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Technical note: Whole-body postmortem angiography of the arterial and venous systems with barium sulfate

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Abstract

In the field of postmortem angiography, a great deal of diverse methods has been used since 17th-18th centuries. In recent years significant technical developments, namely CT and MR, played an important role in the field giving that they help to carry the quality of postmortem imaging one step further. The principal aim of this study is to present an autopsy center with a postmortem imaging technique that is practical, cheap and easy to handle and also able to provide detailed images of whole vascular system of body. In this study, 25% diluted barium sulfate solution was preferred since it has been kept-up-to-date through decades and extensively used in similar studies. It was manually injected through various arteries and veins without pressure control by the aid of injectors or cannulas. The images were analyzed with a C-armed fluoroscopy. 138 corpses, that were sent to Ministry of Justice, Council of Forensic Medicine İstanbul for autopsy, were studied. And 8 of 138 corpses were in the state of putrefaction. After angiographic studies took place, conventional autopsy was performed and the findings of two techniques were compared. This technique can be used as a supplementary method to conventional autopsy and assists resolution of cases involving vascular lesions..

Keywords: Postmortem, barium sulfate, angiography, autopsy, fluoroscopy

Introduction

Radiological imaging techniques—such as X-ray and fluoroscopy—have been used extensively in forensic medicine as supportive methods to conventional autopsy for detection of fractures or metallic residues remaining in the body. Due to technological developments in the field of radiology and consequently the development of advanced techniques such as magnetic resonance imaging (MRI) and computed tomography (CT), radiological imaging techniques have become more significant in forensic medicine and used more commonly as a contributory method to conventional autopsy. Additionally, postmortem angiography is another supportive method, beneficial mainly for detecting bleeding sites in deaths caused by trauma and in diagnosing anatomical variations and malformations as well as vein pathologies such as aneurisms, thrombi and embolisms [1,2,3,4,5,6,7].

The history of radiological imaging, or medical radiology, began with the pioneering works of Graaf, Ruysch and Lower who introduced the method of direct vascular injection in the 17th and 18th centuries [8]. In 1899, 3 years after the discovery of X-rays, coronary arteries of an isolated human heart were injected with radiopaque material. Subsequently, various contrast agents were introduced, mainly red lead oxide, bismuth chloride, gastrophin, silicon rubber, microfil and potassium iodine. Additionally, different injection procedures were used with a similar goal, such as perfusion of the heart in isolated or in vivo conditions, fixating the organs before the injection of various solutions, or performing whole-body injections in newborns, human fetuses or embryos [8,9,10,11,12].

Barium sulfate is a currently used contrast agent. Agar-agar and gelatin are two additives used frequently to prepare a suspension of this compound, and can be used as a mixture prepared with water [8,13,14,15].

Over the last century, the application of postmortem radiology and imaging have proven to be valuable and beneficial non-invasive methods not only for detecting forensic evidence in deaths caused by trauma, but also for determining the possible reasons for unexplained sudden deaths [16,17,18]. In contrast to the common utilization of these methods in other countries, their use in Turkey is limited. Fluoroscopy and X-rays are the only supplementary methods used during autopsies when detection of metallic residues in the body or identification of fractures is necessary.

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With this study, it is showed that a simple contrast material (barium sulfate) and an inexpensive conventionally available radiological tool (fluoroscopy) are sufficient for postmortem angiography. This technique can provide valuable information to all kinds of autopsy centers with limited resources.

Material and Method

The study was accomplished on 138 corpses, which were sent to the council of Forensic Medicine, Ministry of Justice, Turkey, for forensic autopsy. Eight of the corpses were in various stages of decomposition. This study was performed on the corpses, whose autopsies were done and that had to be delivered to the families on the same day of the autopsy. Therefore 138 is the maximum number of corpses that can be examined without determining a certain target number. During the selection of corpses, the criteria of body integrity were taken into consideration. The corpses with the loss of body integrity were excluded from the study. The performance of study on forensic cases and the necessity of delivery of corpses to the relatives are the limiting factors for the extend of the study.

