Postmortem Angiography: A Historical Review

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Silke Grabherr, Hugues Cadas, Beat M. Riederer, Philippe Charlier, and Valentin Djonov

Postmortem angiography (PMA) has a much longer history than most people would suspect. Unfortunately, the greater part of this history is still unknown or has been lost. However, a detailed review of the existing literature indicates that it began in the first days after the discovery of x-rays. This chapter explains the history of the visualization of vessels, starting with casting techniques to explore the interior of hollow anatomic structures, leading to the first injections into the vascular system and the first radiologic PMA images, finally reaching the zenith of classic PMA at the end of the nineteenth and beginning of the twentieth centuries. During that time, various methods have been applied using different injection materials and techniques as well as different preliminary treatments of organs of interest. The types of injected substances can be divided into six groups: vascular casts, corpuscular preparations in gelatin or agar, corpuscular preparations in aqueous solution, hydrosoluble preparations, oily liquids, and miscellaneous formulations. Furthermore, the visualization methods have varied. In the beginning, simple macroscopic observation was used, and injected vessels could be viewed by the naked eye. Eventually, the methods for visualizing blood vessels became more and more sophisticated. With the introduction of radiologic methods, PMA was finally born. Most often, different techniques were combined, allowing comparison of angiography to macroscopic dissection and histology, among others. Although the techniques varied considerably, most of them had one common feature: they were applicable only on single organs or specific for defined anatomic structures. This limitation may be the reason that the classic methods of PMA are not used today in forensic imaging and that new techniques have been developed instead. However, to understand the problems with postmortem vascular injection and perfusion techniques, it is essential to revisit the historical development of the methodology of vascular perfusion and visualization.

S. Grabherr, MD, PhD (✉)
Department of Forensic Imaging, University Center of Legal Medicine Lausanne-Geneva, Lausanne, Switzerland
e-mail: silke.grabherr@chuv.ch

H. Cadas, PhD • B.M. Riederer, PhD, PD
Platform of Morphology, Faculty of Biology and Medicine, University of Lausanne, Lausanne, Switzerland
e-mail: Hugues.Cadas@unil.ch; beat.riederer@unil.ch

P. Charlier, PhD
Section of Medical and Forensic Anthropology, UFR of Health Sciences (UVSQ/AP-HP), Montigny-le Bretonneux, France
e-mail: Philippe.Charlier@uvsq.fr

V. Djonov, MD, PhD
Department of Anatomy, University of Bern, Bern, Switzerland
e-mail: djonov@ana.unibe.ch

4.1 Visualization of the Vasculature Over the Years

The visualization of the vascular system has always been a challenge in medicine. Simple dissection techniques on cadavers were not sufficient for understanding the complex anatomy of human vascularization. To show the interior of hollow anatomic structures, the idea of producing so-called "casts" had already been introduced in the sixteenth century. The injection of liquid substances that hardened after a certain delay produced a beak-shaped spout. During this time, explorers of the human anatomy such as Jakobus Berengius and Leonardo da Vinci injected wax into heart chambers and cerebral ventricles. After they hardened, the casts were freed from the surrounding tissues by maggots [1, 2]. It is suspected that both men also produced such wax casts of the vascular system. Unfortunately, none of these preparations have survived, and there is no confirmatory proof that these two pioneers really made the first "vascular casts." According to Olry [3], anatomists had injected blood vessels with various colored substances as far back as the Middle Ages. Olry indicates that Alessandra Gigliani, who assisted the famous Bolognese anatomist Mondino dei Luzzi (ca. 1275–1326) in his lectures, is sometimes regarded as the first person to have successfully injected blood vessels with various colored substances. However, no information could be found concerning the nature

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of these substances or the injection procedure. It is certain, nevertheless, that Graaf, Ruysch, and Lower produced magnificent vascular injection preparations in the seventeenth and eighteenth centuries [1], permitting them to investigate the anatomy of the cardiovascular system, for example (Fig. 4.1). At that time, vascular injection was only a preliminary prior to dissection and preparation of the organ to be investigated. The injected vessels were easier to identify, expose, and visualize. According to Faller [4], this injection and preparation were also followed by maceration with the aim of increasing the visibility of the vessels. In the late eighteenth century, the preparations were even brightened and rendered lucent (Fig. 4.2).

A very interesting sample was found in 2003 in Paris (Fig. 4.3) and may be proof that vascular injections were performed even earlier than in the medieval era [5], confirming Olry's hypotheses [3]. A mummified human torso was sold by a medical antiquities art dealer from Paris and is now conserved in a Belgian private collection. Radiocarbon dating dated the mummy as from the thirteenth century. Different approaches were used to examine the rare sample, and among these, a multidetector computed tomography (CT) scan served with an opacification of the vascular system of the sample. In fact, the vessels were injected with a complex mixture that included different metals and colors as well as different fatty substances, leading to the suspicion that already at that time, plastination of the vessels had been performed, probably with the aim of facilitating anatomic dissection. As such, an injection implies the use of a needle or cannula, and this sample indicates that such objects had been used about 150 years before previously thought in the history of medicine. It is not clear if this injection was really a postmortem injection or a perimortem procedure that eventually induced the death of the individual. Regardless, this case highlights many unanswered questions and emphasizes that much remains to be clarified about the history of postmortem visualization of the vascular system.

As a last step in the development of vascular injections, another examination was added for visualizing vessels: postmortem angiography (PMA). Angiography means the radiographic visualization of the blood vessels after injection of a radiopaque substance. The first PMAs followed rapidly on the detection of x-rays by Röntgen in 1896. Indeed, only 3 years later, in 1899, radiopaque materials were injected into the coronary arteries of isolated human hearts [1]. Vascular injection has since become a basic investigation that could be followed by macroscopic exposition of the vessels after dissection, corrosion, maceration, or brightening or after postmortem imaging (PMI).

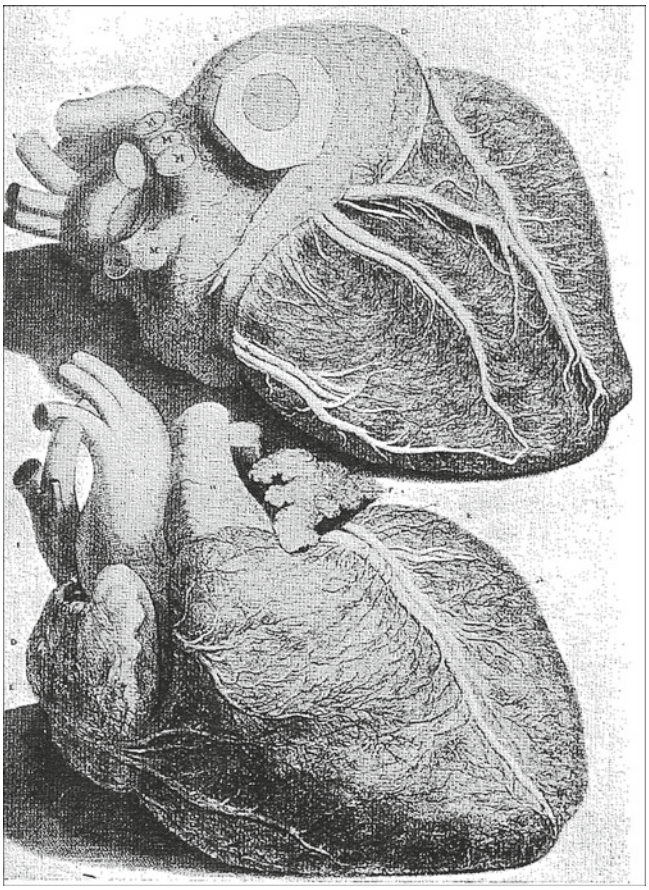

Fig. 4.1 Image of injection preparation, 1704 (Reprinted from Faller [4]; with permission)

