Pathologist Effort in the Performance of Fetal, Perinatal, and Pediatric Autopsies

A Survey of Practice

M. Cristina Pacheco, MD; Robyn C. Reed, MD, PhD

• ***Context.***—**Autopsy is an important tool for quality assurance and improving patient care. Fetal, perinatal, and pediatric autopsies have the additional benefit of identifying conditions that may have increased risk of recurrence. In contrast to adult autopsies, special collections and testing are frequently used. Pathologist effort in fetal, perinatal, and pediatric autopsy has not been well documented.**

Objective.—**To prospectively quantify pathologist time required to complete fetal, perinatal, and pediatric autopsies, and to gather information on special studies and whether or not a cause of death was identified.**

Design.—**The Society for Pediatric Pathology Practice Committee disseminated a survey to pathologists to complete for each autopsy performed. Surveys recorded age/gestation, time spent on chart review, prosection, and microscopy, special testing performed, time spent on a discussion or presentation of findings, and whether a cause of death was found.**

Results.—**We report results of 351 surveys. Pathologist effort in fetal cases was, on average, 5.9 hours; in perinatal cases, 9.8 hours; and in pediatric cases, 15.4 hours. Reflecting complexity, a total of 603 collections for ancillary studies were performed, most commonly karyotype, frozen tissue, and microbiology cultures. A cause of death was identified in 295 of 351 cases (84%). Most cases were presented at conferences.**

Conclusions.—**Fetal, perinatal, and pediatric autopsies are time intensive and frequently complex. They have high clinical value, guiding risk assessment and reproductive decision-making by families. Understanding the time contribution by pathologists allows departments and hospitals to predict staffing.**

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Autopsy is an important aspect of clinical service, providing clinicians with critical feedback regarding diagnostic accuracy, therapeutic efficacy, and medical complications. Autopsy reports provide families with a final diagnosis, cause of death, and information about their loved one's condition and clinical course. Fetal, perinatal, and pediatric autopsies can provide information about genetic syndromes and metabolic conditions that may not have been previously diagnosed. Placental factors leading to fetal demise can also be uncovered during autopsy. Examining and understanding these pathologic processes allows risk assessment for future pregnancies and can provide guidance for monitoring of future pregnancies, as well as direct genetic counseling, prenatal testing, and testing of surviving siblings and other family members.[1,2] Traditionally, pediatric autopsy rates have been higher than those for adults, but both groups have seen a decline over time in most institutions.[1,3] The decrease in autopsy rates is concerning because of the essential quality assurance function that autopsy plays in medical care.

Autopsies are a powerful quality assurance tool. Retrospective reviews of pediatric autopsy findings indicate that new diagnoses are made in 19% to 48% of cases. Notably, 1.1% to 15% of autopsies reveal class I diagnoses, which are defined as new findings that, had they been known before death, would likely have changed patient management and may have resulted in a cure or prolonged survival.[1,4–7] The incidence of class I diagnoses in pediatric autopsies is similar to that estimated for contemporary adult autopsies.[8] Pediatric autopsies also provide important information about treatment effects, including therapeutic errors and unintended or unexpected therapeutic complications.[1,9] When results are communicated promptly and effectively to clinicians, pediatric autopsies provide feedback that is crucial in a hospital quality improvement program and helps drive advancement in medical care.

The expertise of perinatal and pediatric pathologists is valuable to patients and physicians, and therefore, to institutions. In a recent review of examination of nonintact

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From the Department of Pathology, Microbiology & Immunology, Monroe Carell Jr. Children's Hospital at Vanderbilt, Nashville, Tennessee (Dr Pacheco); and the Department of Pathology, Children's Hospitals and Clinics of Minnesota, Minneapolis (Dr Reed).

