The Autopsy in Medical Education and Training

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Autopsy as Historical Apprenticeship

As in a statement attributed to Pasteur, in the fields of observation, chance favors only the prepared mind. The use of the autopsy observation of human disease for the education of students and practitioners has provided insights that have opened doors for the development of many advances in medicine.

The use of agents that interrupt the renin-angiotensin system, for example, is based upon the elucidation of the biochemical interactions of those factors with one another and with their cognate receptor and effector systems. The nature of the humoral factor renin, in turn, derives from the observation by Goldblatt that surgical stenosis of the renal artery in experimental animals released into the circulation a factor capable of producing hypertension [1, 2]. The experiments of Goldblatt were in turn founded upon nineteenth-century observations made by Bright of patients at autopsy who had myocardial hypertrophy and a shrunken kidney caused by renal artery stenosis, observations made long before measurement of blood pressure was even performed in humans [3]. That about one century elapsed between the initial observation and the key experiment that made possible our present understanding illustrates the point that the observer and the prepared mind do not necessarily need to coexist in space or time. Our observations and materials from the autopsy may contribute to advances to be made far into the future.

The autopsy has been a traditional part of medical education, predating the advent of the pathologic examination of surgical specimens for diagnostic and prognostic interpretation, the ability to noninvasively visualize the internal structures of the body, and the understanding of the microbial, immunologic, biochemical, and genetic bases of disease [4]. With each of the aforementioned advances in

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understanding and practice, the role of the autopsy has necessarily had to evolve, responding to changes in incentives guiding the time and attention of academic and community pathologists, as well as the depth of examination that was possible because of scientific advances. Whereas in the early twentieth century, autopsies were performed not only by pathologists but also by enlightened and sometimes competitive physicians and surgeons [5], in the modern era, many practicing anatomic pathologists perform few autopsies, if any, as a part of their practice. Autopsy remains as a required part of graduate medical education in anatomic pathology, however, where it provides residents with skills in anatomic dissection, including the ability to recognize and handle fresh, fixed, and processed tissues. The autopsy is often the first opportunity that a pathology resident has to take responsibility for the conduct of a complex medical procedure that may require judicious use of laboratory tests and expert consultations that ultimately affect turnaround time.

In autopsy, a resident must review complex medical records, interact with caregivers to understand their sometimes unwritten concerns, and then concisely synthesize findings in the context of current scientific understanding and medical uncertainty. In many cases, the autopsy is the dominant form of exposure for residents of cardiovascular and central nervous system diseases, which constitute important areas of human morbidity that are not often seen in other pathology rotations. Finally, residency training in autopsy provides a gateway for advanced training for a career in forensic pathology, or for careers where autopsy practice is a key component, such as cardiovascular pathology or neuropathology. Training in autopsy is also useful preparation for careers in academic pathology, because of the need to pass along autopsy training to trainees.

Autopsy Education and Autopsies Performed

As the role of the autopsy has changed, so has the number of autopsies performed, particularly outside of the domain of forensic pathology. The decline in the numbers of autopsies, both in community practice and in academic medical centers, has led to frequent questioning about the relevance and future of the autopsy. Such questioning is not new, but has been ongoing for generations. The reader is invited to review a 1956 editorial, "Potential Values of the Autopsy Today," by University of Pennsylvania cardiologist and former Dean, Dr. Isaac Starr [6]. The theme of the Starr editorial was that the rigorous approach to the autopsy appeared to have declined because academic pathology chairs had allowed their attention, as well as that of their new hires, to be drawn by experimental pathology, which could be performed not only in laboratory animal models of human disease but also by the study of human cells in culture through the newly available immortal cell culture lines. At the same time, the number of autopsies in academic medical centers had actually increased to its peak, reportedly because of the willingness of families to contribute to the tangible progress in medical and surgical therapeutics. The autopsy, once a privilege to the education of pathologist and clinician alike, had now become a drudgery and distraction from more attractive and rewarding undertakings. Huge

amounts of data about autopsies had been collected by disinterested rote in innumerable report volumes, file cards, glass slides, and photographs that Starr foretold would never be used. Dr. Starr proposed that the autopsy should be simplified to answer the immediate questions of clinicians, without histology, if possible. Having performed research leading to the development of the ballistocardiograph on patients sent for autopsy, Starr saw the potential instead to expand the practice of such research in the autopsy room. It appears that Starr may have experienced some resistance to his efforts.

