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PAPER

PATHOLOGY AND BIOLOGY

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Usefulness of Systematic Histological Examination in Routine Forensic Autopsy*

ABSTRACT: The forensic community does not agree on the need to perform histological examination at forensic autopsy. The aim of our study was to determine the usefulness of systematic standard histology in forensic autopsies. A prospective study was carried out on 428 autopsy cases for which standard histological examination was systematic. Mechanism of death not shown by gross anatomic findings was discovered by histology in about 40% of the cases. Cause of death was established by only histology in 8.4% of the cases. Microscopic findings affected the manner of death in 13% of the cases. Histology provided complementary information about prior medical condition of the deceased in about 49% of the cases. Traumatic lesions were better documented by histology in about 22% of the cases. According to the results of our study, systematic standard histology for the main organs should be used in routine forensic autopsies.

KEYWORDS: forensic science, forensic pathology, forensic autopsy, histology, cause of death, manner of death

The main task of the forensic pathologist is to determine cause and manner of death, using all currently available methods including death scene investigation, autopsy, and ancillary tests including histological examination. Forensic autopsies often include histologic analysis, but not always as is usually required with nonforensic autopsies. According to the "Standards for the Practice of Forensic Pathology" proposed by the Forensic Pathology Committee of the College of American Pathologists, the extent of histologic examination of the autopsy tissues is at the discretion of the pathologist (1). According to the Forensic Autopsy Performance Standards of the National Association of Medical Examiners (NAME) (2), the forensic pathologist shall perform histological examination in cases with no gross anatomic cause of death unless remains are skeletonized. Published studies relative to the utility of routine histologic sections in forensic autopsies are rare (3,4). In a retrospective study performed on 638 autopsy cases (3), Langlois showed that histology was regarded as contributory to the cause of death in 53% of the cases. Conversely, in their prospective study carried out on 189 cases for which cause and manner of death were evident by the gross autopsy findings (4), Molina et al. showed that histology altered the cause of death in only one case. One of the limits of these two studies is that they were mainly focused on cause and manner of death. Indeed, evaluation of information provided by histology in routine autopsy cases regarding respectively death mechanism, prior medical condition of the deceased, and documentation of eventual traumatic lesions was not performed. So, the aim of our study was to determine the usefulness of systematic histology in forensic autopsies, not restricted to cause and manner of death.

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Materials and Methods

A prospective study was carried out on 1786 autopsies performed in the Department of Pathology and Forensic Medicine at the Raymond Poincaré Hospital from 2003 to 2007, for which standard histologic examination was systematic according to our autopsy protocol (including microscopic sections of the heart, lungs, liver, kidneys, pancreas, spleen, thyroid, adrenal glands, prostate, and neuropathological study after brain formalin fixation). Histology was performed for every autopsy case in the institution for the 6-year period. Two forensic pathologists reviewed the microscopic sections of 428 randomly selected cases from the included material. Sudden infant death syndrome (SIDS) cases, skeleton cases, and cases with organ retrieval for transplantation were excluded from the study. SIDS cases were excluded from our study because the question of usefulness of systematic histology for such cases is now no longer raised. Indeed, autopsy protocol for SIDS cases includes systematic histology according to international guidelines (5). For each case, information provided by histology regarding respectively cause and manner of death, death mechanism, prior medical condition of the deceased, and documentation of eventual traumatic lesions was analyzed. Documentation of traumatic lesions included determination of the characteristics and/or age of injuries. Discrepancies between gross anatomic and microscopic findings were also studied.

Results

The mean age of the population was 46.2 years (range 5–91 years). The sex ratio (M/F) was equal to 2.46. Bodies showed respectively putrefaction in 92 cases, mummification in one case, and diffuse carbonization in 15 cases. Concerning manner of death, the majority of the cases were natural deaths (n = 130, including 63 cases of sudden death), followed by suicide (n = 113), and accidental deaths (n = 104). Homicide and undetermined manner of

death were respectively found in 40 and 41 cases. The most frequent causes of death were cardiovascular diseases ($n = 90$), blunt force injuries ($n = 73$), mechanical asphyxia including drowning ($n = 62$), acute intoxication ($n = 59$), and gunshot wounds ($n = 47$). No cause of death (after macroscopic and microscopic examinations) was found in about 7.5% of the cases ($n = 32$). In these 32 cases, 18 showed putrefaction and one showed mummification. Manner of death was sudden death in four cases and undetermined in 28 cases.