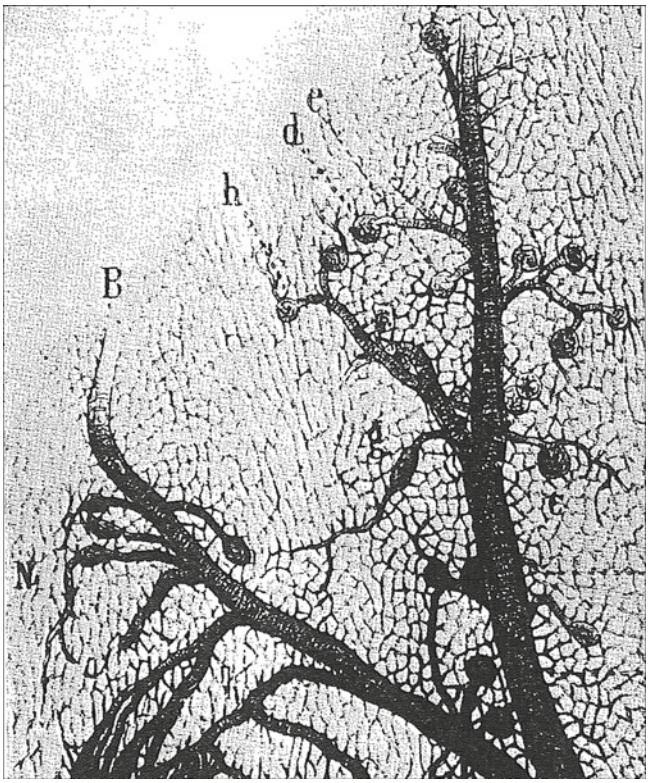

Fig. 4.2 Injection preparation of the kidney after maceration and clearing, 1857 (Reprinted from Virchow [61] [Public domain])

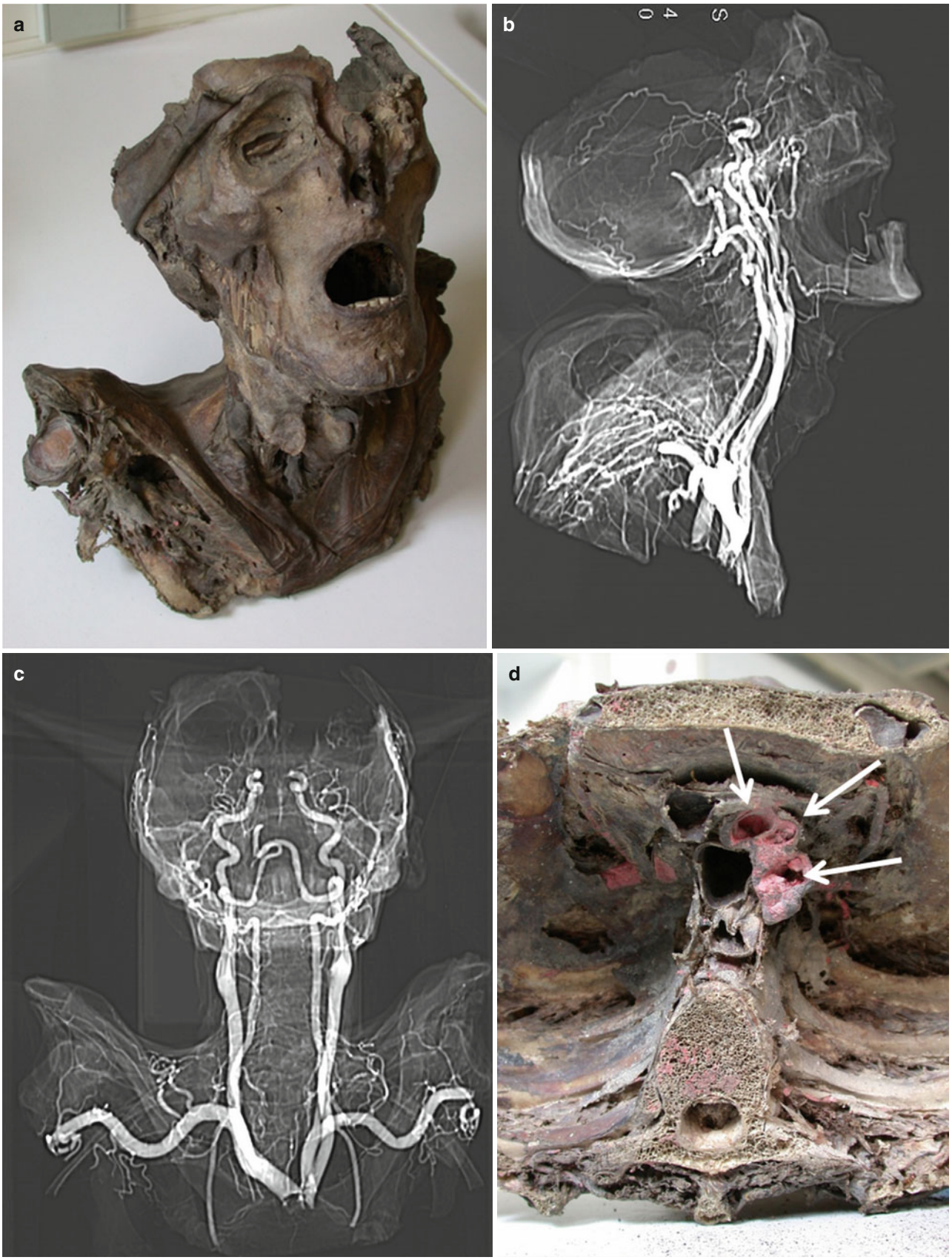

Fig. 4.3 (**a**) Mummy from the thirteenth century found in 2003 in Paris and investigated using different modern techniques. (**b**, **c**) Multidetector CT scan revealed opacification of the vascular system due to contrast agent. (**d**) A detailed inspection of the sample revealed the presence of a "metallic wax" that was injected into the vessels (*arrows*) and consisted of a complex mixture including different metals and colors as well as different fatty substances

4.2 The Development of Postmortem Angiography

During the first half of the twentieth century, the performance of PMA underwent a real boom. Hundreds of techniques for PMA existed, and new injection materials were developed with such rapidity that it is hard to follow their development in detail. However, the range of mixtures reported by Schoenmackers in 1964 [1] illustrates the immense knowledge about vascular preparations that anatomists had at that time. Unfortunately, most of this knowledge has been lost for many years, and of the hundreds of techniques, only a few survived until the twenty first century. The others were only rediscovered with the beginning of modern research in PMI and PMA. A summary of the applied methods is given here. As recently proposed [2], the techniques can be divided into six groups according to the nature of the injected material (Table 4.1):

- vascular casts,
- corpuscular preparations in gelatin or agar,
- corpuscular preparations in aqueous solution,
- hydrosoluble preparations,
- oily liquids, and
- miscellaneous.