Responses from leading pathologists of the day came swiftly to correct some generalizations made by Dr. Starr, but, at the same time, the respondents admitted that some of the points raised in the editorial had merit [7–9]. It was noted that changes in the practices of departmental leadership might contribute to the increased emphasis placed by departments on experimental pathology, as opposed to the simply observational skill of autopsy. It was proposed that the devaluation of simple autopsy observation was passed down from chair to faculty to trainees. As a consequence, the caliber of practitioners of pathology at all levels began to decline. Another point raised was that there seemed to be a large amount of information gathered by autopsy which never in turn was used after having been collected. Autopsy technique was felt by some to have become stagnant and excessively detailed. It was proposed that perhaps streamlining the autopsy to restrict its scope to specifically answer the questions posed by concerned clinicians would help the autopsy to regain some of its relevance to pathology attendings and trainees of the day. Others proposed that the time had come for stakeholder pathology organizations to take a more active role in advising pathology leaders about balancing the roles of service and research, as well as to support the role of education in academic practice, since there was a growing perception that academic pathologists had become too busy to teach. The engagement with clinical colleagues that once occurred over the autopsy had begun to diminish, an interaction that was in fact believed to have even more value for experienced clinicians than it did for students, largely because fewer pathologists fully became proficient at the technical and interpretive skills required to master autopsy practice. In the words of one observer, “The main thing that is wrong with pathology is that pathologists no longer teach it.”

Evolving Standards for Documentation of Competency in Autopsy

The point of raising the editorial exchange from 1956 is that many of the observations about academic pathology remain true 60 years later. In the face of progressively declining numbers of hospital autopsies being performed, the Accreditation Council for Graduate Medical Education and the American Board of Pathology instituted number-based criteria for the training of pathology residents [10]. Although initially set as 100 autopsies per resident [11], the autopsy requirement was soon reduced to 75 [12] and then 50 autopsies [13], and sharing of autopsies by two residents was also permitted. Several adjustments have been made since then to

limit abuse of the system by residents claiming too many lower teaching value cases, such as macerated fetopsies, as complete cases. The necessity of imposing such restrictions indicates that the emphasis placed on quality teaching of autopsy in various programs is likely not uniform.

The existing number-based criterion for assessing competency in autopsy has been perceived as having failed to achieve its desired goals. Some large and otherwise excellent programs do not have enough available autopsies to support the numerical standards and must rely heavily upon local forensic pathology authorities to provide autopsy experience that is beyond the control of the department. It has been argued that simply reducing the numerical requirement might adequately address the needs of large programs. There are anecdotal complaints to the American Board of Pathology about recently board-certified anatomic pathologists, who presumably had met the number-based criterion during residency training and yet were unable to undertake an autopsy when called upon to do so in the course of their practice (Rebecca Johnson, personal communication). On the other hand, recent trainees have indicated in surveys that they find that the amount of time spent during training on autopsy is excessive and that the utility of autopsy training in their subsequent practice is not great.

In one such recent survey, about 50% of new-in-practice pathologists reported that they did not perform autopsies as a part of their routine practice [14]. The question has been raised whether autopsy should even be included as a part of training in anatomic pathology, perhaps better required only as a component of advanced training in forensic pathology fellowships. On the other hand, the sentiment persists that autopsy training provides some unique experiences in anatomic pathology residency training that should be retained, including the opportunity to review complete hospital records in the context of careful gross, microscopic, and laboratory observations, and to communicate interpreted results to stakeholders, including clinicians and the lay public, in a timely, concise, and accurate way. It is also true, particularly in academic medical centers where pathology residency training and undergraduate medical education occurs, that the need for carefully performed hospital autopsies arises not infrequently to account for unanticipated patient outcomes. To incorporate all of the above considerations, the institution of a competency – rather than number-based criterion for assessment of autopsy proficiency – has been called for.

Stakeholders in Autopsy Education

The public, as the ultimate stakeholder, requires medical investigation of deaths, including autopsy, to inform good government and health policy, to monitor the efficacy and consequences of new diagnostic and therapeutic advances, and to maintain vigilance for emerging disease states arising either from nature or from human activity. Trust in the practice of autopsy in the United States and Canada has resided with the specialty of pathology since the emphasis on scientific patient-centered specialized medical education became the gold standard with the Flexner Report at the beginning of the twentieth century [15]. Many organizations serve the

public trust in advising and setting the standards for education and practice of pathology, including the autopsy. There is fortunately considerable overlap, particularly among the pathologist members of these organizations.

American Board of Pathology and Accreditation Council for Graduate Medical Education

The American Board of Pathology (ABP), founded in 1936, establishes the standards for board certification of individual pathologists and also participates in the review of training programs in pathology and its subspecialties in liaison with the Review Committee for Pathology of the Accreditation Council for Graduate Medical Education. The Accreditation Council for Graduate Medical Education (ACGME) has as its role the accreditation of institutions and training programs in all disciplines of medicine, including pathology, and sets standards to which programs and institutions are held for new or continued accreditation, including the permitted length of the training programs, which in most cases benefit from Federal funding. Since 2013, the ACGME has monitored the progress of individual pathology residents and fellows in reaching progressive milestones, coauthored with the ABP, which include autopsy practice (Accreditation Council for Graduate Medical Education and American Board of Pathology, 2013). The ABP and the ACGME interact closely in their duties in other ways. The ABP names members to serve on the Review Committee for Pathology of the ACGME and requires that physicians seeking board certification as pathologists complete training in programs accredited by either the ACGME or the Royal College of Physicians and Surgeons of Canada. Among other standards, the ABP and the ACGME have together set and monitored current numerical standards for education in autopsy during training in anatomic pathology residency programs, as well as fellowship programs in forensic pathology, pediatric pathology, and neuropathology. Any change in the standard for documenting competency in autopsy practice will have to come from the ABP and the ACGME.