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Reprints: M. Cristina Pacheco, MD, Department of Pathology, Microbiology & Immunology, Monroe Carell Jr. Children's Hospital at Vanderbilt, 11223 Doctor's Office Tower, Box 3-9065, 2200 Children's Way, Nashville, TN 37232-9065 (email: cristina.pacheco@vanderbilt.edu).

fetuses, abnormalities were identified in 77% of cases examined by a perinatal pathologist, and only 9.5% of cases examined by general pathologists.[10] Few to no data exist on the diagnostic sensitivity of perinatal and pediatric pathologists versus general pathologists in other autopsy settings. However, perinatal and pediatric pathologists undergo extensive training in autopsy pathology, with the Accreditation Council for Graduate Medical Education requiring participation in a minimum of 40 pediatric and perinatal autopsies during the fellowship.[11] Reflecting the belief that this added experience and expertise confer increased diagnostic accuracy, guidelines from the Society of Obstetricians and Gynaecologists of Canada recommend that fetal and perinatal autopsies be performed by a trained perinatal or pediatric pathologist.[12,13]

Autopsies have never been officially assigned relative value units, a widely used basis in the United States for comparing different kinds of work in surgical pathology based on Current Procedural Terminology (CPT) codes, because the procedure is not billable. Thus, it is difficult to compare the workload and productivity of pathologists performing autopsies to those involved in surgical pathology. In 2013, the Autopsy Committee of the College of American Pathologists (CAP) attempted to define the time value associated with autopsies. Members of the committee, which included academic and community pathologists, estimated the average amount of pathologist professional time they required to complete an autopsy, and validated their estimates with a survey of pathologists subscribing to the CAP autopsy education program. The committee proposed that a full adult autopsy without brain examination, on average, required 4.7 hours of pathologist professional time, and a fetal/neonatal autopsy required an average of 3.3 hours. Examination of the brain was allotted an additional 1.2 hours for adults and 0.5 hours for fetal/neonatal cases. A detailed clinical-pathologic discussion was allotted 1.2 hours in all cases.[14]

Members of the Society for Pediatric Pathology (SPP) have since questioned the study methodology and conclusions, and raised concerns that the proposed standards undervalue the time involved in performing fetal and neonatal autopsies, which are frequently time-consuming and complex, involving extensive review of medical records, complex dissections, and detailed clinical-pathologic discussion correlating the findings to ancillary studies and placental examination.[15] When performing fetal, perinatal, and pediatric autopsies, careful gross examination is imperative because of the need to assess developmental stage and the presence or absence of congenital anomalies. Similarly, microscopic examination, while looking for disease, also focuses on the appropriateness of organ development relative to gestational age. A detailed obstetric history is relevant to fetal and perinatal cases, and comprehensive autopsy reports integrate this information. Finally, placental examination is essential to understanding fetal and perinatal loss in many cases. These considerations are unique to fetal, perinatal, and pediatric autopsies.

An absence of prospectively collected data has hindered the discussion of how much pathologist professional time is required to perform a high-quality fetal, perinatal, or pediatric autopsy. Accurate data are needed to allow pathology departments and hospitals to predict staffing needs and ensure that pathologists and ancillary staff are available in sufficient numbers to perform autopsies and communicate findings to other physicians and to families.

Table 1. Age Group, Number of Surveys, and Institution Type Represented in the Survey Return

Age	No. of Surveys Returned	Teaching Institutions	Nonteaching Institutions
Fetal <20 wk	31	8 (30 surveys)	1 (1 survey)
Perinatal	208	20 (182 surveys)	6 (26 surveys)
Pediatric >1 mo	112	20 (104 surveys)	5 (8 surveys)

The aim of this study was to define the pathologist effort required to perform fetal, perinatal, and pediatric autopsies by analyzing data derived prospectively from a multicenter survey.

MATERIALS AND METHODS

The Practice Committee of the SPP designed a survey to be completed concurrently with each fetal, perinatal, and pediatric autopsy (Figure). Information collected in the survey included gestational age (in fetal and perinatal cases); age at death if liveborn; any autopsy restrictions; amount of time spent reviewing chart; time spent reviewing imaging; time to perform gross dissection excluding brain; time to perform microscopic examination excluding brain; time to perform gross dissection of the brain; time to perform microscopic examination of the brain; what additional studies were performed; whether a template was used; whether a detailed discussion was included; whether literature references were included; whether the cause of death was identified; whether, in fetal and perinatal cases, the cause of death was related to placental factors; whether the case was presented at a conference; and the amount of time spent preparing for conference. Additionally, there were questions regarding who was involved in performing the autopsy (staff pathologist, resident/fellow, pathology assistant, neuropathologist). The survey did not designate whether or not the physician of record was a board-certified pediatric pathologist. The Council of the SPP approved distribution of the survey by the Practice Committee.