Table 4.1 Overview of different classic methods

Technique	Injection material	References
Vascular casts	Various metals such as lead, bismuth, cadmium, rose metal, or Wood's metal	[1]
	Nylon	[7]
	Neoprene latex	[8]
	Vinyl	[9]
	Polyester resins	[10, 11]
	Silicon rubber	[12]
	Silicon rubber and lead oxide	[13–15]
	Mercox (prepolymerized methyl methacrylate)	[18]
	Microfil (colored silicone rubber)	[19]
	Polyurethane-based compounds	[20]
Corpuscular preparations in gelatin or agar	Barium sulfate in gelatin or agar	[23, 24]
	Potassium iodine in gelatin or agar	[22]
	Menninge in gelatin	[21]
	Lead sulfate in gelatin or agar	[23]
Corpuscular preparations in aqueous solution	Barium sulfate in water	[25–27]
	Micropaque (finely divided barium sulfate)	[30, 31]
	Bismuth chloride in water	[28]
	Potassium iodide and Karo corn syrup	[29]
Hydrosoluble contrast agents	Formalin with added dyes	[36]
	Cardiografin (diatrizoate meglumine)	[37]
	Hypaque (diatrizoate sodium)	[38]
	Coloropaque	[39]
	Gastrografin (diatrizoate meglumine)	[40]
	Telebrix Gastro (ioxithalamate)	[41]
Oily liquids	Jodipin (iodized oil)	[46]
	Dionosil (propyliodone)	[47]
	Lipiodol Ultra Fluide (iodized oil)	[44]
Miscellaneous	Different mixtures containing essentially: 1. A radiopaque substance or radioactive isotopes 2. Watery or oily liquids 3. Casting materials or gelatin or agar 4. Dyes	[2, 3, 49, 50, 51, 52, 53]

4.2.1 Vascular Casts

As mentioned before, the production of vascular casts represents the oldest method for visualizing the vascular system. In the beginning, the casts were viewed with the naked eye after maceration (Fig. 4.4), but PMA methods using different imaging techniques have been added, although in most cases they were only complementary. Other visualization techniques, as described above, would be sufficient. However, with the discovery of x-rays, researchers preferred combining their imaging techniques by using at least two of them, as proposed by Schoenmackers [1]. Vascular casts are fragile once the soft tissue is removed, and the risk of breaking them or a part of them is high. Therefore, the idea was to x-ray them before removing the surrounding tissue. This step was simple because the only difference between the simple injection casts and PMI casts was the addition of a radiopaque material into the injection mixture.

Various casting materials have been used over the years, most of them without combination angiography [6]. Among the first materials used, which had already been applied for such injections by around the year 1700, were different metals with low melting temperatures, such as lead and mixtures of lead, bismuth, and cadmium [1, 2]. In the nineteenth century and the early part of the twentieth century, celluloid and celloidin were mostly injected [1, 2]. These techniques were then replaced by the use of derivations of rubber with a radiopaque compound added to render it visible on the x-ray images. At the same time, various casting materials existed based on nylon [7], neoprene latex [8], vinyl [9], and polyester resin [10, 11]. At the end of the twentieth century, these injection materials were mostly replaced by silicon rubber [12]. In 1987, Segerberg-Kottinen described a technique using silicon rubber combined with lead oxide to demonstrate esophageal varices [13]. This technique has become the most cited in the literature [14, 15], although it has only isolated applications [2]. In fact, at the beginning of the twenty first century, the anatomic vascular casts disappeared. Several explanations for this disappearance are possible. Casting techniques are not really practicable for routine application in the medico-legal context. They can be used only locally on the body or on single organs. As the casting material is hardening inside the vessel after the application, it cannot be removed, and the injection and preparation of the material are tricky [2].

Although these techniques are no longer used to investigate vascular pathologies, they are still used in anatomy for teaching (Fig. 4.5a–c) (see Chap. 34). In fact, the vascular casts are impressive demonstrations of the vessels of organs and organ systems (Fig. 4.6a–d), allowing students to better visualize vessel anatomy. Also, for clinical anatomy, such prepared samples with injected vessels, also called "plastinations," are used to allow surgeons to train students on the anatomy of regions of interest [16, 17].

Another application that is being used increasingly today is microangiography, such as that applied in angiogenesis research. The vascular casts, made using specific commercially available injection materials such as Mercox (Ladd Research Industries, Williston, VT) [18] and Microfil (Flow Tech Inc., Carver, MA) [19] are viewed by electron beam microscopy and micro-CT. Increasing angiogenesis research also has led to the development of new casting substances [20], allowing the visualization of the microvascular system.

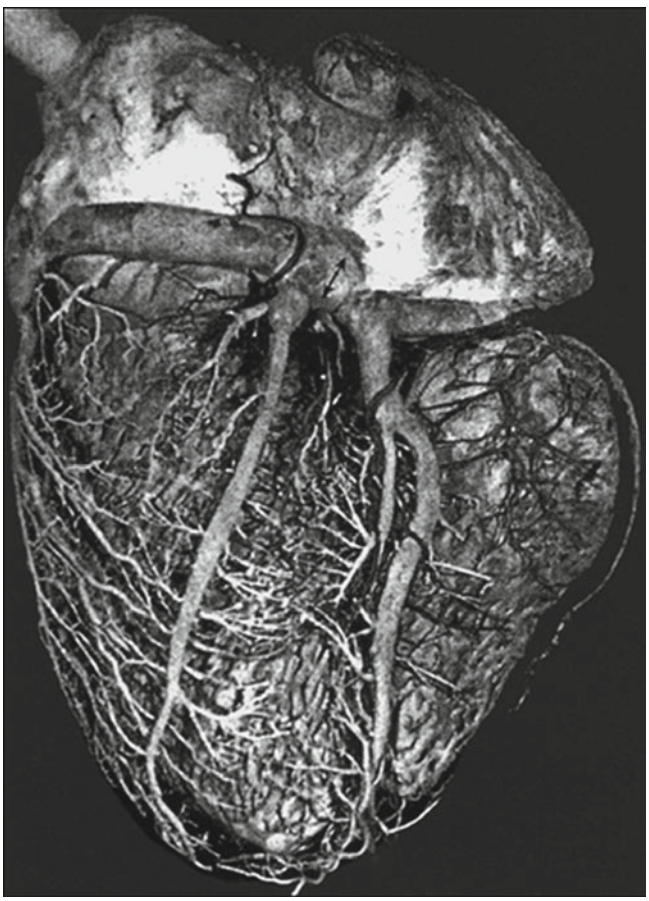

Fig. 4.4 Vinylite cast of coronary arteries prepared by Stern et al. [9] in 1954 (Adapted from Stern et al. [9]; with permission)