Association of Pathology Chairs and Its Program Directors Section

Whereas the ABP and the ACGME are responsible for setting and enforcing training standards for individuals and organizations, respectively, the Association of Pathology Chairs (APC) and its Program Directors Section, usually referred to by the acronym PRODS, have among their roles the execution of the required training and the maintenance of program accreditation, according to the current standards set by ACGME. As recently as the mid-1980s, pathology chairs often also served as the residency program director, with other key faculty directing the respective fellowship programs. As the process of maintaining the accreditation of training programs has become progressively complicated, the naming of a separate residency

program director became expedient, and thus PRODS was born to keep close liaison between the chairs and program directors. Pathology residency program directors, among other duties, must ensure that residents in their programs have the required experiences to be documented as competent in autopsy practice. The availability of hospital autopsies, the proximity of a forensic pathology facility, and the incentives and disincentives of faculty to participate in autopsy education are all factors that concern the membership of APC and PRODS.

National Association of Medical Examiners

The National Association of Medical Examiners (NAME) advocates for the practice and training of forensic pathology, a required component of the autopsy experience of every resident in anatomic pathology and every fellow in pediatric pathology, neuropathology, and forensic pathology. The work of NAME to set high standards for investigation of deaths that fall under the jurisdiction of government plays an important role in supporting the civil and criminal justice systems. As professional medical death investigators, members of NAME can play important roles in the autopsy education of residents and fellows, particularly regarding unnatural deaths and the collection and handling of materials to be admitted as evidence in courts of law. Members of NAME figure prominently among the directors of forensic pathology fellowships.

Society for Pediatric Pathology

The Society for Pediatric Pathology (SPP) represents a subspecialty of pathology that has close involvement with autopsy education and practice. The investigation of perinatal and pediatric deaths caused by maternofetal factors, inborn errors of metabolism, congenital malformations, and malignant tumors of childhood are important to the training of every anatomic pathologist. Members of SPP are highly represented among the directors of pediatric pathology fellowships.

College of American Pathologists

The College of American Pathologists (CAP) is a professional organization of pathologists and laboratory professionals with broad representation in both academic and community pathology practice, including autopsy. CAP has a strong interest in the education of residents, fellows, and practicing pathologists, providing print and online educational materials. The college performs advocacy at the State and Federal levels to promote the interests of practicing pathologists. Among its committees, the CAP has Autopsy, Forensic Pathology, Neuropathology, and Graduate Medical Education committees that make recommendations to support autopsy education and practice.

Assessing the Current State of US Autopsy Education

A Working Group was convened in 2016 by the Association of Pathology Chairs and the American Board of Pathology with representation from other stakeholder organizations (Table 6.1) to make a recommendation about how to move forward from the existing number-based criterion.

The Working Group in early discussions had to address significant background limitations before proceeding. Although many works about the value of the autopsy and using autopsy-derived information had been published, the present standard of autopsy training in US pathology residency programs had not been addressed in recent memory. It was deemed imprudent to proceed with making recommendations for the future without fully understanding the present state of autopsy residency education. The best source of information about current autopsy training in residency was determined to be the autopsy service directors of residency training programs, a group which had not been systematically polled in recent years.

The Working Group solicited from current pathology residency program directors through email the name and contact information for the autopsy service director for their residency training programs. Requests to 142 residency training program directors yielded 113 named autopsy service directors. The responses from some of the residency program directors indicated that there was no such autopsy service director for the residency program. The 113 named autopsy service directors were then sent an online poll that addressed available autopsy case volumes and case types, the extent of the practice of sharing of autopsies among residents to extend the available cases, standard methods used on the service for prosecting autopsies, the roles of various personnel on the autopsy service in teaching several key aspects of autopsy performance and reporting, as well as the accountability of the autopsy service director to provide information to the residency program director about the numbers and types of autopsies completed by the residents. Autopsy service directors were asked about the practice of teaching forensic pathology and neuropathology on their services. Finally, autopsy service directors were asked about their opinions about the suitability of the existing number-based criterion of 50 autopsies and whether residents on their service were having difficulty meeting the criterion. The survey respondents were asked to self-identify to assure data integrity, but with

Table 6.1 Stakeholder organizations represented on the Autopsy Working Group

Accreditation Council for Graduate Medical Education
American Board of Pathology
Association of Pathology Chairs
Chairs Section (APC)
Program Director's Section (PRODS)
National Association of Medical Examiners
Society for Pediatric Pathology
College of American Pathologists
Autopsy Committee
Graduate Medical Education Committee

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the effect that any results obtained would reflect a best-case scenario. Of the 113 surveys sent to autopsy service directors, 66 at least partial responses were obtained, 42 did not open the survey, 4 opened the survey but did not respond, and 1 email was returned as undeliverable. Of the 66 respondents, 28% stated that they were both the residency program director and the autopsy service director for their program.