Cause of death was established by only histology in 8.4% of the cases ($n = 36$). Causes of death determined by only histology are shown in Table 1. Mechanism of death not shown by gross anatomic findings was revealed by histology in about 40% of the cases ($n = 173$). The main mechanisms of death found were respectively cardiac arrhythmogenic substrate ($n = 98$), acute myocardial ischemia ($n = 17$), pulmonary infection ($n = 17$), vital alimentary aspiration ($n = 14$), fat embolism ($n = 13$), pulmonary thromboembolism ($n = 5$), diffuse axonal injury ($n = 3$), disseminated intra-vascular coagulation ($n = 2$), and sickle cell crisis ($n = 2$). Cardiac arrhythmogenic substrate were respectively, multifocal interstitial fibrosis in 51 cases (Fig. 1), right ventricular fat infiltration associated with fibrosis in 20 cases, scar tissue corresponding to an old infarct (Fig. 2) in 15 cases, and focal myocarditis in 12 cases (Fig. 3). For the cases showing putrefaction or mummification ($n = 93$), mechanism of death not seen grossly was discovered by histology in about 41% of the cases. Concerning sudden death cases ($n = 63$), mechanism of death not seen grossly was discovered by histology in about 70% of the cases ($n = 44$). Microscopic findings affected the manner of death in 13% of the cases ($n = 56$):

- Undetermined versus natural death in 45 cases (in which a cause of natural death was found by histology).
- Accident versus natural death in eight cases (in which the individuals suddenly lost consciousness in circumstances seemingly accidental, the loss of consciousness being a lethal pathology diagnosed by histology).
- Undetermined versus homicide in two cases.
- Suicide versus natural death in one case (in which a suicide by drug overdose was initially suspected and ruled out by toxicological analyses).

In the two homicide cases, the cause of death was closed head injury secondary to blows. The death was delayed after head trauma, occurring respectively 3 weeks and 1 month after acts of violence. For the two cases, the only evidence of trauma was provided by histology showing diffuse axonal injury.

For the cases showing putrefaction or mummification ($n = 93$), histology did alter manner of death in about 20% of the cases ($n = 19$).

Histology provided complementary information about prior medical condition of the deceased in about 49% of the cases ($n = 211$).

TABLE 1—*Causes of death provided by only histological examination (*n = *36).*

Cause of Death	Number of Cases
Ischemic heart disease	9
Acute myocardial ischemia	6
Cardiomyopathy	5
Myocarditis	6
Artery fibromuscular dysplasia	1
Fat embolism	1
Acute pneumonia	6
Acute pancreatitis	2

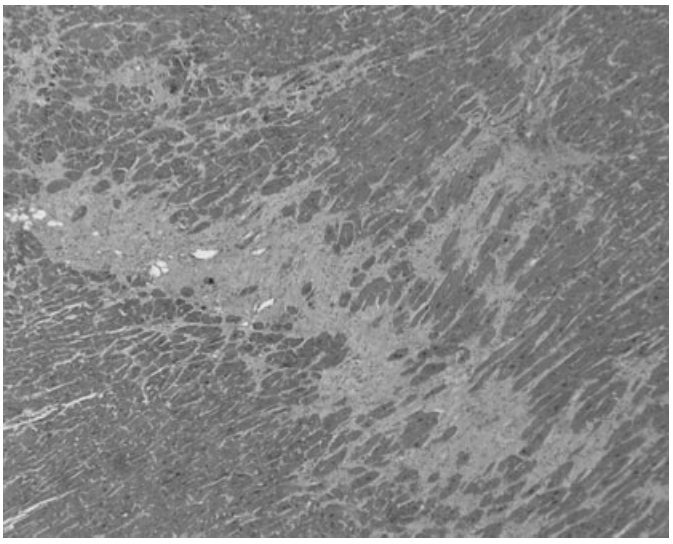

FIG. 1—*Significant interstitial fibrosis in a case of a 67-year-old man who died from an accidental carbon monoxide poisoning (HES, ×100).*

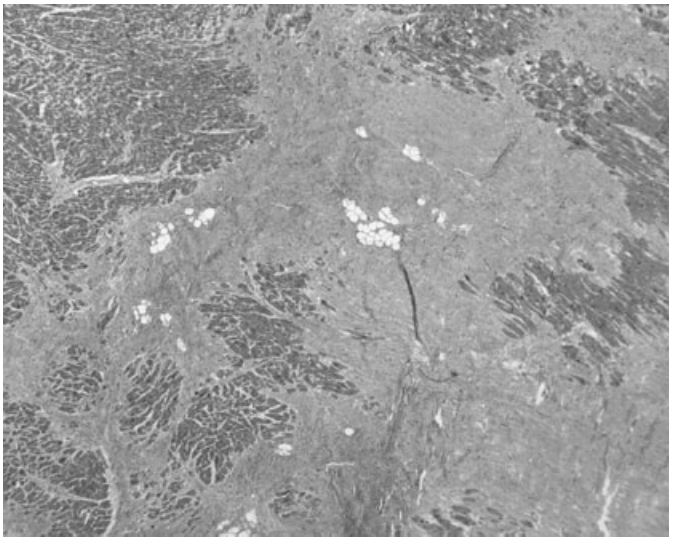

FIG. 2—*Scar tissue corresponding to an old infarct in a case of a 52-year-old man who died suddenly at rest (HES, ×25).*

The main pathologies found were respectively liver disease ($n = 97$), lung disease ($n = 55$), neoplasia ($n = 25$), heart disease ($n = 22$), kidney disease ($n = 8$), and brain disease ($n = 4$).