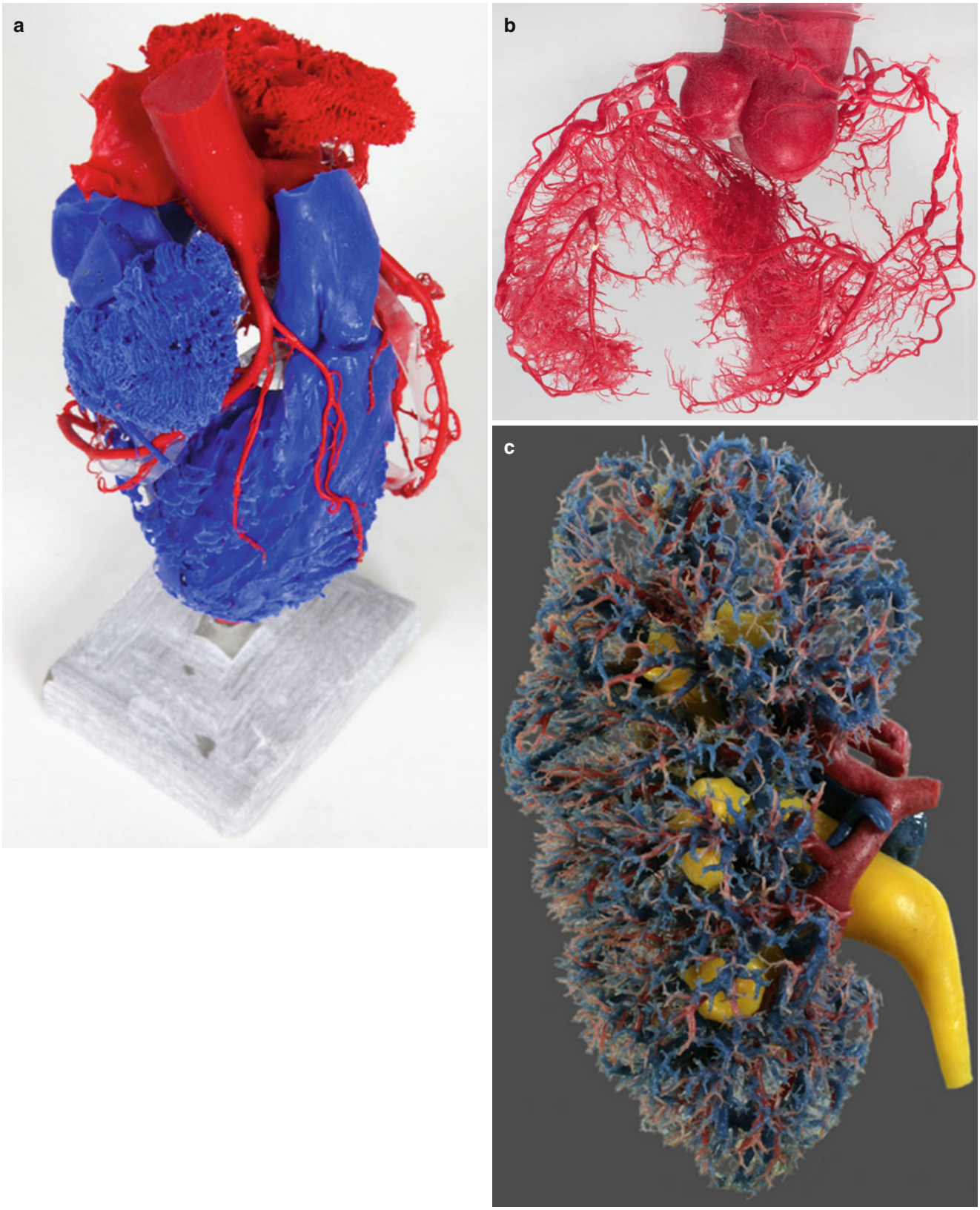

Fig. 4.5 Modern vascular casts used for teaching organ vascularization to medical students in the Institute of Anatomy of the University of Bern. (**a**) Vascular cast of the heart showing the arterial (*red*) and venous (*blue*) systems by different colored dyes added to the injection material (silicon rubber). (**b**) Cast of the coronary arteries obtained by injection of methyl red and glycol methacrylate (Technovit by Heraeus Kulzer, South Bend, IN). (**c**) Cast of the arterial, venous, and urinary systems of a kidney, each colored differently by the addition of dyes to the Technovit (Images published with the kind permission of Kati Hänssgen, Institute of Anatomy, Bern, Switzerland)

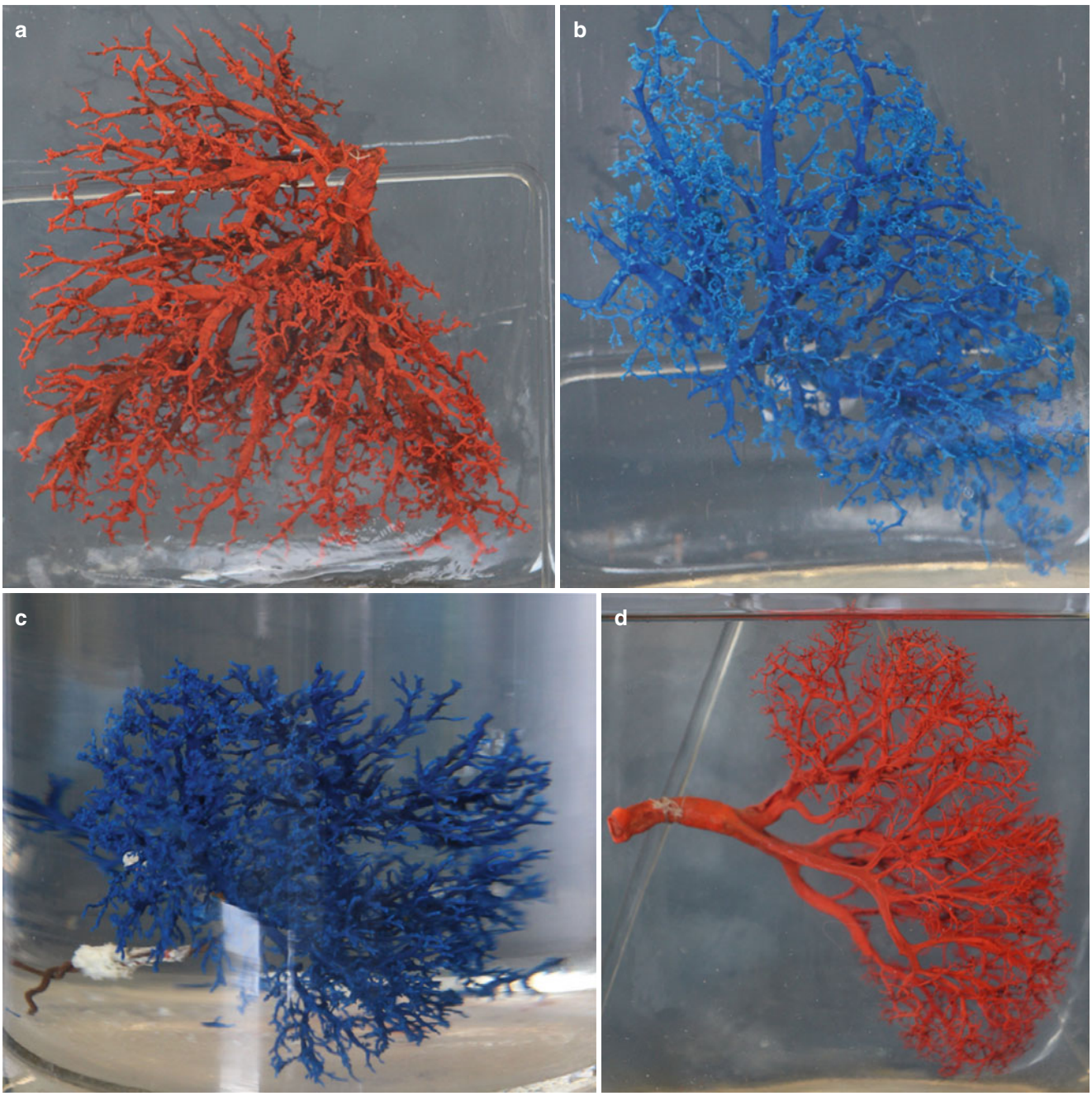

Fig. 4.6 Vascular casts kept in fixation media from the Institute of Anatomy at the University in Lausanne, Switzerland representing (**a**) a segmental pulmonary artery, (**b**) a segmental pulmonary vein, (**c**) the venous system of the spleen, and (**d**) the arterial system of a kidney

4.2.2 Corpuscular Preparations in Gelatin or Agar

Corpuscular preparations are the most frequently used for PMA. They consist of a corpuscular radiopaque material that is usually soluble in water and mixed with gelatin or agar, allowing for hardening after cooling. In addition to the radiologic image that can be obtained thanks to the radiopaque material, those preparations allow for sectioning and histologic analysis of the injected organ. Therefore, similar to vascular casts, the vascular system can be viewed in different ways. As contrast material, a red lead oxide called "menninge" was an early injectable, already in use by 1907 [21] (Fig. 4.7). Potassium iodine [22] and lead sulfate [23] were alternatives to it. The most commonly used substance, however, was barium sulfate [23, 24], which was especially applied for visualizing the coronary arteries. A pioneer in this field was Schlesinger, who developed a special technique [24] for injecting and preparing the heart, leading to a detailed coronary angiography (Fig. 4.8a). The method consisted of the cannulation of both coronary arteries on the isolated heart, which were simultaneously injected with a warm barium sulfate or lead agar mixture while the heart was kept in a warm bath of physiologic salt solution. Before the angiography, the heart was opened following a special dissection technique to "unroll" it before x-ray imaging. In this way, one x-ray could visualize the three main branches of the coronary arteries without overlapping of the vessels in the image, allowing for detailed analysis of coronary stenosis (Fig. 4.8b). The method has since been modified by Rodriguez and Reiner [23] and was regularly used until the end of the twentieth century.

