Recommendations for the Autopsy of an Infant Who Has Died Suddenly and Unexpectedly

Kathryn Pinneri, Evan W. Matshes

ABSTRACT

As the result of improved death scene investigations and the performance of more thorough and thoughtful pediatric forensic autopsies, there has been a widespread increase in the recognition of asphyxial mechanisms of death as well as lethal natural diseases that might have otherwise been erroneously labeled as sudden infant death syndrome (SIDS) or sudden unexpected infant death (SUID). Although it is fair to state that "more thorough autopsies provide more thorough medical evidence" from which to draw upon when determining cause and manner of death, there is no standard, accepted baseline from which forensic pathologists operate. Although anatomic pathologists are quite accustomed to practicing within well-defined boundaries for specimen (and thus diagnostic) adequacy, forensic pathologists are frequently hesitant to embrace or adopt such concepts. This has made it difficult to evaluate standards of practice in forensic pathology. Recommendations have been developed and published by the National Association of Medical Examiners for the postmortem assessment of suspected infant head trauma. However, significant variation exists in the way autopsies are performed on infants without trauma, such as the common scenario of an infant who has died suddenly and unexpectedly of asphyxial or apparent natural means. A wide variety of autopsy techniques and ancillary studies are available to forensic pathologists, but as survey data indicates, are not consistently used throughout the United States. This paper will discuss the different components of the pediatric autopsy and make recommendations for the best use of available tests and consultation services. *Acad Forensic Pathol. 2017 7(2): 171-181*

AUTHORS

Kathryn Pinneri MD, Montgomery County Forensic Services

Roles: Project conception and/or design, manuscript creation and/or revision, approved final version for publication, accountable for all aspects of the work, writing assistance and/or technical editing.

Evan Matshes MD FRCPC, NAA Group

Roles: Project conception and/or design, manuscript creation and/or revision, approved final version for publication, accountable for all aspects of the work, principal investigator of a related study listed in the citations, writing assistance and/or technical editing.

CORRESPONDENCE

Kathryn Pinneri MD, 205 Hilbig Road, Conroe TX 77301, kpinneri@hotmail.com

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INTRODUCTION

A pediatric postmortem examination is a complicated process – one that evolves and changes based on clinical history, scene investigation, and autopsy findings. The autopsy on an infant with externally or radiographically visible unexplained trauma will require specific procedures and dissections to properly document the injuries; a position paper has previously been published by the National Association of Medical Examiners (NAME) (1), and followed with variable consistency across the United States. However, standards of practice have not been accepted for use in cases where infants die suddenly and unexpectedly, of apparently natural or accidental asphyxial mechanisms. Although advanced dissections and special laboratory techniques are more widely accepted in cases of allegedly criminal infant head trauma, there is no standard of practice upon which to evaluate the degree of thoroughness generally thought necessary in an unexpected infant death. While criminal implications aren't a factor in these cases, accurately determining the cause of death of an infant may have significant implications for the parents, siblings, and institutional stakeholders in public health, criminal, and civil justice systems.

The term "complete" autopsy is often used in forensic pathology to suggest that a thorough internal and external examination has been performed. This is in contrast to the "partial" or "limited" autopsy in which only a part or parts of a body are examined, such as the heart and lungs or brain. Partial or limited autopsies are inadequate for most medicolegal cases, and we unreservedly state that they should never be performed on infants or children whose deaths fall under investigation by a coroner or medical examiner. The concept of a complete autopsy was discussed at length by Matshes et al., who stated that a "complete" autopsy by simplistic definition is one in which "*every conceivable test has been performed*" and which they acknowledge is impossible (2). They further specify that an autopsy is considered complete when it 1) allows for the accurate determination of cause and manner of death, 2) facilitates the collection and documentation of evidence and determines the underlying nature of disease or injury (and thus creating a minimal dataset for independent inquiry), and 3) allows practitioners to maintain competency through exposure to a broad variety of cases, which enables them to better interpret complex cases.

As many pediatric autopsies, in isolation, fail to identify an anatomic cause of death, in a very strict since, they may not be considered "complete" by this definition, despite performance of multiple ancillary tests, consultation with specialists, and extensive histologic sampling of organs and tissues. The conclusion of the Matshes et al. paper is that when forensic pathologists select and perform tests and procedures based on the case information on hand at the time, document their work, and ultimately formulate an opinion based on the results available, the autopsy is considered complete. This paper provides recommendations for what constitutes a complete autopsy on an infant who has died suddenly and unexpectedly without evidence of trauma.