The survey link was distributed through the SPP membership email directory, was available on the SPP Web site, and a notification was sent through the pathology chair email list. The survey was open to anyone performing fetal, perinatal, and pediatric autopsies. Surveys were collected through October 2014 on cases performed between January 15, 2014, and July 15, 2014.

All surveys were returned to one of the authors (M.C.P.) by mail, email, or fax, and survey data were entered into an Excel spreadsheet (Microsoft, Redmond, Washington). Surveys that appeared to contain aggregated institutional data were excluded, as the intention was to collect data on an individual autopsy basis. Surveys that were partially completed were used to the extent possible (eg, if complete data on the body component were present, but not the brain, the body data were used), and surveys that lacked the age or gestation of the patient were not included. The data were divided into 3 categories by patient age. Fetal was defined as less than 20 weeks gestational age. Perinatal was defined as 20 weeks gestational age to 1 month of postnatal age. Pediatric patients were considered those older than 1 month of age through age 18 years.

To calculate the time to perform an autopsy on a body, we summed the time to perform chart review, review of imaging and/or echocardiogram, time to perform gross dissection excluding brain, and microscopic examination. To quantify time to perform the brain examination, we combined the time of the prosecting pathologist or neuropathologist to perform brain gross dissection and microscopic examination. Many of the cases had detailed discussions and were presented at multidisciplinary conferences, and the time to perform these tasks was recorded. For each group of patients (fetal, perinatal, and pediatric), the mean, standard deviation, median, and range of time to perform the body and brain examinations, as well as the discussion and conference presenta-

Table 2. Time Spent on Autopsy (in Minutes) by Age Group Separating Body and Brain Examination With Separate Discussion and Conference Components

	Mean ± SD	Range	Median	n	Conversion to RVUs
Fetal					
Body	179 ± 77	52–390	165	31	3.6 × 88309
Brain	34 ± 31	2–90	20	18	0.7 × 88309
Total					4.3 × 88309
Discussion	69 ± 59	2–240	60	19	1.4 × 88309
Conference	74 ± 41	15–120	90	12	1.5 × 88309
Perinatal					
Body	290 ± 182	12 (gross only)–1260	240	196	5.8 × 88309
Brain	79 ± 47	4–240	60	156	1.6 × 88309
Total					7.4 × 88309
Discussion	114 ± 98	10–720	90	185	2.3 × 88309
Conference	106 ± 92	5–720	90	128	2.1 × 88309
Pediatric					
Body	497 ± 288	120–1800	413	104	9.9 × 88309
Brain	125 ± 85	20–480	120	80	2.5 × 88309
Total					12.4 × 88309
Discussion	167 ± 150	10–960	120	103	3.3 × 88309
Conference	136 ± 88	10–600	120	80	2.3 × 88309

Abbreviation: RVU, relative value unit.

tion, were calculated. To allow direct comparison to autopsy work values proposed by the CAP, all times were converted to multiples of an 88309 CPT code, with a conversion factor of 1.2 × 88309/h.[14] In a separate analysis, cases with complex heart disease were separated from those that did not have heart abnormalities, and the average time to perform chart review, imaging review, dissection, microscopic examination, and total time were calculated for these groups.

RESULTS

A total of 351 surveys contained sufficient information for inclusion in the study, representing work performed at 26 institutions (Table 1). Contributing institutions included both teaching and nonteaching hospitals, and the sample included surveys from both children's hospitals and other hospitals. Teaching hospitals were defined as institutions in which pathology residents or fellows regularly rotate in the pathology department, whereas nonteaching hospitals are those that do not have pathology trainees. Perinatal and pediatric autopsies represented most of the cases recorded.