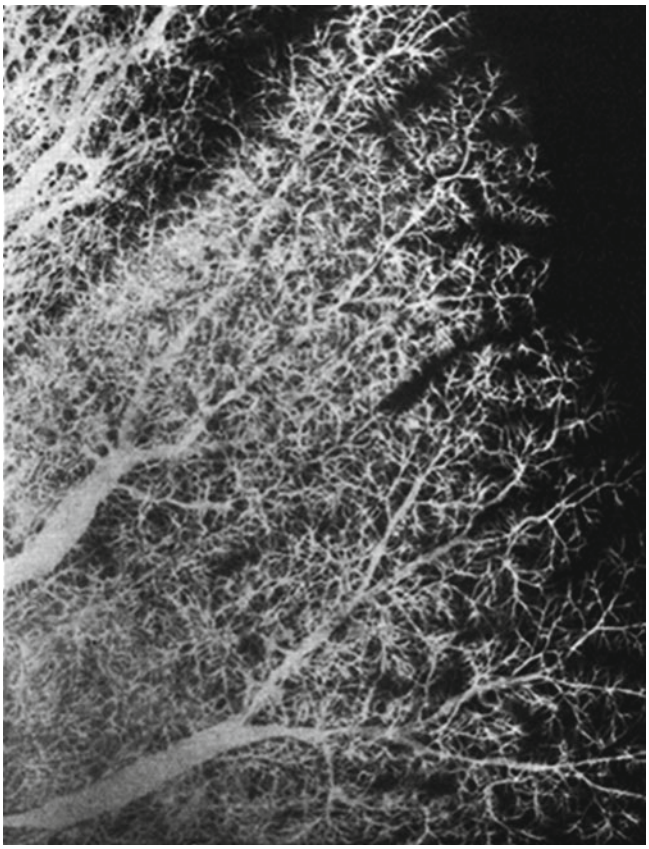

Fig. 4.7 Postmortem angiography after the injection of menninge in gelatin (Reprinted from Mitaya [21]; with permission)

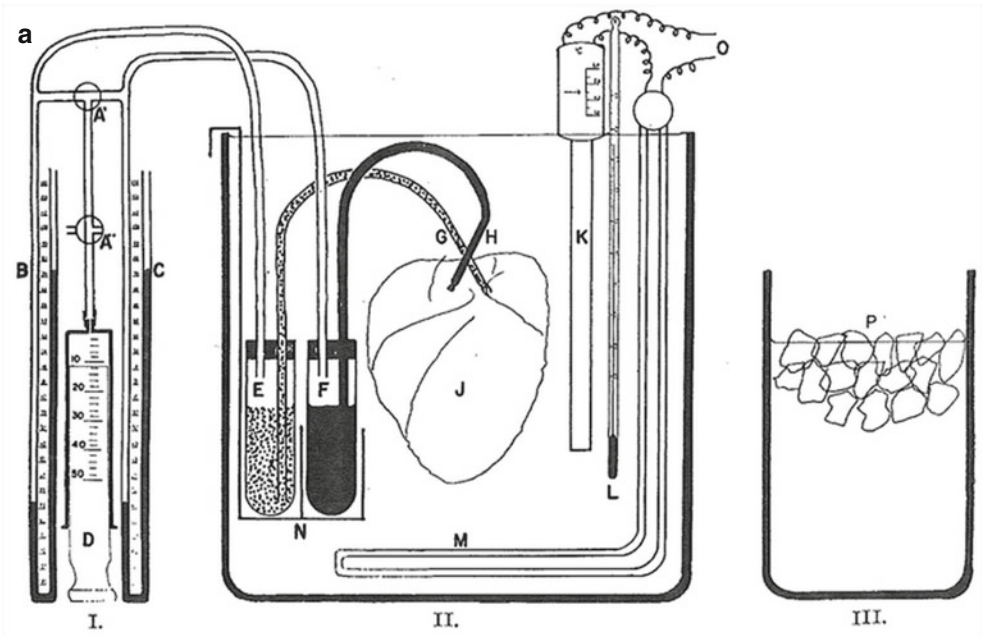

Fig. 2.—Apparatus for injection, composed of:

I. Double manometer consisting of:

A' and *A''*, three-way stopcocks
B, Manometer for left coronary artery
C, Manometer for right coronary artery
D, 50.0 c.c. syringe for pressure.

II. 45° C. salt solution bath containing:

E, Reservoir for injection mass for left coronary artery
F, Reservoir for injection mass for right coronary artery
G, Cannula in left coronary mouth
H, Cannula in right coronary mouth
J, Heart
K, Thermoregulator
L, Thermometer
M, Electric Heating Coil
N, Holder for reservoirs
O, To electric outlet.

III. Cold salt solution bath with:

P, Ice.

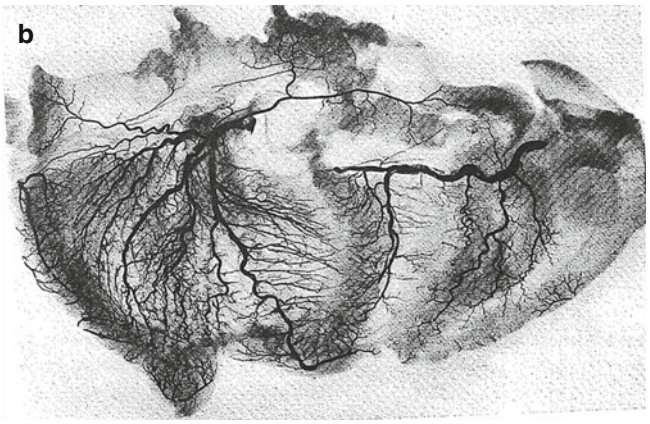

Fig. 4.8 (**a**) Schema of the injection technique of the coronary arteries published by Schlesinger [24] in 1938 (Reprinted from Schlesinger [24]; with permission). (**b**) Postmortem CT angiography of the coronary arteries; dissection of the heart according to the Schlesinger technique (Reprinted from Schoenmackers [1]; with permission)

4.2.3 Corpuscular Preparations in Aqueous Solution

As with the corpuscular preparations in gelatin or agar, this group of injection materials contains a corpuscular radiopaque substance that is mixed in a watery solution. Contrasting materials are the same, with barium sulfate as the most representative [25–27]. Other, less frequently used corpuscular preparations include aqueous bismuth chloride, introduced by Wedel et al. [28] in 1955, and corn syrup (Karo, ACH Food Companies, Memphis, TN), introduced by Stein and Svare [29] in 1963. In contrast to the earlier mentioned injection mixtures, this group was the first to be exclusively used for PMA without subsequent dissection, maceration, or another visualization technique. This change may reflect the increasing trust in radiologic techniques that began to arise in the second part of the twentieth century, whereas before then every PMA was still followed by another visualization method. The most common application of such preparations in addition to coronary angiography was investigation of the vascular system of human fetuses and newborns. Probably the most important pioneers of this technique were Richter [26] and Stoeter [27], whose PMAs were famous in pediatrics (Fig. 4.9).