DISCUSSION

Infants Are Not Just Small Adults

It should go without saying that "infants are not just small adults," but it is a basic tenet that cannot be overstated in forensic pathology. Evidence of contributory injuries or natural diseases may be subtle or minute, demanding a heightened level of scrutiny on the part of the pathologist. As such, a full autopsy on a child is different than that on an adult, regardless of the presence or absence of trauma.

Pediatric forensic pathology is a distinct and recognized subspecialty interest of forensic pathology. It is not an area of medicine for which separate fellowships can be undertaken, nor can practitioners take recognized board examinations to demonstrate competency. Rather, forensic pathologists with an interest in this area may focus on the development of special competencies and expertise through additional focused training, research, and publication. Fundamental to the practice of pediatric forensic pathology is core competency in forensic pathology. The story of

Dr. Charles Smith (a pediatric pathologist without forensic pathology training) and the many miscarriages of justice in infant and child death investigations in the Canadian province of Ontario (3) should haunt every forensic pathologist who performs pediatric autopsies, and should serve as a reminder of the significant consequences to society that can accompany errors made during pediatric forensic autopsies and child death investigation.

Perhaps the most important defining feature of a successful pediatric forensic pathology service is a willingness to consistently regard the death investigations and autopsies of infants and young children as "special." Put another way, the forensic pathologist who performs infant autopsies does not just perform standard adult autopsies on small infant bodies. Access to standardized, broad, autopsy datasets (well beyond those usually prepared during "routine" sudden adult death investigations) have been regarded as being of tangible importance in unexpected infant death investigations (4). In fact, in at least one international setting, it is believed that "*implementing uniform investigative and autopsy protocols would…be an essential prerequisite to gain better understanding of the mystery of* [unexpected infant death]" (5). Publications from individual or small groups of pathologists (6), and collaborative efforts (7) have provided some perspectives on the evaluation of the deceased infant at autopsy.

Is There a "Standard of Practice" in Performing Unexpected Infant Death Autopsies?

To our knowledge, most major systems of death investigation in the United States would consider it standard practice to perform some type of invasive autopsy on infants who die suddenly and unexpectedly, though some rare exceptions may exist because of religious exception laws. To our knowledge, there is no currently accepted standard for what constitutes an infant autopsy. Despite that, results of recent research conducted by the Centers for Disease Control and Prevention (CDC) on seven US states indicated relatively uniform utilization of toxicology testing (97%), microbiology, histology and "other pathology" (98%), and radiography (87%). Other ancillary laboratory studies were used less consistently including blood chemistry (41%), genetic testing (23%), and metabolic testing (71%) (4).

We had an interest in the typical infant autopsy practices of forensic pathologists beyond those recorded in the CDC's published research. To that end, a survey was distributed to forensic pathologists via the NAME listserv. This survey reveals significant variation in current pediatric autopsy practices across the United States.

Survey Results

Participants were asked to complete ten online questions during a two-week period. Of 749 registered recipients of the NAME listserv, 85 responses were received (an 11% response rate); however, not all respondents answered all of the questions.

The first four questions had the exact same 30 choices for answers but had slightly different worded questions (**Table 1**). When asked "*what procedures are routinely performed for a nontrauma-related pediatric autopsy in a child less than 2-years-of-age*," only the following five items were selected by more than 90% of respondents: 1) full-body radiographs; 2) histology; 3) toxicology testing for common drugs of abuse; 4) head circumference; and 5) crown-heel length (body weight was inadvertently not included as a choice).

Only four procedures were considered to be required for a nontrauma-related pediatric autopsy: 1) histology; 2) crown-heel length; 3) toxicology testing for common drugs of abuse; and 4) full-body radiographs.

Of the 30 choices, 14 were selected by greater than 60% of respondents to be performed based on the discretion of the pathologist, including: 1) metabolic screening; 2) formal cardiac, neuropathology, and pediatric pathology consultations; 3) photographs of the conjunctivae, genitalia, and frenulae; 4) removal of the eyes and spinal cord; 5) exposure of the long bones; and 6) dissections of the posterior neck and back.