APC/ABP Survey Results

The survey results provided findings that highlighted a number of inconsistencies among residency training programs in the way autopsy training is accomplished and documented. The number of autopsies available on the main autopsy service varied over orders of magnitude, with one program having approximately 900 cases available per year for residents on the main service, whereas at the other extreme, 1 program had only 14 cases per year in-house, relying upon the local medical examiner office to supply additional experience for a program of 18 residents. The different types of available autopsies likewise varied considerably, with a number of programs, typically those with the highest total case volumes, showing a very high percentage of the total available cases on the main service as forensic pathology cases. Fetal and pediatric autopsies were heavily represented in the case volumes of several programs with low case volumes.

Because the survey was conducted identifying the programs where residents rotated, the sizes of residency training programs could be incorporated by accessing data on the public resource of the Accreditation Council of Graduate Medical Education. Combining the case volume data with the number of residents in the corresponding residency training program, an estimate of the available autopsy cases per resident could be calculated, with the assumption that all residents were in 4-year anatomic and clinical pathology training programs (Fig. 6.1). Because sharing of autopsies between two residents has been permitted for a number of years by the American Board of Pathology for the purpose of documenting the number-based criterion, the extent of the use of sharing was solicited from autopsy service directors as a percentage of total cases on the main service that were shared by residents. Not surprisingly, sharing was implemented in all autopsies in some programs, whereas in others, autopsies were never shared. The reported rate of sharing was then used to extend the number of available autopsies per resident on the autopsy service. Even with sharing of autopsies between two residents at the reported rates, most responding programs were not able to achieve the number-based criterion of 50 autopsies utilizing cases on the hospital autopsy service. It is presumed that such services must rely heavily upon experience at an outside facility, such as the local medical examiner office for residents to meet the number-based criterion.

The roles and opinions of autopsy service directors were examined next. In about 28% of responses, the autopsy service director also served in the role of residency training program director. Of those autopsy service directors who did not fill both roles, the majority indicated that they did not provide a listing of autopsies completed by each resident to the residency training program director. The autopsy service

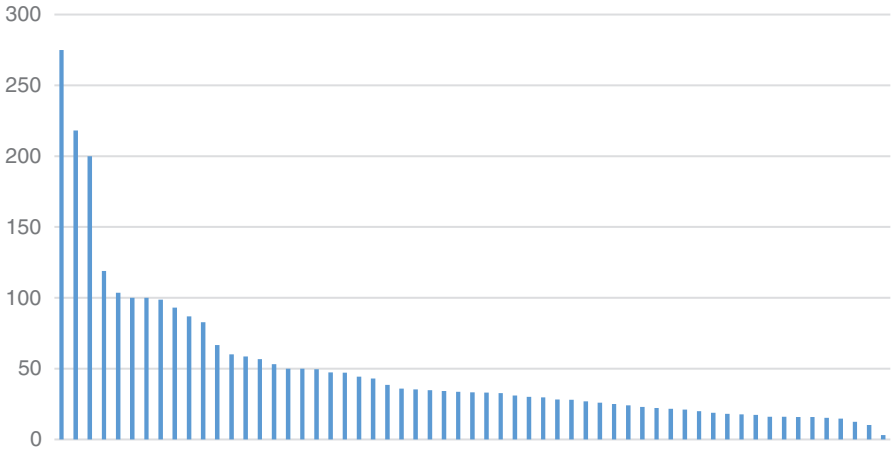

Fig. 6.1 Number of autopsies available per resident by responding program. For each program, the total number of autopsies per year reported by that program was multiplied by four and divided by the total number of residents in the program according to publicly available information from the Accreditation Council for Graduate Medical Education. This calculation estimates the number of autopsies available per resident if sharing of autopsies were not permitted. The order of programs is from the highest available number of autopsies volume to lowest. (Reprinted with permission from Academic Pathology © 2018)

directors responding to the poll indicated a wide range of involvement as the attending of record for autopsies completed by residents on their service, ranging from 100% to 0%. The opinions of autopsy service directors about the current number-based criterion of 50 autopsies per resident were solicited. Although 41% of respondents felt that the present number-based criterion of 50 autopsies was "about right," 7% of respondents felt that 50 autopsies were too many, and 12% felt that 50 autopsies were too few. These data were further resolved by the sizes of the residency training programs, with smaller programs having fewer than 18 residents and larger programs having 18 or more residents. There was a slight trend for directors of autopsy services in larger programs to believe that the number-based criterion of 50 autopsies was excessive, but the results were otherwise relatively evenly divided (Fig. 6.2). Although only 4 of 60 responding autopsy service directors indicated that their residents had difficulty achieving the number-based criterion of 50 autopsies, 3 of the 4 responses came from programs with 18 or more residents.