Depending on the size of the corpuscular component of the mixture, this type of injection material could also be used for microangiography. In fact, a finely divided barium sulfate called Micropaque (Guerbet AG, France) [30, 31] was one of the first commercially available contrast agents for microangiography. Similar to vascular casting, it could essentially be injected for postmortem visualization of the vascular system of mice and rats by microcomputed tomography. However, because of its preparation in watery solution only, without a hardening effect, artefacts arising from sedimentation of the corpuscular component have been described in cases when there is an extended time delay between injection and scanning.

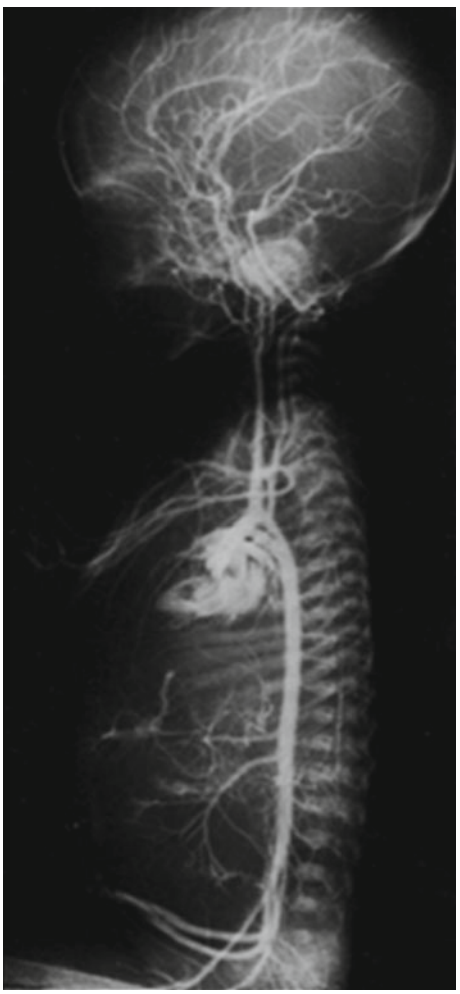

Fig. 4.9 Corpuscular preparation in aqueous solution from the archive of Stoeter: whole-body angiogram of human fetus, which was prepared by perfusing a solution of barium sulfate (Reprinted from Stoeter and Voigt [27]; with permission)

4.2.4 Hydrosoluble Preparations

Although hydrosoluble contrast agents are almost exclusively used in clinical radiology, they play an insignificant role in PMA. Because of changes in the vascular system after death, the permeability of the vascular wall increases significantly. Therefore, any injection of a hydrosoluble liquid leads to its rapid extravasation from the vascular lumina into the surrounding tissue [32]. This effect can be clearly observed and is even required in embalming procedures [33, 34], in which the increase in turgescence of the soft tissue indicates a successful embalming. However, for PMA, the remainder of the injection liquid inside of the vascular system is essential, in part to better demonstrate the lumina and in part to avoid deformation of the body as a result of edema in the surrounding tissue [32]. For this reason, the application of hydrosoluble liquids remains strongly restricted to a very short postmortem period. The first application of a simple hydrosoluble contrast agent for PMA was reported in 1866 [35]. At the beginning of the twentieth century, various water-soluble contrast agents were tested, including formalin with added dyes [36], Cardiografin (diatrizoate meglumine, Bracco Diagnostics, Cranbury, NJ) [37], Hypaque (diatrizoate sodium, Sterling Winthrop; Princeton, NJ, USA) [38], Coloropaque (Pilot Chemical Company, Avenel, NJ) [39], Gastrografin (diatrizoate meglumine, Mallinckrodt, Bethlehem, PA) [40], and Telebrix Gastro (ioxitalamate, Guerbet, Zone Paris Nord II, 93420 Villepinte, France) [41]. In several cases, the exact type of contrast agent was not specified, such as the one used by Foote and coworkers [42] for investigating the vascular system of newborns and fetuses directly after death (Fig. 4.10).

Although the easy injection and simple availability of aqueous contrast solutions (mostly the use of expired clinical contrast agents) are an advantage, today their use in PMI is limited. In fact, they are used only for targeted angiography of coronary arteries when extravasation does not play such an important role because only one organ is perfused (see Chap. 8) or directly after death as a method of PMA using cardiopulmonary resuscitation (see Chap. 9).

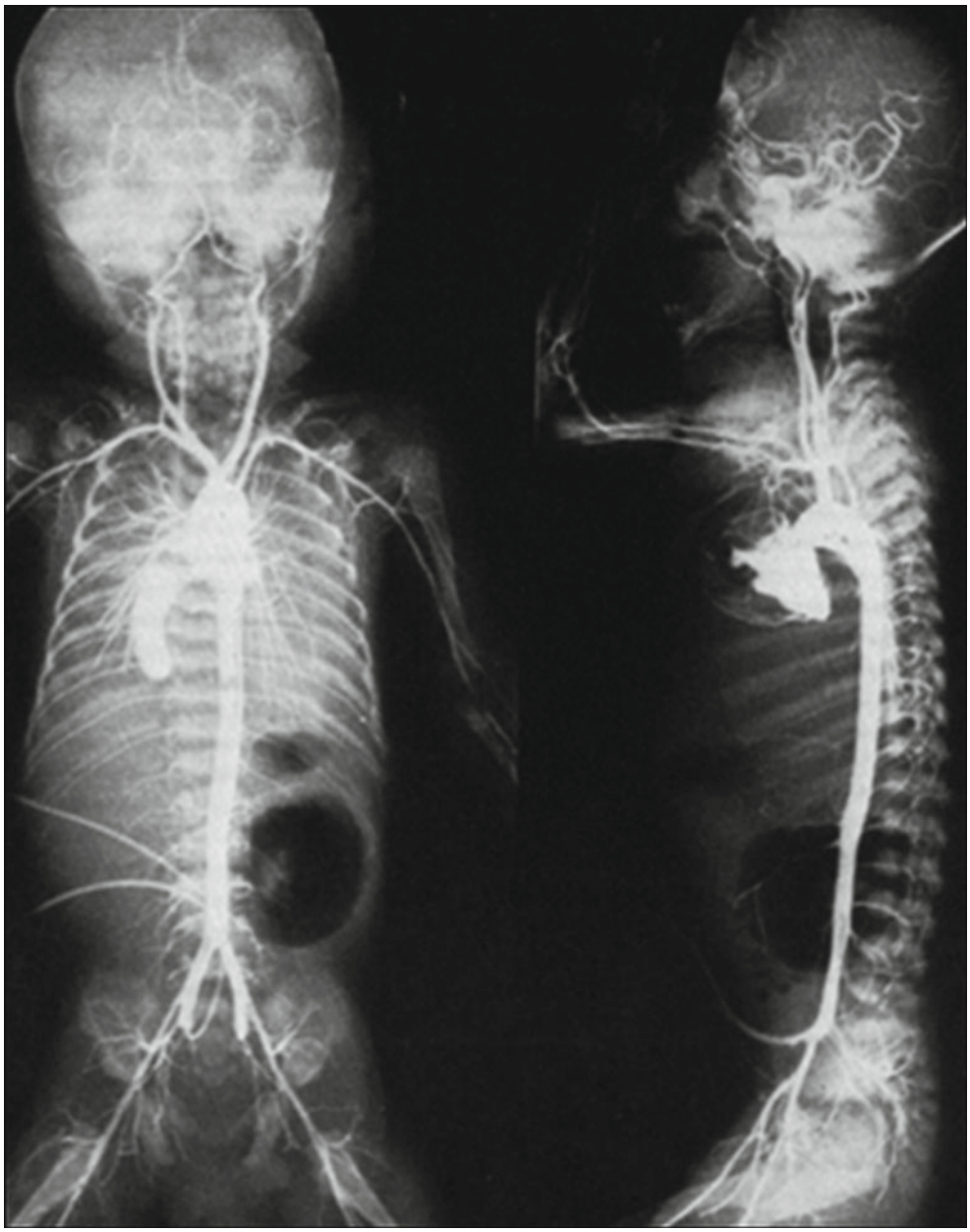

Fig. 4.10 Injection of an aqueous contrast agent: whole-body angiogram of a newborn, performed by Foote after injection of undefined water-soluble contrast agent (Reprinted from Foote et al. [42]; with permission)