The use of consultants varied by type of consultant, case history, and autopsy findings. As expected, neuropathologists are the most frequently consulted. Cardiac pathologist consultations are limited to those cases with known cardiac history (41%) and only if something abnormally is seen grossly or microscopically (78%). Pediatric pathology consultations are sought predominantly when something abnormal is identified either grossly or microscopically. Approximately half of those with on-site access to consultants

Table 1: Results of NAME Listserv Survey on Current Pediatric Autopsy Techniques

Procedure	Routine (#)	Required (#)	Discretionary Basis (#)	Unnecessary (#)
Blood cultures	69 % (59)	56 % (48)	41 % (33)	6 % (3)
Lung and/or spleen cultures	45 % (38)	33 % (28)	55 % (44)	8 % (4)
Viral cultures	62 % (53)	45 % (38)	47.5 % (38)	4 % (2)
Vitreous electrolytes	86 % (73)	78 % (66)	21% (17)	2 % (1)
Toxicology testing for common drugs of abuse	96.5% (82)	94 % (80)	12.5 % (10)	2 % (1)
Carbon monoxide testing	13 % (11)	15 % (13)	72.5 % (58)	10% (5)
Metabolic screening for organic acid disorders	56.5 % (48)	55 % (47)	44 % (35)	6 % (3)
Formal neuropathology consultation	21 % (18)	15 % (13)	75 % (61)	13.5 % (7)
Full body radiographs	93 % (79)	91 % (77)	10 % (8)	0 % (0)
Formal cardiac pathology consultation	0 % (0)	2 % (2)	89 % (71)	19 % (10)
Blood retained for DNA testing - stain card	87% (74)	84 % (71)	9 % (7)	0 % (0)
Blood retained for DNA testing - purple top tube	49 % (42)	51 % (43)	24 % (19)	6 % (3)
Histology	96.5 % (82)	98 % (83)	9 % (7)	0 % (0)
Formal pediatric pathology consultation	2.4 % (2)	1 % (1)	85 % (68)	19 % (10)
Reference ranges for organ weights listed in autopsy report	38 % (32)	34 % (29)	46 % (37)	25 % (13)
Head circumference measurement	93 % (79)	88 % (75)	15 % (12)	0 % (0)
Crown rump length measurement	84 % (71)	61 % (52)	20 % (16)	13.5 % (7)
Crown heel length measurement	99 % (84)	92 % (78)	15 % (12)	2 % (1)
Photographs of genitalia	34 % (29)	26 % (22)	65 % (52)	17 % (9)
Photographs of the conjunctivae	32 % (27)	25 % (21)	65 % (52)	15 % (8)
Photographs of the frenulae	35 % (30)	28 % (24)	64 % (51)	15 % (8)
Soft tissue dissection of the back (flay)	14 % (12)	9 % (8)	74 % (59)	44 % (23)
Anterior neck dissection	49 % (42)	47 % (40)	44 % (35)	17 % (9)
Posterior neck dissection	14 % (12)	9 % (8)	71 % (57)	33 % (17)
Sexual assault exam	1 % (1)	5 % (4)	82.5 % (66)	44 % (23)
Removal of the eyes for examination	3.5 % (3)	3.5 % (3)	82.5 % (66)	48 % (25)
Examination of the middle ear canal, with or without histology	27 % (23)	22 % (19)	66 % (53)	21 % (11)
Removal of the parietal pleura to visualize the ribs	43.5 % (37)	39 % (33)	50 % (40)	17 % (9)
Exposure of the long bones	0 % (0)	1 % (1)	82.5 % (66)	56 % (29)
Removal of the spinal cord	30.5 % (26)	25 % (21)	62.5 % (50)	23 % (12)
Number of respondents	85	85	80	52

tend to utilize their services more because of the convenience, while the other half tends to use them only on cases deemed necessary, so the ease of obtaining a consultation is not a factor. Price and availability of the consultant were listed as reasons for not using their services.