In this study, Radiobarit® (barium sulfate 100%) was the generic product used because it is a common contrast enhancement medium used in numerous radiological studies to examine the stomach, intestine, colon or rectum. To obtain the optimum distribution of the contrast agent material and achieve the best radiological images for the most accurate diagnostic findings, the optimal concentration of the contrast agent was determined. For this specific purpose, a cannula was placed in both femoral arteries in five cases that were the ones first included in the study, and after occluding clamps were placed at the proximal ends of arteries; 50, 75, and 100% aqueous solutions of barium sulfate were injected. No significant differences were observed in the radiological images obtained from the injection of 75% and 100% barium sulfate solutions. However, the contrast agent was better distributed throughout the bodies after injection of the 75% barium sulfate solution. The radiological images obtained after the injection of 50% barium sulfate solution were of lower quality. Accordingly, preparation and utilization of the 25% diluted barium sulfate solution was considered the optimal choice for the remainder of the study. The radiological imaging was performed using a 100 mA Opescope, a generic system manufactured by the Shimadzu Corporation that has a 50-N mobile C-Arm system as well as dual monitors [Figure 1].

The arteries or veins into which the radiopaque material was injected were dissected using conventional autopsy procedures. The radiopaque material was injected using injection syringes or/and cannulas of various sizes [Figure 2]. The most convenient method was utilization of a 50- cc injection syringe attached to an I.V. tube. The tube was tied inside the vessel to prevent backflow of the radiopaque material when the intravenous (I.V.) tube was inserted in a large blood vessel. Next, the injector was attached to the tube and the radiopaque material was injected with no pressure control by pressing the syringe injector piston with the thumb. This process was continued as long as there was no significant backflow of the radiopaque material; when backflow started, the injection was stopped. Filling of the vessels was monitored continuously. If closing of the vessels or their branches was necessary, the appropriate number of clamps were placed or the vessels were tied. For radiological imaging of the isolated organs during conventional forensic autopsy, the open end of the vessel was cannulated using a thick injector syringe or catheter. The end was then clamped or tied to prevent backflow.

The best quality image was obtained at W 856, C 344, E1 display panel settings through changing the contrast by buttons on the fluoroscopy. This fixed value was used as the standard imaging value for all images that were obtained. During imaging, when the proper angiography image was found, that image was fixed on the screen. When suitable images of the examined area were obtained, the screen was frozen at that time and photographs were taken from a 115-cm distance using a digital camera mounted on a tripod, in automatic mode and using a 3x3 optical zoom. Additionally, the photographs were taken in a dark room without using the camera flashlight. Radiological interpretation was performed in a lead room constructed for this purpose. The digital photographs were transferred to the computer from the camera using the Kodak Easy Share, version 3.3, software. The photographs were evaluated and interpreted by qualified radiology and cardiology specialists. Next, the autopsy report, as well as the notes of the specialist who performed the autopsy and the investigator were taken into consideration.

Figure 1. Angiography setup

Figure 2. Cannulated femoral artery

Radiological imaging of head and neck arteries

For radiological imaging of head and neck arteries, the radiopaque material was injected through the common carotid artery, femoral artery or various sites in the aorta. In all situations, clamps were placed at the distal ends of the arteries. Two different techniques were performed. One involved simultaneous injections of the radiopaque material into the common carotid arteries on both sides, filling all intracranial arteries, including the vertebral artery. In the other procedure, the appropriate volume of radiopaque material was injected only one-sided; filling of all related vessels with identical clearness was obtained [Figure 3].

No differences in the quality of radiological images according to the injection site were observed. Nevertheless, for examination of neck vessels, the femoral arteries or lower levels of the aorta were used to prevent clamp shadows or other similar artifacts.