Traumatic lesions were better documented by histology in about 22% of the cases ($n = 94$). Table 2 shows the information provided by histology regarding injuries. Information provided by histology in the age determination of traumatic lesions in 52 cases were the following ones:

- In 44 cases, macroscopic examination found skin bruises which seemed recent. Histology showed skin bruises from different ages, including recent and old bruises. Hemosiderin deposits and inflammation were found in the old bruises.
- In five cases, microscopic signs of organization were found in fractures which appeared recent on macroscopic examination.
- In three cases, microscopic signs of organization were found in cerebral contusions and/or subdural hematomas which appeared recent on macroscopic examination.

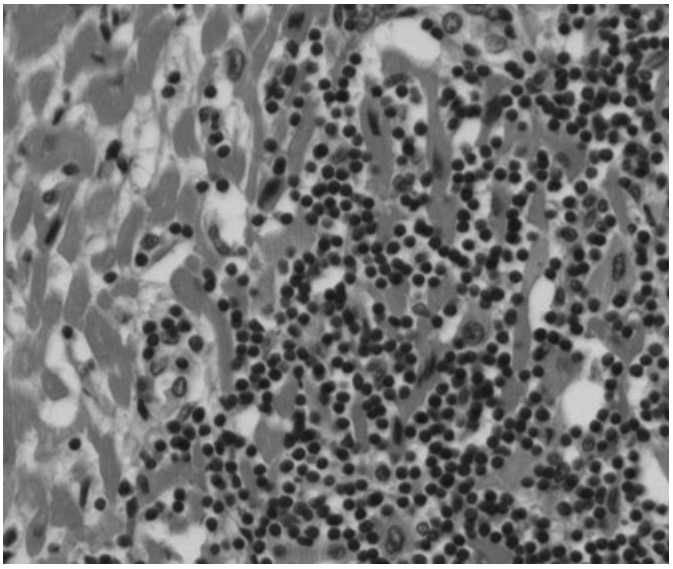

FIG. 3—*Focal lymphocytic myocarditis in a case of a 23-year-old woman who died after being stabbed by her husband (HES, ×400).*

Precision on gunshot wounds included information about range of fire and distinction between entrance and exit wounds. In 35 cases, macroscopic examination showed neither soot nor powder tattooing on the outer margins of entrance wounds. For these cases, histological findings on the sampled wounds were smoke stains and/or interspersions of gunpowder.

In six cases showing putrefaction, skin bruises found on macroscopic examination were subsequently ruled out as traumatic based on histology.

In one case who died from drowning without signs of putrefaction, histology revealed a recent skin bruise in an anatomic zone where only livor mortis was visible on macroscopic examination.

Table 3 shows discrepancies found between gross anatomic and microscopic findings. Discrepancies did exist between microscopic and gross autopsy findings; most of them involved the liver, the heart, and the lungs. The noncorrelates of hepatic steatosis were in cases of mild to moderate except one case with severe steatosis overlooked grossly.

For all the cases included in the study, histological examination did not significantly contribute to macroscopic findings in about 14% of the cases (n = 59).

Discussion

There is some discussion as to the necessity of histological examination in routine forensic autopsies. Systematic histological examination may be thought by some to be expensive or too time-consuming. Molina et al. (4) feel that according to the results of their study microscopic examination should be used, as needed, in certain circumstances, but is not necessary as a matter of routine.

TABLE 2—*Type of information provided by histology regarding injuries (*n = *94).*

Type of Information	Number of Cases
Dating	52
Precision on gunshot wounds	35
Traumatic nature of the sampled lesion ruled out	6
Traumatic nature of the sampled lesion revealed	1

TABLE 3—*Discrepancies between gross anatomic and microscopic findings.*

Finding	Not Seen Grossly	Misidentified Grossly	Correctly Diagnosed Grossly
Hepatic steatosis	71	2	45
Hepatic fibrosis/cirrhosis	10	2	23
Chronic hepatitis	19	1	0
Myocarditis	12	0	0
Acute myocardial ischemia	10	0	5
Ischemic heart disease	14	0	39
Cardiomyopathy	9	0	27
Acute pneumonia	14	1	6
Chronic interstitial lung disease	15	0	2
Pulmonary embolism	1	0	2
Multiorgan granuloma	7	0	0
Neoplasia	13	4	13
Nephrosclerosis	2	0	2
Chronic nephritis	3	0	4