Time required to perform a complete autopsy varied by age group and increased progressively with increasing age from the fetal (31 cases) to perinatal (208 cases) and perinatal to pediatric (112 cases) categories (Table 2). The heart cases required considerably more time on average in all age categories (Table 3). Reflecting the complexity of many of the cases, a total of 603 ancillary tests and collections were performed at the time of autopsy and included 22 different subcategories (Table 4). The most frequently used studies were karyotype (performed on 89 of 351 cases [25%]) and frozen tissue (performed on 121 of 351 cases [34%]) in all age groups, and bacterial and viral cultures (performed on 143 of 351 cases [41%]), predominantly in the perinatal and pediatric groups. Complex genetic testing was also frequently used in the perinatal group (performed on 30 of 208 perinatal cases [14%]). No information about results from the ancillary testing was collected.

The cause of death was identified in 295 of 351 cases (84%). In fetal cases, the cause of death was identified in 25 of 31 cases (81%) and was attributable to placental factors in 15 of 31 cases (48%). In the perinatal group, 171 of 208 cases (82%) had an identifiable cause, of which 69 of 208 (33%) were attributable to a placental etiology. Finally, the pediatric group of autopsies revealed a cause of death in 99 of 112 cases (88%).

DISCUSSION

We report a prospective multicenter study of pathologist effort in the performance of fetal, perinatal, and pediatric autopsies. Important findings include the observation that

Table 3. Average Times and Total Times to Complete Complex Heart Disease Cases and Those Without Complex Heart Disease (in Minutes)

Age Group and Heart Group	No. of Cases	Chart Review	Imaging Review[a]	Dissection	Microscopic Examination	Total Time
Fetal autopsy						
Congenital heart case	1	120		120	60	300
Without congenital heart disease	30	29		92	50	171
Perinatal autopsy						
Congenital heart case	26	112	26	242	112	492
Without congenital heart disease	182	57	10	122	67	256
Pediatric autopsy						
Congenital heart case	37	185	56	289	125	655
Without congenital heart disease	67	97	20	178	114	409

[a] Blank spaces in the "Imaging Review" column indicate absence of recorded time in these categories.

Table 4. Additional Studies Performed at Autopsy by Age Group[a]

Study	<20 wk Gestation	20-wk Gestation to 1 mo	<1 mo
No. of cases with additional tests	11 (31)	150 (208)	86 (112)
Frozen tissue	5	68	48
Karyotype	3	63	23
Bacterial cultures	1	69	73
Viral cultures	1	29	34
Radiology	1	14	5
Complex genetic testing	1	30	5
Fibroblast culture		24	21
Fungal culture		4	6
PCR bacterial and/or viral		6	4
Special stains/ immunohistochemistry		10	5
Toxicology		4	10
Bile paper blot		7	7
Collections for research		3	4
Cytology			2
Bone marrow collection			2
Chemistry		3	1
State laboratory			1
Electron microscopy		1	1
Flow cytometry			1
Immunofluorescence			1
Touch/squash of tissue			1
Fluorescence in situ hybridization		1	

Abbreviation: PCR, polymerase chain reaction.

[a] Blank spaces in columns indicate that no testing of the indicated type was performed.

autopsies take increasing amounts of professional time with increasing gestational and postnatal age, and for all populations except fetuses less than 20 weeks gestational age, the time required to perform a complete autopsy is considerably greater than previously estimated by the CAP Autopsy Committee (Table 5).[14] Time required to complete an autopsy varied considerably from case to case. We identified the presence or absence of complex heart disease as one factor contributing to this variation; likely there are others including medical and surgical history and complexity of anatomic findings. However, just as surgical pathology codes and relative value units are applied uniformly, regardless of the complexity of an individual specimen, pathologist effort in autopsy performance should probably also be calculated from an average.