4.2.5 Oily Liquids

Oily liquids have been used less frequently than other liquids for PMA in spite the emphasis in the literature of their great advantages. Similar to most other solutions used for PMA, they remain intravascular for an almost unlimited period (depending only on the alteration of the vessel itself) [32, 43]. Also, they are known for their high radiopacity, leading to high-contrast angiographic images [44]. The most important parameter for the injection of oily liquids is the viscosity of the oil, as described by Schoenmackers [1], who listed different high- and low-viscosity oils that can be used as basic substances for injection mixtures. The viscosity of the oil is a critical determinant of the caliber of the vessel that can be penetrated. High-viscosity oils are not suited for injection into the vascular system, whereas low-viscosity oils, such as diesel oil and paraffin oil, are more suitable. Low-viscosity oils lead to microembolism and occlusion of the microcirculation, which is an advantage for PMA (see Chap. 6).

The strict intravascular remainder of oily liquids and the occlusion of the microvascular system are the reasons that these liquids can be used to perform postmortem perfusion of vessels without loss into the surrounding tissue. Barmayer demonstrated this in 1968 by perfusing the coronary arteries with a mixture of diesel oil and paraffin oil to measure their flow capacity [45].

Commercially available oily contrast agents that have been used for PMA include Jodipin (iodized oil, Merck, Kenilworth, NJ) [46], Dionosil (propyliodone, Glaxo Laboratories, London, England) [47], and Lipiodol Ultra Fluide (iodized oil, Guerbet, Zone Paris Nord II, 93420 Villepinte, France) (Fig. 4.11) [44]. In clinical angiography, such contrast agents are used for lymphography and for chemoembolization of tumors [48].

In the context of PMI, oily liquids vanished from the clinical picture at the end of the twentieth century, together with most of the other injection techniques and materials. Only in recent research on behalf of modern PMI techniques have these buried studies been rediscovered, along with the information they contain about the potential of such liquids and techniques. This information has made possible the development of new contrast agents and perfusion mixtures for modern PMI based on the concept of oily liquid perfusion (see Chap. 6).

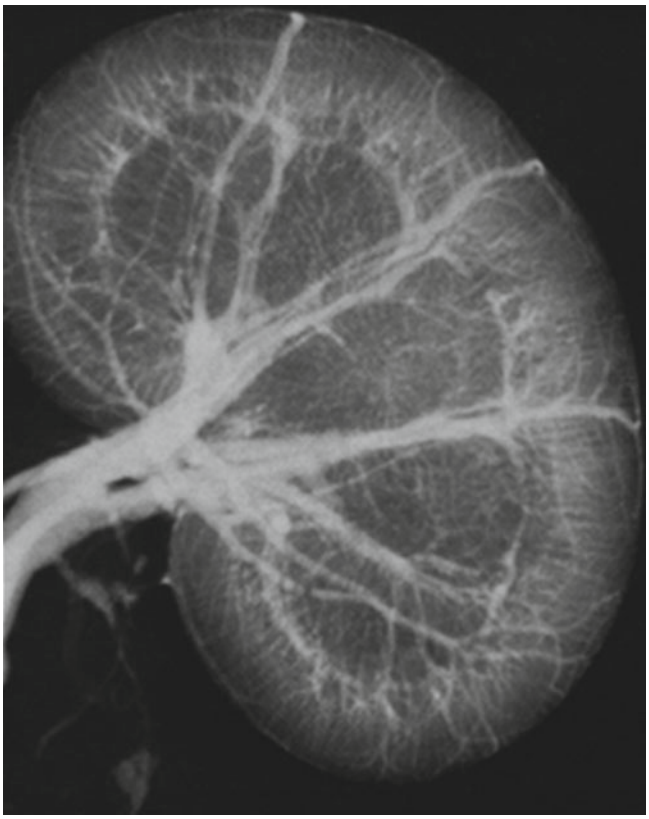

Fig. 4.11 Oily contrast agents: single-organ angiogram of kidney after injection of Lipiodol Ultra Fluide (iodized oil) (Reprinted from Pfeifer et al. [44]; with permission)

4.2.6 Miscellaneous

At the zenith of classic PMI (end of the nineteenth and beginning of the twentieth centuries), hundreds of injection materials were used to render the vascular system visible, either for macroscopic or radiologic techniques and most often for both. Anatomists and other researchers created their own injection mixtures, some of them documented by Schoenmackers [1], but most of them were probably lost forever. Literature concerning those mixtures is rarely available and mostly found only in libraries of old universities in Europe. Most of the articles are written either in German or Italian, making them accessible only to a limited number of researchers. A detailed explanation of the applied techniques would be outside the context of this chapter; therefore, only some examples are given here. In 1931, Hintze published a report of a preparation consisting of silicon arabicum and methylene blue [49]; in 1922, Crainicianu reported on a mixture containing gelatin, menninge, calcium carbonate, linseed oil, and hydrogen sulfide [50]; in 1949, Scott and coworkers published the results of a PMI using barium, latex, and liquid ammonia [51]; in 1963, Davis presented a mixture consisting of barium, latex, and radioactive isotopes [52]; and in 1954, Coccetti and Donini published images using an injection mixture of menninge, turpentine oil, and Vaseline (petroleum jelly; Unilever USA, Englewood Cliffs, NJ) [53] (Fig. 4.12).

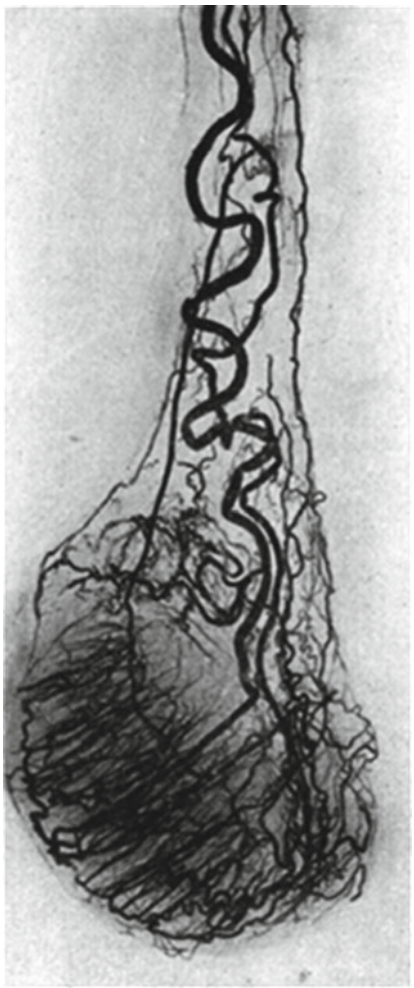

Fig. 4.12 Miscellaneous angiogram of testicular vessels, injected with a mixture of menninge, turpentine oil, and Vaseline (Reprinted from Cocchetti [53]; with permission)

4.3 Injection Techniques

As with the choice of injection material, classic methods of PMA may also vary considerably in terms of injection technique; however, most of the mentioned injection materials were introduced into the vascular system by simple manual injection. This choice may essentially be explained by the fact that the classic techniques were almost exclusively applied on single organs or small bodies such as those of embryos and fetuses. Most of the organs were injected after their removal. Exceptions are the studies of Schlichter [54] and Gloor [55], in which the injection was performed in situ, prior to the extraction of the organ. In addition, the investigation of specific anatomic regions was done in situ. Schoenmackers [1] described this procedure in detail and represented well-performed angiograms of, e.g., the head and neck region (Fig. 4.13a), the knee (Fig. 4.13b), the thorax (Fig. 4.13c), and the pelvis (Fig. 4.13d).