Entrustable Professional Activities

Because there are many skills related to the autopsy that residents should acquire as a part of their training, and many categories of staff who may participate in that training, the distribution of teaching responsibilities was also examined. A rising trend in medical education is the concept of "Entrustable Professional Activities," defined as those activities in which residents, because of their performance during

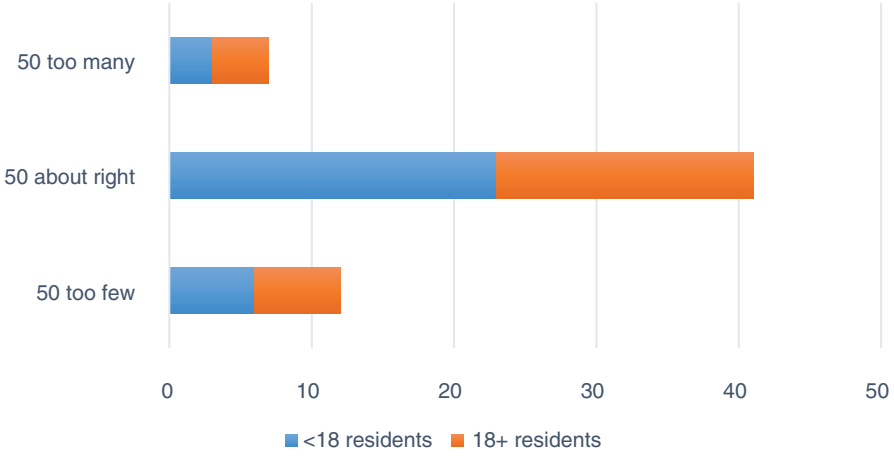

Fig. 6.2 Autopsy director opinions about current requirement of 50 autopsies for resident (58 responses, 8 not answered). (Reprinted with permission from Academic Pathology © 2018)

training, gain the trust of their teachers to perform independently and without direct supervision. Several groups have attempted to identify such Entrustable Professional Activities for pathology in general and for autopsy education in specific [16]. A limited list of possible Entrustable Professional Activities was therefore presented to autopsy service directors, who were asked to describe which type of staff – autopsy service director, other faculty, other residents, fellows, pathology assistants, dieners, or other staff – was most likely to teach each specific Entrustable Professional Activity. An option was provided for autopsy service directors to respond that the Entrustable Professional Activity was not taught to residents on their service. Autopsy service directors were most instrumental in teaching residents about matters of reporting, including composing preliminary and final reports and formulating the cause of death statement. They also were involved in teaching residents to obtain information by interviewing caregivers, to review the medical record, and to evaluate histologic slides. Autopsy service directors played a relatively minor role in teaching residents to open and restore the body and to conduct examination of the central nervous system.

Other program faculty participated most strongly in teaching examination of the central nervous system, review of slides and laboratory data, as well as in reporting. Other trainees, including residents and fellows, were most instrumental in teaching about reviewing patient medical records, performing the gross dissection and sampling, and teaching to review other laboratory information. Other support staff, including pathology assistants and dieners, were most active in teaching about performing opening, evisceration, and closing procedures. Although relatively few instances of procedures not being taught to residents were documented, the most common procedures not taught surprisingly included interviewing caregivers about concerns to be addressed by the autopsy and reviewing the patient's medical record, as well as restoring the body for release and how to extract the brain and spinal cord.

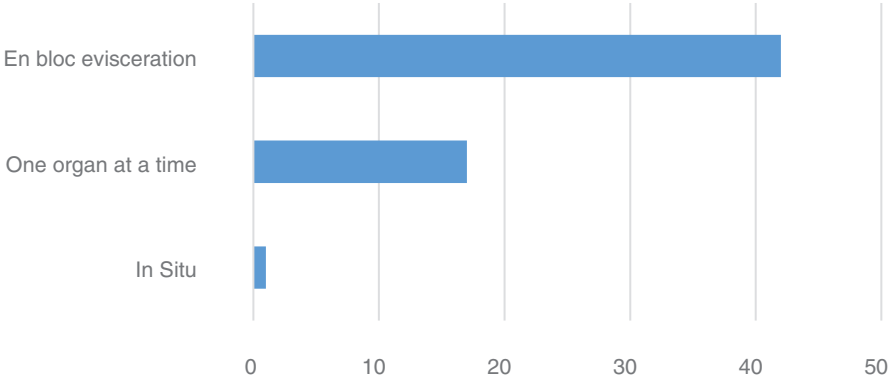

Fig. 6.3 Autopsy dissection technique most commonly employed by programs (60 responses, 6 not answered)

Autopsy Prosection

A significant area of procedural variation in autopsy practice was identified in the method used for autopsy prosection (Fig. 6.3). Although the majority of respondents indicated that the most common autopsy technique was that of en masse evisceration followed by dissection, sometimes described as the Rokitansky or Letulle method, a significant number of programs most commonly taught the method of removing and sampling one organ at a time, sometimes referred to as the Virchow method, with one program indicating that the most common method of prosection involved only in situ sampling of organs. This considerable variation in technical training indicates that programs and autopsy services have varied appreciation of the needs of new medical graduates entering anatomic pathology training to review and build upon gross anatomy skills acquired in medical school.

Recommendations for Autopsy Education

On the basis of the survey, the Autopsy Working Group came to the conclusion that there was so much variation in teaching autopsy pathology to residents that simply reducing the number-based criterion from the current 50 would result in a "race to the bottom" unless an intervention to improve and to recast autopsy education into a competency-based standard was implemented. Toward this end, the Autopsy Working Group discharged its duty by making several recommendations to the Association of Pathology Chairs and the American Board of Pathology.