Two groups of authors have previously attempted to define the average amount of professional time required to conduct a pediatric or perinatal autopsy. In 1989, pediatric pathologists from 2 teaching hospitals in Canada reported on average they required 17.5 hours to complete a pediatric/perinatal autopsy. This estimate was based on a productivity formula. Tasks they specifically included in their description of a complete autopsy included review of the medical record, gross prosection, microscopic examination, literature review, composing the report, and presentation at conferences and committee meetings (Table 5).[16]

By contrast, the CAP Autopsy Committee has recently suggested that far less time is required to perform a fetal/neonatal autopsy (Table 5). The group suggested that the time needed to conduct a fetal/neonatal autopsy with examination of the brain and detailed clinicopathologic discussion is approximately 5 hours, or, expressed as multiples of the 88309 CPT code, 6×88309 (4×88309 [body] + 0.5×88309 [brain] + 1.5×88309 [discussion] = 6×88309).[14] As compared to our findings, we find this estimate appears to be accurate for fetuses less than 20 weeks' gestation (Table 5). However, our study suggests that the average time to perform a perinatal autopsy (>20 weeks' gestation to 1 month postnatal age) is 8 hours, or 9.7×88309 for the brain, body, and discussion. The time required for a complete pediatric autopsy (postnatal age of 1 month to 18 years) is even greater at 13 hours, or 15.7×88309. Additionally, more than half the autopsies in our perinatal and pediatric groups were presented at

Table 5. Comparison of Autopsy Studies

Source, y	Time Estimated to Perform Autopsy	No. of Respondents	How Time Was Estimated	Elements Included in Estimate
Current study	3.6 h fetal body and brain + 1.2 h discussion + 1.2 h conference 6.1 h perinatal body and brain + 1.9 h discussion + 1.8 h conference 10.4 h pediatric body and brain + 2.8 h discussion + 2.3 h conference	Pathologists from 26 institutions, reporting on: 31 fetal autopsies 208 perinatal autopsies 112 pediatric autopsies	Time data collected prospectively on a per case basis	Medical record review Image review Gross prosection Microscopic examination Literature review and generation of detailed report ("discussion") Preparation and presentation at conference ("conference")
Sinard,[14] 2013	3.8 h fetal/neonatal body and brain + 1.2 h discussion 5.9 h adult body and brain + 1.2 h discussion	4 committee members 159 survey responses 6 committee members 172 survey responses	Respondents gave estimated time to perform an average autopsy of the given case type	Performance of autopsy Review materials Sign-out case Generation of detailed report ("discussion")
Favara et al,[16] 1989	17.5 h neonatal/pediatric body, brain, discussion, and conference	4 authors	Determined by productivity formula	Medical record review Gross prosection Specimen preparation Microscopic examination Literature review and generation of detailed report ("discussion") Preparation and presentation at conference ("conference")

SPP Autopsy Survey Data Sheet for Perinatal and Pediatric Autopsy (to age 18 years)

Gestational age if fetal/perinatal autopsy_____

Age at death if liveborn_____

Limitations on autopsy_____

Time spent reviewing chart_____

Time to perform gross dissection excluding brain_____

Was the autopsy performed by pathologist? Yes No Pathologist Supervision Only

Was the autopsy performed with a resident / fellow? Yes No Resident Fellow Pathologist Assistant

If performed with resident/fellow or pathologist assistant

What percentage of the prosection were you involved in?_____

If the autopsy had complex congenital anomalies how much time was spent reviewing imaging / echocardiograms?_____

If the autopsy was related to complex congenital heart disease status post repair do you present findings during prosection to cardiovascular surgeon? Yes No circle one

Time to perform microscopic examination excluding brain_____

Time to perform brain gross dissection_____

Time to perform brain microscopic examination_____

Was the brain examination performed by prosecting pathologist or neuropathologist? Prosecting pathologist Neuropathologist (circle one)

What additional studies were performed (please check all that apply):

_____ Bacterial cultures

_____ Viral cultures

_____ PCR bacterial or virus

_____ Chemistry

_____ Karyotyping

_____ Fibroblast culture

_____ Complex genetic testing

_____ Frozen tissue

_____ Other:_____

Did you use a template? Yes No (circle one)

Did you include a detailed discussion in the final report? Yes No (circle one)

If yes how long did you spend researching and writing it?_____

Did you include references? Yes No (circle one)

Did you identify a clear cause of death? Yes No (circle one)

If the autopsy was fetal or perinatal was the cause of death related to placental factors? Yes No (circle one)

Was this case or will this case be presented at a conference? Yes No (circle one)

How much time will you spend preparing for and attending the conference?_____

Society for Pediatric Pathology Autopsy Survey. Abbreviations: PCR, polymerase chain reaction; SPP, Society for Pediatric Pathology.

multidisciplinary conferences; preparation and presentation of these conferences took an average of 90 to 120 minutes per case of additional pathologist time not included in the CAP figures. When conference time is included, our numbers for pediatric autopsies are intermediate (fetal 5.9 hours; perinatal 9.8 hours; pediatric 15.4 hours) between those reported by Sinard[14] and Favara et al[16] (Table 5).