According to previous studies (6–8), histological examination has a major impact on macroscopic diagnoses performed on hospital autopsies. Indeed, such studies showed that diagnoses made on macroscopic examination were altered by histology and that macroscopically normal organs showed histological abnormalities. In a series of 108 hospital autopsies, Zaitoun et al. (6) found that histological examination contributed significantly to the final diagnosis in major (5%) and minor clinicopathological findings as well as in new pathological findings (23%). In a series of 371 hospital necropsies, Bernardi et al. (7) found that the lung and the liver were the organs with the most frequent discrepancies between the gross and microscopic findings (38.7% and 35.1%, respectively). Such findings were consistent with the results of the study of Hunt et al. (8) who showed that there is a considerable discrepancy rate between naked eye diagnoses of bronchopneumonia at necropsy and diagnoses confirmed on microscopy. Bronchopneumonia could be confirmed on independent histological review in 69.2% of the cases (n = 279) (8). Moreover, according to Roulsen et al. (9), over 20% of clinically unexpected autopsy findings, including 5% of major findings, can be correctly diagnosed only by histological examination.

Our results are consistent with these studies and with the study of Langlois performed on forensic material (3). Conversely, our results conflict with those of Molina et al. (4). One element of explanation of these discrepancies could be due to the fact that in our series, natural death was the main manner of death. In the series of Molina et al. (4), the majority of the cases reviewed were accidents, with natural death representing only 25% of the cases. Natural deaths more often require the use of microscopy to establish cause of death than violent deaths. Our series is more representative of a common forensic autopsy material than the series of Molina et al. Indeed, in one huge forensic autopsy series (n = 13,227), about 50% of the cases had a natural manner of death (10). Another element of explanation could be that autopsy samples for histology were not sufficient in quantity and/or quality. The third element of explanation is that our study was not focused only on cause and manner of death. Langlois found in a retrospective study performed on 638 autopsy cases (3) that histology was contributory in 53% of the cases regarding cause of death but not regarding manner of death. In our study, histology rarely altered manner of death, in 13% of the cases. In most of the cases manner of death was changed from undetermined to natural. Histology provided complementary information about prior medical condition of the deceased and traumatic lesions in about 49% of the cases and 22% of the cases respectively. Prior medical conditions should be

adequately evaluated to answer questions regarding contributory causes of death and survival length. Another contribution of histology is the documentation of control cases, especially hearts. Unspecific lesions such as fatty infiltration of the right ventricle without fibrosis may be found in control cases. Such findings should not prompt a diagnosis of pathology when circumstances of death are different, for example in case of sudden death.

According to the results of our study, standard histology for the main organs should be systematically performed in routine forensic autopsies. Microscopic findings are relevant especially concerning cause and manner of death if the autopsy samples for histology are sufficient in quantity and quality. An autopsy protocol including histology should be performed according to published guidelines (1,2,11–13). Our study also showed that injuries which seem recent at autopsy may present microscopic signs of organization in about 22% of the cases. Consequently, injuries found at autopsy should be sampled for histological study.

In our study, only routine histology was assessed. Special procedures such as immunohistochemistry are now currently used in forensic pathology. In sudden cardiac death, early diagnosis of acute myocardial ischemia can be done using four immunohistochemical markers including myoglobin, desmin, cardiac troponin I, and the C5b-9 complex (14). In closed head trauma, diffuse axonal injury can be highlighted using beta-amyloid precursor protein expression (15). Immunohistochemical markers such as collagens, fibronectin, adhesion molecules, inflammatory cytokines and chemokines may aid in the age estimation of skin wounds (16,17). If the same study was carried out including immunohistochemistry procedures when necessary, we can presume that the rate of discrepancies with macroscopic findings would probably increase.

The concept of virtual autopsy or virtopsy has been introduced in forensic pathology for some years. Numerous studies have indeed shown the interest of whole body forensic imaging, using magnetic resonance imaging (MRI) or multislice computed tomography (MSCT) (18–22). In spite of advances in postmortem diagnoses, the spatial resolution of such techniques is still poor. For example, in recent MR imaging research, MRI only enabled the differentiation of all layers of the gastric wall in *ex vivo* studies (23,24). According to the results of our study, macroscopic findings should be complemented by histology. Even if some macroscopic findings can now be well documented by forensic imaging using MSCT and MRI, such tools cannot replace a complete forensic autopsy which includes large sampling for histology.

In conclusion, there is a considerable discrepancy rate between macroscopic and microscopic findings in forensic autopsy. Histology is an important feature regarding forensic autopsy quality and is still essential to confirm, refine, or refute macroscopic findings. According to the results of our study, systematic standard histology for the main organs should be used in routine forensic autopsies.

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