A Move Towards a Standardized Infant Autopsy

The influences of personal training and experience, office culture, and accessibility to content expert consultants weigh heavily on individual practices. Without any question, this has an impact on the quality and consistency of death investigation conclusions across the country (and likely across the globe). In an effort to promote the development of standards of practice for our profession, or at a minimum, to increase the discussion/debate around this topic, we propose a standardized infant autopsy workflow (**Figure 1**) that we believe provides an approach to the autopsy of all unexpected infant deaths. Although we feel that a high level approach to such an autopsy can be proposed in a manuscript such as this, the fine details about how to perform each step is well-beyond the scope of our efforts. Those elements we consider to be core components of an infant's postmortem examination are included in **Table 2**. Similarly, specialized advanced or extended dissections that we do not consider routine or standard during the autopsy of an apparently uninjured infant are listed in **Table 3**, along with their fundamental indications.

Major Considerations of the Proposed Workflow

Photography

Knowledge of the case history and death scene investigation are essential to the autopsy process. Specific guidelines for scene investigation have been developed and previously published (8); therefore, will not be reiterated here. However, we feel it necessary to state that recognition and documentation of an infant's initial lividity pattern can be critical to the determination of cause and manner of death. Since patterns of livor mortis can shift rapidly in the early postmortem period, we strongly recommend that the deceased infant be photographed as early as possible after death. Comparison of photographs of the infant at or near the time of death with those of the infant after supine positioning in the morgue refrigeration unit in the hours prior to autopsy may reveal dramatic differences.

Autopsy photography is not addressed by the workflow diagram in **Figure 1**. In general, we believe that the baseline for practice should be all photographs required by NAME inspection and accreditation standards plus photographs of all external body surfaces, overall photographs of all major soft tissue dissection planes of the chest and abdomen, and at least one *in situ* photograph of the thoracoabdominal organs. Photographs of any abnormal findings and pertinent negative findings are also suggested as good practices.

External Examination

A thoughtful, detail-oriented external examination is the cornerstone of forensic autopsies in general (**Figure 1, External Exam "1"**). Beyond those basic features which forensic pathologists would consider standard, we recommend recording major body measurements (unclothed body weight with medical treatment removed, head circumference, body length, hand length, foot length, and both inner and outer intercanthal distances). Although reference charts exist, chest and abdominal circumferences, hand and foot lengths, and inner and outer canthal distances have less significance in infants over six months of age, unless the child is malnourished or has a dysmorphic appearance (9). As mentioned previously, attention to detail about lividity patterns may be of great importance. It may be important to divide the external examination into two distinct parts, before and after radiology, thus facilitating imaging techniques without clothing, diapers, and medical paraphernalia (e.g., intra-osseous catheters, defibrillator pads; **Figure 1**, **Radiology "1" and External Exam "2"**); however, it is also noted that many workflows initiate radiographic imaging upon admission to the facility, prior to the initial external examination. In these instances, a second set of radiographs after removal of clothing and medical devices may be necessary to view the skeletal elements without obstruction.