Different techniques have been used to generate the necessary pressure for injection. In addition to manual control, which is used most often, these include gravity [56] and pressure regulators [57]. The injection pressure has been a matter of discussion in the literature, with proposed pressures ranging from 40 to 60 mmHg [1] to 100 mmHg [58] and 120 to 180 mmHg [57] to 220 mmHg [28]. The most complex technique was probably that described by Schlesinger [24] and already mentioned earlier (Fig. 4.7a).

Some investigators have recommended a preliminary preparation of the organs before the injection of the contrast medium. In this context, chemical fixation [8, 49] or even decalcification [50] of the organ before injection has been proposed. Most authors agree that postmortem clots should be flushed out prior to injecting the contrast medium. This flushing could be achieved by infusion of saline at 38 °C [29], as first suggested by Spalteholz [59] in 1907. Special perfusion techniques with the aim of preparing the vascular system have been performed using kerosene [60] and a mixture of diesel oil and paraffin oil [45].

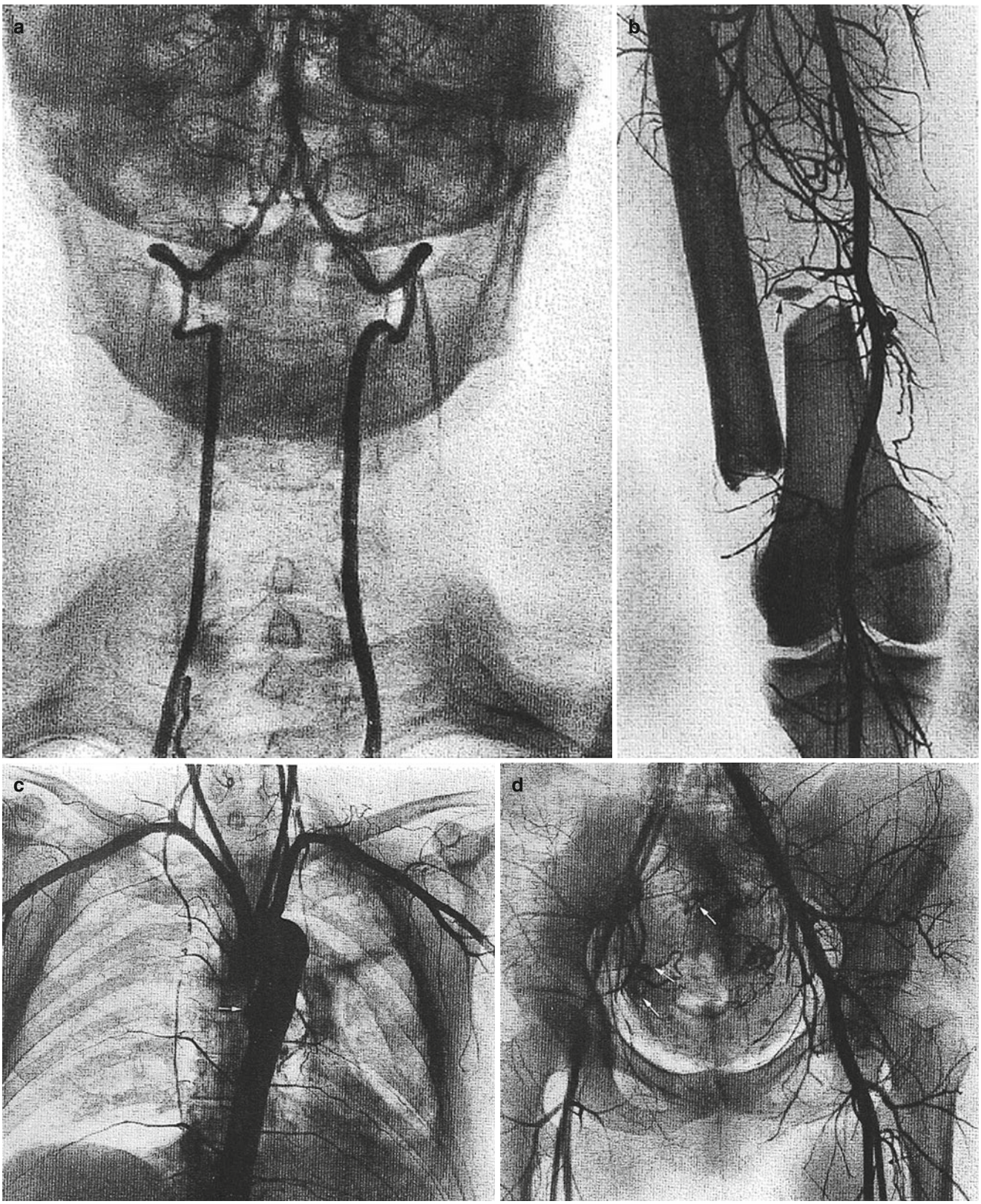

Fig. 4.13 In situ injection PMA, published by Schoenmackers in 1960, showing vessels of various anatomic regions: (**a**) neck, (**b**) knee, (**c**) thorax, and (**d**) pelvis (Reprinted from Schoenmackers [1]; with permission)

4.4 What Can We Learn from the Classic Techniques?

Although the classic techniques are not regularly applied today in combination with modern PMI, we can learn many things from them. Many of the "old anatomists" were specialists in the perfusion of the vascular system of human bodies. They already understood that the vascular system needs special treatment after death and that it is not enough to simply inject contrast agent, as is done in living patients. These experts had many different techniques for injection and used even very sophisticated methods to perform a perfect perfusion of the organ's vessels. The results were fascinating and clearly superior compared to some trials achieved with modern methods. They were also specialists in the development of perfusion liquids and mixtures of contrast agents. Knowledge about the abilities of different liquids inside the vascular system was copious, as Schoenmackers' [1] paper makes clear. He already knew all of the advantages of oily liquids, hyperosmolar liquids, and corpuscular solutions, for example, and was familiar with the properties of any liquid type that could be injected into the vessels, clearly describing the advantages and disadvantages of each. However, most of this knowledge seems to have been lost; a review of the modern literature addressing experimental approaches to PMA indicates that the same "errors" are being made that have already been described in the literature, including in that excellent publication from 1960 [1]. To develop new contrast agents and new perfusion liquids and devices as well as new methods for PMI, familiarity with the information in the classic literature is essential for avoiding unnecessary trials and choosing the best basic material and approach. Essentially, the classic techniques teach us the following:

1. Every liquid injected into the vascular system shows a specific behavior in the vessels. This behavior depends on the kind of liquid (e.g., oily, corpuscular mixture, aqueous) and its physical properties (viscosity, osmolarity, radiopacity).
2. The longer the postmortem delay, the more specific the injected liquid should be. Although clinical aqueous contrast agents may produce sufficient quality directly after death, they are not suited for PMA in the later postmortem phase.
3. The injection site, pressure, and material are essential for the correct perfusion of the organ or the body.

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