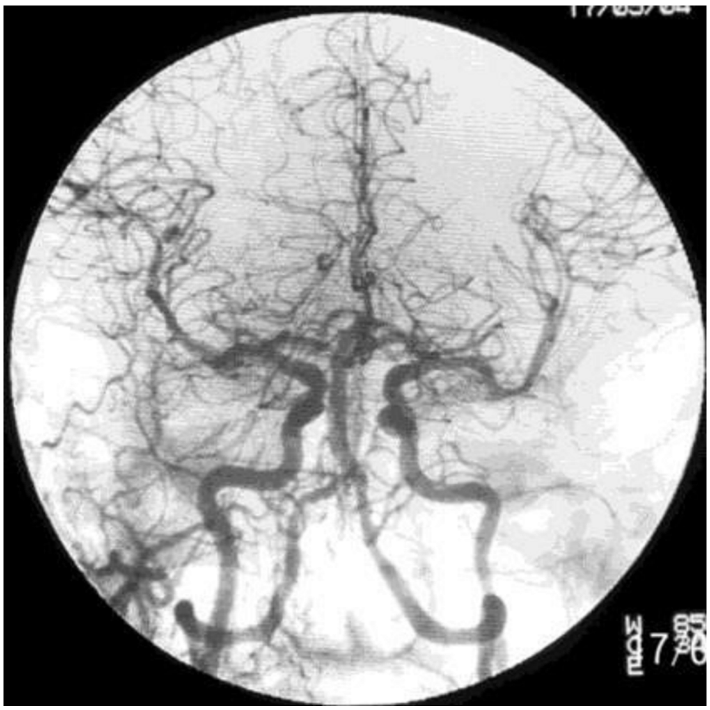

Figure 3. Dual imaging of the common carotid artery

Radiological imaging of the isolated brain

For isolated radiological imaging of the brain, the brain was dissected totally as a whole for the complete separation from the body; clamps were first placed at one end of both carotid arteries, which were already cut. Next, the arteries were filled by entering the distal end of the basilar artery with a butterfly needle. Since the peripheral veins were dissected during isolation of the brain, the radiopaque material extravasated during filling.

Radiological imaging of the thyroid arteries

To visualize the thyroid arteries, the radiopaque material was injected into the blood vessels of the neck. However, because of the probable difficulties due to the superposition of the common carotid and vertebral arteries, exclusive radiological imaging of the thyroid arteries was performed.

To obtain a radiological image of the inferior thyroid artery, after the necessary dissections a clamp was placed at the bifurcation of the subclavian artery and the common carotid artery, thus closing both. A second clamp was placed at the distal end of the subclavian artery and a third clamp was placed at the proximal end of the axillary artery. After entering the subclavian artery through the middle section, the radiopaque material was injected and allowed to proceed only towards the thyrocervical trunk.

For radiological imaging of the superior thyroid artery, after the necessary dissections a clamp was placed at the bifurcation of the internal carotid artery and external carotid artery, thus closing both. The second clamp was placed immediately above the site where the superior thyroid artery branches from the external carotid artery. After entering through the middle section, the radiopaque material was injected and allowed to proceed only towards the superior thyroid artery.

Radiological imaging of the thoracic organs

For radiological visualization of the thoracic and abdominal organs, the radiopaque material was injected into the dissected femoral artery. The aortic bifurcation was used to obtain radiological images prior to opening the abdomen and removing the sternal valve. After the abdominal valve was removed, all sections of the aorta were used. Pulmonary arteries could not be observed due to blood flow dynamics. Therefore, the radiopaque material was injected separately into the pulmonary artery [Figure 4].

Figure 4. Imaging of right pulmonary arteries

For radiological imaging of the coronary arteries before and after the isolation of the heart, radiopaque material was injected into the aorta, which had been clamped at the distal end, allowing the observation of both coronary arteries. In several cases, problems such as the superposition of certain parts due to simultaneous filling of coronary arteries or the filling of ventricles with the radiopaque material due to aortic valve dilatation caused difficulties in evaluation of the coronary arteries.

As an alternative method for the radiological imaging of the isolated heart, catheters were placed through each coronary artery ostium and the radiopaque material was injected. Because pathological lesions are more commonly found in the left coronary artery, the radiological images were obtained from this side first.