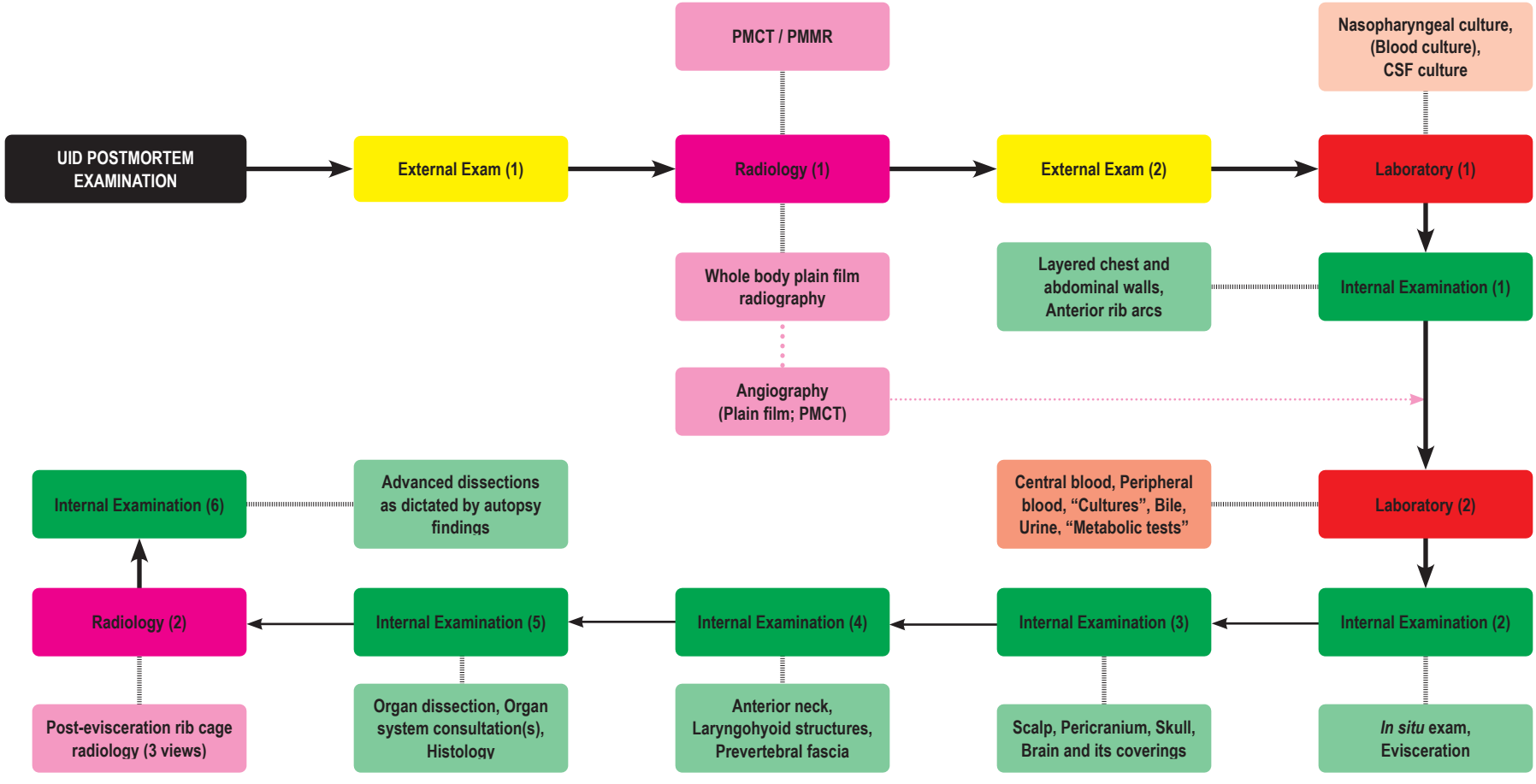

Figure 1: Unexplained infant death workflow chart.

Abbreviations: UID - Unexpected infant death; PMCT - Postmortem computed tomography; PMMR - Postmortem magnetic resonance imaging; CSF - Cerebrospinal fluid

Lab tests within quotation marks are suggested to be performed only when indicated by the available investigative dataset. Pink dotted lines are used to indicate optional procedures requiring very specialized equipment.

Radiology

Whole body radiography is critical to the identification of bony trauma, primary osseous pathology, and pathologic collections of air. Although it may seem desirable or even preferable to efficiently or rapidly radiograph an infant over one or two cassettes or with a whole body scanner, this is not best radiographic practice as major features may be obscured by inappropriate body positioning. Standardized radiographic views are summarized in **Table 2**; radiology technicians should be able to perform each of these techniques with ease. Due to the overlapping bones of the face and skull base, it is recommended to utilize three views (anteroposterior, lateral, and Towne's) so the entire skull can be visualized. Tilting the head towards the chin for the Towne's view enables better visualization of the posterior fossa and mandible. With even basic training, autopsy technicians should also be able to gain comfort with obtaining high quality infant radiographs.

Table 2: Core Components of the Postmortem Examination of an Infant Who Has Died Suddenly and Unexpectedly, and Without Evidence of Blunt Trauma