Autopsy's Importance in Pathology Resident Training

The first recommendation was that training in autopsy pathology should remain as an important part of training in anatomic pathology in US pathology residency programs. Many new-in-practice pathologists indicated in recent surveys that they

did not perform autopsies as a part of their practices and that they believed that too much of their time in training was spent on the autopsy. Although based on those surveys there have been proposals to relegate autopsy training exclusively to forensic pathology fellowship programs, the Working Group believed strongly that forensic and hospital autopsy practices are in many ways complementary to one another. Anatomic pathology residents benefit from review and improvement of their gross and microscopic anatomy skills by learning to perform and interpret hospital autopsies, particularly including the exercise of integrating autopsy findings with thorough review of the complete medical record. Autopsy remains the principal opportunity that pathology residents have to see important causes of natural morbidity and mortality in the US population, such as cardiovascular and infectious diseases, which are not commonly seen in other anatomic pathology rotations.

Role of the Autopsy Service Director

The second recommendation made by the Autopsy Working Group was that all accredited residency training programs should have an autopsy service director, charged with the quality and standards of practice of autopsy education, in addition to those of autopsy practice. The Working Group was concerned that there were several programs where no such director existed. Because the subsequent recommendations create important responsibilities regarding the autopsy training of residents, it was determined that those responsibilities necessarily must reside with a member of the faculty who possesses a defined portfolio [17]. At a minimum, the autopsy service director must be certified by the American Board of Pathology in anatomic pathology and have recent experience in autopsy pathology. The autopsy service director must show diplomatic ability to resolve disputes with fairness. An unwavering belief in the value of the autopsy as it improves medical practice and public health is important. From these minimum requirements flow other important roles. The autopsy service director needs to assume responsibility for all aspects of autopsy education as a hands-on teacher, serving as a role model and mentor in autopsy practice and reporting for trainees and faculty. The service director must have a record of competence in technical details of evisceration and dissection, as well as proper documentation and presentation of gross and microscopic autopsy findings. Sensitivity to cultural differences in practices related to death must be observed. A scholarly interest in autopsy as well as experience in participation in multidisciplinary research related to autopsy is important.

Relationship of Autopsy Service Director to Program Director

To the extent that any number-based criterion exists, the Autopsy Working Group as its third recommendation proposed that the autopsy service director be accountable to the program director to report the number and types of autopsies

completed by the residents, either shared or not, in addition to ongoing evaluation of the progress of residents in their autopsy competency. The majority of surveyed autopsy service directors indicated that they did not provide any record of autopsies completed by residents to the program director. To the extent that the residency program director is required to attest to the accuracy of the list of autopsies submitted by a resident to the American Board of Pathology as a part of the application for primary certification in anatomic pathology, it seems reasonable that there be a communication between the autopsy service director and the residency program director in the very common situation where both roles are not performed by the same person.

Standardizing the Dissection Method

The fourth recommendation made by the Autopsy Working Group was to standardize the dissection method taught to residents during training. A method using en masse evisceration followed by dissection, sometimes referred to as the method of Letulle or Rokitansky, does far more to reinforce the anatomy skills acquired by the resident during medical school than do other methods, such as organ-by-organ examination or examination in situ. With some planning of the case, the recommended method allows novice prosectors to proceed with less chance of destroying an important anatomic relationship. If the resident is ever in the position of training an assistant to perform autopsies, the method has the same advantage for the practice of the trained assistant.

Progress Benchmarks in Attaining Autopsy Skills

Beyond any number-based criterion for documenting autopsy competency, the Autopsy Working Group proposed as its fifth recommendation that residency training programs also employ Entrustable Professional Activities (see below) as benchmarks for documenting progress in learning autopsy skills. As a resident learns autopsy skills, the attainment of trust to perform agreed upon component autopsy tasks without direct supervision should be documented. These tasks should include all parts of the prosection from evisceration to closing, in addition to microscopic interpretation and integration of all findings into timely and concise preliminary and final reports. The survey sent to autopsy service directors suggests some possible Entrustable Professional Activities; other stakeholders have proposed similar lists. There is a need to have a consensus before further progress is made.

Finally, the Working Group as a sixth recommendation requested that no change be made in the number-based criterion until after the above changes were implemented. A diminished number may eventually be implemented, or progress may be made to a purely competency-based criterion. These recommendations were received by the Association of Pathology Chairs and its Program Director's section, and a position paper endorsing the recommendations has been published [17].

Autopsy as an Entrustable Professional Activity

The foregoing proposals necessitate significant rethinking of the models used to evaluate and document the competency of residents on autopsy rotations. As with other aspects of medical training for complex procedures, one important criterion for the quality of education is the monitoring of attainment of graduated responsibilities by the resident moving through training. After a period of direct supervision, residents may progress to indirect supervision by their attending or senior resident and then even later may assume the role of providing supervision for junior trainees.

