form to non-medical individuals. In addition, small fractures in inaccessible body parts and which may be missed in autopsy, can be determined easily. Another advantage is that certain areas of the body which are not routinely dissected, such as theface, can be examined for fractures in a non-destructive way, thereby protecting the relatives of the deceased from further psychological trauma [3,7,9,10,23].

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