External examination	General observations Dysmorphology survey Weight and measurements Postmortem changes Evidence of medical intervention Photographic documentation
Internal examination	Layered dissection of the chest and abdomen *In situ* examination of the thoracoabdominal organs Documentation and measurement of cavity fluids Evisceration Examination of the internal organs with documentation of weights Stripping of the pleura Peeling of the scalp Pericranial fascia examination Removal of the calvarium Removal of the brain Removal of the dura Removal of the spinal cord Examination of the brain, dura, and spinal cord Photographic documentation
Radiology	Full body radiographs including: Three views of skull (AP, lateral, Towne's) Two views of the cervical spine (AP, lateral) Two views of the trunk/torso (AP, lateral) Two views of the ribs (left posterior oblique, right posterior oblique) Four views of the upper extremities (left upper extremity, right upper extremity, left hand, right hand) Four views of the lower extremities (left lower extremity, right lower extremity, left foot, right foot)
Histology	Brain, dura, and spinal cord Heart Lungs and major airways Liver Kidneys Hematopoietic (thymus, spleen, bone marrow) Endocrine (pituitary, thyroid gland, pancreas, adrenal glands) Gastrointestinal (gastroesophageal junction, stomach, small intestine, colon)
Toxicology	At least alcohol and drug screen; vitreous electrolytes
Microbiology studies	Only as directed by history, circumstances and autopsy findings, such as: Nasopharyngeal swabs (viral cultures) Tracheal swabs/aspirates (viral cultures) Blood culture (via cardiac puncture; aerobic and anaerobic bacterial cultures) Bacterial tissue culture (lung; spleen) Cerebrospinal fluid culture (via lumbar puncture)
Molecular testing	Blood saved in EDTA (purple top) tube or on stain card

As postmortem computed tomography (PMCT) gains popularity across the globe, some centers are routinely making use of full-body imaging. When available, we strongly recommend the use of PMCT to complement infant autopsy techniques (10). Some institutions have access to PMCT angiography (PMCTa), the results of which may augment the approach to autopsy or facilitate more detailed understanding of the cardiovascular system and other organ systems. Rare offices have access to postmortem magnetic resonance (PMMR) imaging. At least one institution believes that:

> *…gold standard perinatal and pediatric autopsy services would include complete PMMR imaging prior to autopsy…this approach would provide maximal diagnostic yield to the pathologist, forensic investigator and most importantly, the parents* (11).

Following full-body evisceration, radiography of the chest is strongly recommended to facilitate detailed examination of all aspects of the rib arcs (**Figure 1**, **Radiology "2"**).

Internal Examination

Given the recurring theme of commitment to the performance of detail-oriented, pediatric forensic autopsies, we suggest a stepwise, regimented evaluation of the infant from skin incision through internal organs. With a desire to observe and document subtle injuries, we believe it to be best practice to evaluate the subcutaneous soft tissues of the chest and abdominal walls in a layered fashion, ultimately facilitating detailed observations of the anterolateral rib arcs (**Figure 1**, **Internal Examination "1"**). Given the complex and subtle nature of some pathologic entities, we believe it is best practice for a forensic pathologist to always personally perform the dissection and evisceration on pediatric cases (**Figure 1, Internal Examination "2" through "5"**). The approach to evisceration and organ dissection, when to make use of a consultant, and how to select histologic sections are well beyond the scope of this paper. In general, we offer that pathologists should practice within their comfort zones and seek counsel where appropriate and available, recognizing also the heightened scrutiny that surrounds pediatric

Table 3: Special Dissections Not Considered Routine* For Unexpected Infant Death Forensic Autopsies, and Some of the Indications for Performing Those Studies

Dissection	Indication(s) Include
Face dissection†	Search for impact site(s) in infant with intracranial hemorrhages Part of a "formal" anterior neck dissection, facilitating greater exposure of the soft tissues of the upper anterior neck in cases of suspected or alleged strangulation, or in complex cases that might involve face or neck pressure Facilitate an assessment of oral mucosal pathology such as in cases of suspected facial pressure or impact trauma to the mouth
Posterior neck dissection	Clarify suspected cervical spine injuries, including cases with alleged or suspected shaking / whiplash Evaluate the extent of impact injury Refine evidence of ligature or manual strangulation, or cases of neck pressure
Cervical spine removal†	Search for nerve root pathology in infants with subdural and subarachnoid hemorrhages that may be unnatural in etiology Clarify the extent of known or suspected blunt spine trauma
Layered back dissection	Evaluate for evidence of impact blunt trauma of the posterior trunk Examine for evidence of pressure being applied to the chest or back Study the paravertebral and posterior rib arcs in search of acute or remote trauma
Extremity dissections	Confirm or refute suggestions of blunt trauma
Osseous examinations	Confirm or refute suggestions (including radiologic) of acute or remote osseous injuries, or primary osseous pathology

* In routine "negative" unexpected infant death autopsies, it may be considered unnecessary to perform any of the above autopsies. In cases where the routine pediatric autopsy does not reveal evidence of injury, or when circumstances do not reasonably suggest pathologic face, chest or back pressure, forensic pathologists should carefully consider their ability to demonstrate the "medical necessity" of using a non-routine autopsy technique, if asked.