Radiological imaging of abdominal and pelvic arteries

To obtain radiological images of only the abdominal and pelvic arteries without isolating the organs, clamps were first placed on the thoracic aorta and femoral arteries, or they were tied.

Radiopaque material was injected into either the distal portion of the aorta or the iliac arteries. For radiological imaging of arteries of the isolated organs, catheters were placed into the main veins of the respective organs and the radiopaque material was injected (Figure 5).

Figure 5. Imaging of renal arteries

Radiological imaging of the arteries of the extremities
For radiological imaging of the arteries supplying the extremities, the radiopaque material was injected into various areas of the aorta, iliac artery or femoral arteries. The proximal end of the chosen vein was clamped and/or was tied. With the injection of the appropriate amount of the radiopaque material, arterial supply of both the upper and lower extremities up to the distal ends was observed (Figure 6).

Figure 6. Imaging of right hand arteries

Radiological imaging of the arterial system of the whole body
To obtain radiological images of the arterial system of the whole body, the radiopaque material was injected into the femoral artery. Accordingly, the entire arterial system, with the exception of the pulmonary circulation, was visualized.

Throughout this experiment, the amount of radiopaque material injected was determined according to the physical characteristics of the body. Therefore, 250 cc of the radiopaque material was injected when the body studied showed the physical characteristics of a normal adult. Likewise, 150 cc of the radiopaque material was used for weak bodies and 40 cc was used for newborns.

For the radiological imaging of the venous system, the same technique was used (Figure 7). Accordingly, the entire venous system was visualized, excluding the venous system of the extremities since the venous valves prevented the flow of the radiopaque material. To overcome this insufficiency, the radiopaque material was injected to ensure flow from the distal to the proximal end, facilitating visualization of the venous system of the extremities (Figure 8). Because the venous blood vessels were more dilated than the arterial vessels, the volume of radiopaque material used was increased.

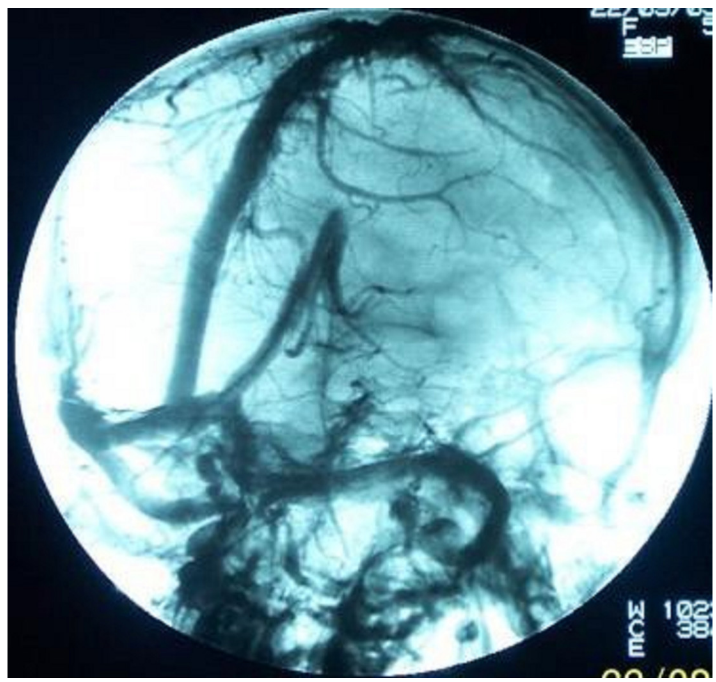

Figure 7. Head and neck veins

The dissection techniques used in the postmortem angiography of specific organs or areas of decomposed bodies caused frequent problems such as rupture of the blood vessels or extravasation of the radiopaque material. These problems occurred because the blood vessels of those bodies were more fragile due to autolysis and may result in unclear radiological images of the vessels; the radiopaque material was injected into femoral blood vessels without harming the integrity of the bodies. Consequently, the only vascular systems that could not be visualized were the pulmonary and cerebrovascular systems, particularly in cases with excessive autolysis.