The system of progressive responsibility has already been implemented in some departments, which provides an opportunity for senior residents to act as "charge resident," overseeing the early progress of their junior colleagues. A thorough assessment of the progress of residents during training also requires that training be complete and that residents are able to perform technical and cognitive tasks in a reliable fashion. The implementation of checklists has been introduced in several medical specialties to improve the consistency of patient care and to reduce medical error [18]. The implementation of standardized checklists that include a set of tasks that include not only the performance of the autopsy itself but also the pre-analytic and post-analytic phases of the procedure has been implemented in some programs.

In 2013, the Accreditation Council for Graduate Medical Education and the American Board of Pathology implemented the Milestones for Pathology (Accreditation Council for Graduate Medical Education and American Board of Pathology, 2013), a set of benchmark scales, parallel to those in many other disciplines of graduate medical education, that describes the progress of pathology residents in training across a number of important tasks. Two of the benchmark scales within the Milestones for Pathology are specifically dedicated to the autopsy: Patient Care 4 (Reporting), analyzes data and appraises, formulates, and generates effective and timely reports, and Medical Knowledge 3 (Procedure, Autopsy), demonstrates knowledge and practices that enable proficient performance of a complete autopsy (analysis and appraisal of findings, synthesis and assembly, and reporting). These describe in general terms the expected progress of pathology residents on several of the key elements of autopsy procedure and reporting. Although the Milestones for Pathology have achieved their intended goal of providing benchmarks to document the progress of residents in pathology training and have specifically added an element of assessment to resident progress in autopsy practice, they fall short of providing the level of standardization that was recommended by the Autopsy Working Group.

In recent years, the evaluative model of Entrustable Professional Activities has been proposed in other medical specialties [19], and more recently in pathology [16, 20], as a way to assess the progress of residents in obtaining the trust of their supervising attendings to perform critical professional duties without direct supervision. Specifically, for pathology training, the model of Entrustable Professional Activities has the great advantage over the existing Milestones for Pathology in that Entrustable

Professional Activities can be directed to specific tasks in specific rotations, rather than having to be integrated across all of anatomic pathology rotations or all of clinical pathology rotations, as is the case for the current iteration of the Milestones for Pathology. The Milestones for Pathology are in the process of review for updating. The Graduate Medical Education Committee of the College of American Pathologists has proposed a set of Entrustable Professional Activities for Pathology, which includes a set of specific benchmarks for autopsy pathology. The Autopsy Working Group has produced a more detailed set of Entrustable Professional Activities specifically for the autopsy. Stakeholder organizations including the American Board of Pathology, the Accreditation Council for Graduate Medical Education, the Association of Pathology Chairs, and the Program Director's Section of the Association of Pathology Chairs have organized to plan pilot implementation of Entrustable Professional Activities, which in all likelihood will include application to the autopsy.

Autopsy Training Continues to Evolve

Elevating the standards for autopsy training is not a task that is undertaken for its own sake. The autopsy continues to have applications to the "real world," and it plays a strong role in institutions at the forefront of healthcare. Team-based autopsy practice to integrate clinical information bridging between the classical domains of anatomic pathology and clinical pathology has been implemented to provide comprehensive understanding of the anatomic and laboratory data for clinical colleagues [21, 22]. The autopsy continues to find its place in answering diagnostic questions which did not even exist only a few years ago. The timely diagnosis of emerging pathogens may depend upon situational awareness of unusual case presentations and subsequent close collaboration between autopsy services and government disease surveillance services, as in recent deaths attributed to Heartland Virus, for example [23, 24]. Prompt attention to hospital autopsy diagnosis was also instrumental in halting deaths caused by injections of pharmaceutical preparations with microbial contamination [25] and in bringing those responsible to justice.

Advances in targeted therapies for malignancies have raised further novel uses for the autopsy, as powerful biological response modifiers including checkpoint inhibitors have been shown at autopsy to have adverse effects apparently caused by immune dysregulation [26]. Even in cases of successful dramatic responses to targeted therapies for malignancy, after recurrence of tumor and widespread metastasis, autopsy is a unique and powerful tool to collect tissue from many sites of recurrence, each of which may represent a "roll of the dice" by which a malignant tumor has acquired resistance to the targeted therapy [27, 28]. Close scrutiny of such sets of tumor tissue samples obtained from individual patients who have responded to targeted therapy, but who went on to die from recurrent metastatic disease, has the potential to eventually provide predictive information whereby a second- or even third-line targeted therapy may be employed to block the escape of the tumor from the effects of the first targeted therapy [29–31]. Each patient's

autopsy sample set may include frozen and fixed normal tissues as well as dozens of individual metastases sampled as frozen tissue for genetic analysis, fixed tissue for histologic studies, and photographic documentation of the anatomic origin of the sample in reference to the dissected organ block. Planning such rapid autopsies requires an ongoing dialog among the autopsy service, clinicians, and investigators to provide a service for a unique subset of patients that can be provided with advance preparation. Minimizing the delay between death and autopsy has been employed for many years [32, 33] and has provided important information for our understanding of shock at the level of cell injury.