† A face dissection cannot be performed on the same case as a cervical spine removal. This results in "uncontrolled" decapitation of the infant.

cases. Broad categories of tissue selection for histologic evaluation are included in **Table 1**, with a more detailed, idealized list included in **Table 4**.

We recommend that any incisions into the infant beyond those required to remove the internal organs and brain (**Figure 1, Internal Examination "6"**) are approached with caution, and as suggested by the available dataset. Soft tissue dissections of the back or extremities, following a negative autopsy, are extremely unlikely to yield positive results and as such, may be considered unnecessary or mutilating. Similarly, removal of the eyes or cervical spine from an infant without any evidence of blunt head trauma is unlikely to yield results of value to the entire case. Furthermore, following proper radiography and a thorough autopsy, an infant without evidence of radiologic abnormalities or autopsy evidence suggestive of trauma does not require exposure or removal of skeletal elements. As such, when selecting additional dissections, the responsible pathologist is cautioned to consider the necessity of the study in the context of what the autopsy has already demonstrated, and what was objectively raised as suspicious during the course of the death investigation.

Laboratory Studies

The results of our survey and other literature cited in this review confirm that toxicology is considered a core component of a pediatric forensic autopsy. However, the use of other ancillary laboratory studies remains very controversial (12). Blood cultures, for example, are widely recognized as being unreliable

Table 4: Recommended or "Ideal" Histologic Sections in a Typical Case of Unexpected Infant Death

Nervous system	Frontal lobe Parietal border zone Basal ganglia (anterior and posterior) Hippocampi Brainstem (three levels) Cerebellum (including dentate nucleus) Spinal cord Dura mater
Heart	Right ventricle Left ventricle Interventricular septum (at least mid-heart) Interatrial septum (AV nodal region)*
Respiratory	Larynx Trachea Mainstem bronchi At least one section of each lung Diaphragm (representative)
Hepatobiliary	Right and left liver lobes (representative) Pancreas (representative)
Gastrointestinal	Gastroesophageal junction Stomach (body, pylorus) Intestine (representative) Colon (representative)
Hematopoietic	Spleen Bone marrow (vertebral centrum or rib)
Endocrine	Pituitary gland Thyroid gland Adrenal glands
Genitourinary	Kidneys (representative) Ovary or testicle Uterus or prostate gland Urinary bladder

* This section is selected not for the atrioventricular nodal component of the conduction system, but rather as an excellent or primary location of identification of myocarditis.

because of postmortem proliferation of organisms and contamination (13). Similarly, postmortem metabolic screening tests can yield unreliable results because of both postmortem interval and the nature of the specimens selected for study (14). Molecular analysis of postmortem blood or frozen tissue samples (e.g., heart, liver, or spleen) has been shown to be beneficial in the identification of cardiac channelopathies in an otherwise negative autopsy (12, 13, 15-21). Ultimately, the forensic pathologist will need to consider all of the available data, including the results of the evolving (progressing) autopsy, and the reliability of the results, as they choose whether or not to pursue specialized laboratory testing.

CONCLUSION

A wide variety of autopsy techniques, consultants, and ancillary studies are available to forensic pathologists for performance of pediatric autopsies (22-25). The degree to which they are used varies considerably throughout the United States. We have proposed a workflow and recommendations for the core components of a complete pediatric autopsy after the sudden unexplained death of an infant. Specialized dissections performed routinely and without merit do not make the autopsy more "complete." As with all forensic cases, the scene findings, history, and evolving autopsy findings should guide the pathologist to make decisions on appropriate testing and techniques based on the needs of the case.

NAME is working with the Sudden Unexpected Deaths in Childhood foundation and other experts, including members of the American Academy of Pediatrics, to study current practices for the investigation, autopsy, and certification of sudden unexpected deaths in infants and children as well as discuss recommendations for best practices with the goal of creating a joint position paper.

REFERENCES

1) Gill J, Andrew T, Gilliland M, et al. National Association of Medical Examiners position paper: recommendations for the postmortem assessment of suspect head trauma in infants and young children. *Acad Forensic Pathol*. 2014 Jun; 4(2):206-13. https://doi.org/10.23907/2014.032.