There is considerable discrepancy between the time our respondents indicate they required to perform perinatal and pediatric autopsies, and the time estimated by the CAP committee. Several factors may account for this. First, we suspect a significant contributor to the differences between our study and the CAP committee's estimates is the methodology used to calculate professional time. The CAP committee's guidelines were based on retrospective esti-

mates of "average" cases. This methodology carries the risk of underestimating the time required to perform a complex, multipart task that takes place over several days.[15] In contrast, our study reports prospectively collected data, which lack this bias. In addition to gross dissection and microscopic examination, pathologist time in our study included review of the medical records, imaging studies, and laboratory reports; these activities were specifically mentioned by Favara et al[16] but were not discussed in the CAP publication.[14] Additional factors contributing to the discrepancy may be case mix and pathologist training. The present study was distributed primarily through the SPP membership and Web site, and although not all members are board-certified pediatric pathologists, many are. It is possible that settings in which a pediatric pathologist is on staff may frequently have more complex autopsy cases and there may be a selection bias to the data because of this phenomenon. Finally, the discrepancy may be partially due to differences in category definitions, although this is difficult to evaluate because the CAP publication did not define the age range of its "fetal/neonatal" category. Using the definition of 20 weeks' gestation to 1 month of age for perinatal encompasses the understanding of pathologists and the legal world, which in many states requires an autopsy permit for autopsy examinations on fetuses and infants older than 20 weeks gestational age. The practice of many pediatric pathology groups is to perform and report fetal and perinatal cases as full autopsies; however, examination of a fetus less than 20 weeks gestational age is coded as a surgical specimen with a single 88309 CPT code. It is unclear whether this age group was included in the CAP study and what impact it had on the time assessment to perform the fetal/perinatal cases. The array of ancillary testing ordered in these autopsy cases (Table 4) illustrates the multidisciplinary nature of modern perinatal autopsy pathology, which requires integration of clinical, imaging, laboratory, and genetic and molecular data in many cases.

Prior studies have substantiated the importance of fetal, perinatal, and pediatric autopsy. Perinatal autopsy has been found to provide new diagnostic information in 15% to 76% of cases in recent studies, depending on the patient population, and is a powerful technique for confirming prenatal imaging or cytogenetic diagnoses.[13] Fetal and perinatal autopsies significantly impact recurrence risk counseling in approximately one-quarter of cases.[17,18] In many cases, autopsy permits refinement of further diagnostic testing, including guidance in selection of costly genetic testing. A diagnosis can profoundly impact a couple's reproductive future; therefore, taking the time to reach a complete and accurate diagnosis is crucial.[2,15] Our study found a cause of death in 84% (295 of 351) of cases. Placental findings contributed to death in many of the fetal and perinatal cases (33% to 48%; 60 of 208 perinatal and 15 of 31 fetal autopsies).

In summary, this prospective, multicenter survey study of pathologist effort in the performance of fetal, perinatal, and pediatric autopsies indicates that these autopsies require significantly more pathologist professional time than has previously been estimated in all but the youngest (<20 weeks) fetuses. Pediatric autopsies require, on average, more time than perinatal cases, and indeed, more time than has been estimated for adult autopsies.[14] For departments trying to estimate staffing needs, time spent presenting these cases in multidisciplinary conferences is also significant. Autopsies in this young patient population are frequently complex, require multiple modes of diagnosis, and are of high clinical value, guiding risk assessment and reproductive decision making by families. Allowing pathologists the time needed to arrive at a correct diagnosis through a careful and thorough examination will ensure the optimal care for the families of our youngest patients. Additionally, pediatric pathologists should be considered as a consultative resource in fetal, perinatal, and pediatric autopsies performed by general pathologists.

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