The Future of the Autopsy Education

The foregoing discussion has touched on the relationships of autopsy practice with the actions of teaching departments where pathology trainees acquire not only knowledge and skills related to autopsy practice but also attitudes about the autopsy that define the role of the autopsy in education and practice. Autopsy practice has competed through the years with more lucrative and prestigious activities of pathologists including surgical pathology and funded research. Despite distractions from the autopsy, the role of the autopsy in the practice of medicine has remained important because of its several strengths that have remained unchanged against the sweep of history. These constants should be kept in mind as proposals and plans are made for the future of the autopsy.

The first constant feature of the autopsy is that, despite sentiments to the contrary by many of those just beginning to learn autopsy techniques, the competent technical performance of a routine autopsy is attainable by most who seriously attempt to learn it. The author has been privileged to know and work with not only hundreds of residents but also many skilled autopsy technicians with a wide range of education levels who can not only perform superb dissections but also know to stop and get the attention of a more experienced pathologist as soon as an unexpected abnormality is encountered. Particularly memorable in my experience has been the employment of trained funeral director/embalmers [34], having been successfully established at University of Iowa, University of Kansas, and, finally, Case Western Reserve University, where I came to know the system as director of that service from 1992 to 2009. Many college-educated technicians as well as dieners with primary school education have become technically proficient at assisting at autopsy. With regard to autopsy technique, motivation is all, and I have been gratified over the years to learn that, if offered the opportunity, there is a steady supply of staff who wish to learn to assist in the autopsy room. In recent years, the necessities of cost containment have dictated that serving as an autopsy assistant is not a full-time position on my services, but such a position can be leveraged to provide another set of hands in surgical pathology and to assist in autopsy as needed.

The second constant feature of the autopsy is that, relative to other methods used to access the internal structures of the body, the autopsy is inexpensive in its marginal cost, not requiring provisions for anesthesia, life support, or the opportunity

cost required to maintain expensive diagnostic equipment. With regard to fixed costs, maintaining an autopsy room requires less equipment than maintaining an operating room and about the same labor costs for cleaning and stocking as does an operating room. Centralizing the performance of autopsies, for example, in the large teaching hospital of a healthcare system, has been used to extend resources, with the addition of modest transportation costs [35].

The third constant feature is that compared with other modalities, the autopsy is able to recover diagnostic and research samples and implanted medical devices with relative ease. The ability to obtain sets of many contemporaneous samples has already been mentioned in the context of being able to fully document the process by which malignant tumors are able to escape suppression by targeted therapies and may perhaps allow for predictive application of sequential targeted therapies. Although there has been progress made in the use of advanced imaging modalities, particularly for the investigation of trauma casualties [36], radiologic methods do not yield histologic diagnoses that would make them supplant the autopsy for many natural deaths. Although the advantages of radiologic methods to document bone lesions and foreign bodies are clear, radiologic methods have also added new perspectives to autopsy evaluation in cases of drowning [37]. The ability to complement traditional autopsy with tomographic studies remains an area for exploration.

The fourth constant feature of the autopsy has been the archival value of reports and in some cases tissue that may be retained for decades. Proposals for the development of a national autopsy database to improve the quality of health statistics emerged almost as soon as digital computers became available for use in healthcare as a tool [38]. Despite valiant efforts [39], concerns about confidentiality have largely eclipsed the originally intended aggregation of reports from multiple sites and public availability of such a database. This setback notwithstanding, the ability to store and retrieve data from huge sets has allowed autopsy data to become incorporated into much broader data resources. At Vanderbilt University Medical Center, a patient record database, known as the Synthetic Derivative, which includes data from entire electronic medical records including autopsy reports, is automatically scrubbed of all personal identifiers and has all dates shifted by a random constant. This resource can be searched for any conceivable phenotype. The Synthetic Derivative is linked to a corresponding de-identified genomic DNA data bank and biorepository known as BioVU. Linked, de-identified records and genomic DNA are collected and sequenced for patients who opt in at the time of blood collection for laboratory tests [40]. The BioVU-Synthetic Derivative has become a valuable and cost-effective tool for phenotype-genotype correlation with the benefit of containing a growing amount of gold standard autopsy data.

A Final Thought

Despite the dire predictions made for the fate of the autopsy generations ago, the hospital autopsy has nonetheless somehow survived. The place on the stage of medical practice for autopsy has necessarily evolved to accommodate changes in

healthcare finance, medical education, physical and chemical diagnostic modalities, and the corresponding shifting attitudes of the lay and medical communities, including the attitudes of pathologists themselves. The need for autopsy services extends well beyond the forensic interests of good government. Autopsy will likely never be financially self-sustaining, but there will be an ongoing need for trained practitioners of autopsy, particularly in academic medical centers. The core values of autopsy to provide timely, thorough, systematic, and concise observations and to allow relatively unfettered application of the most advanced diagnostic methods of the day have persisted unchanged. Ongoing scrutiny of autopsy education to refocus on the core values of the autopsy in a changing environment should be encouraged to support the continued value of postmortem examination in the future.

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