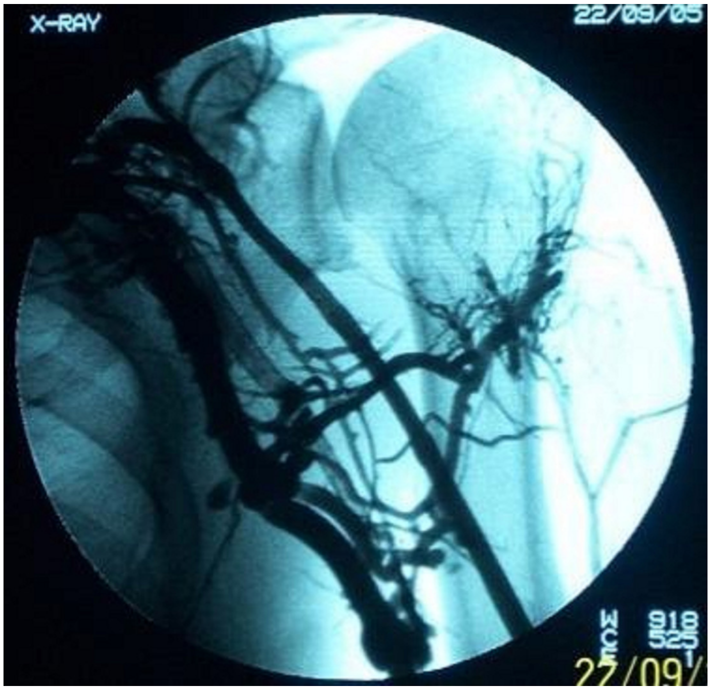

Figure 8. Imaging of upper extremity veins

Results

Technological advances in the field of radiology have had significant impact not only in clinical branches of medicine but also in forensic medicine [8]. From the 17th century to the present, emphasis was placed on visualization of the vascular system. Currently, obtaining three- dimensional images of the vascular system is possible using advanced radiological diagnostic and therapeutic techniques, such as computed tomography angiography (CTA) or magnetic resonance angiography (MRA), which provide clear and detailed images. These imaging modalities not only enhance the conventional autopsy technique but also compensate for their shortcomings [14]. However, these techniques are not used widely in routine, they are typically applied only in advanced experimental research centers.

In this study, a simple and practical postmortem angiography technique is introduced, particularly for autopsy centers with limited resources that do not have access to advanced techniques such as MRA or CTA. The technique presented in this study used a basic C-armed fluoroscopy and injection of barium sulfate solution using injector syringes or cannulas. The optimal barium sulfate concentration was 25% diluted solution. The study has showed that using a simple contrast material (barium sulfate) and easily accessible radiological tool (fluoroscopy), which are available in most autopsy centers, detailed and valuable radiological images could be obtained.

Discussion

The technique presented in this study can be applied to both fresh and decomposed human corpses and represents a valuable supplement to conventional autopsy methods. With this technique, radiological images of vascular pathologies, such as aneurisms, ruptured aneurisms, stenosis of blood vessels, atherosclerosis or the presence of plaque in the vascular system, can be obtained [8]. This method is useful for diagnosis of bleeding sites or detection of rupture levels of large blood vessels injured by firearms, sharp objects or falling from a height. Moreover, damage to small vessels, which is difficult to detect using conventional autopsy techniques, can be visualized. In addition, due to its ease of application, the technique facilitates visualization of small vessel injuries in malpractice cases in which the death occurred after surgery and legal autopsy is required by the authorities.

Hence, this technique provides an easy and cost-effective method for routine postmortem investigations of both fresh and decomposed human corpses. Additionally, the technique can be used as a supplementary method to conventional autopsy and assists resolution of cases involving vascular lesions.

Acknowledgments

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Conflict of interest

There is no conflict of interest related to the study

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