2) Matshes E, Milroy C, Parai J, et al. What is a complete autopsy? *Acad Forensic Pathol*. 2011 Jul; 1(1):2-7. https://doi.org/10.23907/2011.001.

3) Inquiry into pediatric forensic pathology in Ontario. Toronto: Queen's Printer for Ontario, Ontario Ministry of the Attorney General; 2008. 1170 p.

4) Erck Lambert AB, Parks SE, Camperlengo L, et al. Death scene investigation and autopsy practices in sudden unexpected infant deaths. *J Pediatr*. 2016 Jul; 174:84-90.e1. PMID: 27113380. PMCID: PMC5063238. https://doi.org/10.1016/j.jpeds.2016.03.057.

5) du Toit-Prinsloo L, Dempers J, Verster J, et al. Toward a standardized investigation protocol in sudden unexpected deaths in infancy in South Africa: a multicenter study of medico-legal investigation procedures and outcomes. *Forensic Sci Med Pathol*. 2013 Sep; 9(3):344-50. PMID: 23564060. https://doi.org/10.1007/s12024-013-9427-5.

6) Ottaviani G. Crib death - Sudden Infant Death Sundrome (SIDS). 2nd ed. London ; New York: Springer; 2014. 203 p.

7) Krous H. The international standardized autopsy protocol for sudden unexpected infant death. *J Sudden Infant Death Syndrome Infant Mortal*. 1996; 1:203-46.

8) Sudden unexplained infant death investigation: a systematic training program for the professional infant death investigation specialist. Atlanta: United States Department of Health & Human Services (Centers for Disease Control and Prevention); 2006. 250 p.

9) Gilbert-Barness E, Spicer DE, Steffensen TS. Handbook of pediatric autopsy Pathology. New York: Springer; 2014. 750 p.

10) Matshes E, Snyder V, Andrews S. Utilitarian aspects of postmortem computed tomography. *Acad Forensic Pathol*. 2015 Dec; 5(4):603-13. https://doi.org/10.23907/2015.064.

11) Arthurs OJ, Hutchinson JC, Sebire NJ. Current issues in postmortem imaging of perinatal and forensic childhood deaths. *Forensic Sci Med Pathol*. 2017 Mar; 13(1):58-66. PMID: 28083782. PMCID: .PMC5306347. https://doi.org/10.1007/s12024-016-9821-x.

12) Krehbiel K, Pinckard J. The toolbox approach to forensic pathology. *Acad Forensic Pathol*. 2015 Dec; 5(4):534-47. https://doi.org/10.23907/2015.059.

13) Wilson SJ, Wilson ML, Reller LB. Diagnostic utility of postmortem blood cultures. *Arch Pathol Lab Med*. 1993 Oct; 117(10):986-8. PMID: 8215840.

14) Matshes E, Hamilton L, Lew E. Routine metabolic testing is not warranted in unexpected infant death investigations. *Acad Forensic Pathol*. 2012 Dec; 2(4):346-56. https://doi.org/10.23907/2012.053.

15) Tester DJ, Ackerman MJ. Cardiomyopathic and channelopathic causes of sudden unexplained death in infants and children. *Annu Rev Med*. 2009; 60:69-84. PMID: 18928334. https://doi.org/10.1146/annurev.med.60.052907.103838.

16) Duncanson E, Lynch K, Baker A, et al. Establising a multidisciplinary network for the workup of sudden cardiac death. *Acad Forensic Pathol*. 2015 Jun; 5(2):221-32. https://doi.org/10.23907/2015.025.

17) Cunningham K, Pollanen M. Evolution of a molecular autopsy program from within a death investigation system. *Acad Forensic Pathol*. 2015 Jun; 5(2):211-20. https://doi.org/10.23907/2015.024.

18) Severson E, Timm K. The value of molecular autopsy: genetic testing reveals long QT mutations in an autopsy-negative, postpartum sudden unexpected death. *Acad Forensic Pathol*. 2014 Dec; 4(4): 552-6. https://doi.org/10.23907/2014.072.

19) Middleton O, Baxter S, Demo E, et al. National Association of Medical Examiners postition paper: retaining postrmotem samples for genetic testing. *Acad Forensic Pathol*. 2013 Jun; 3(2):191-4. https://doi.org/10.23907/2013.024.

20) Tang Y, Siegel D, Sampson B. Molecular investigations of sudden unexplained deaths. *Acad Forensic Pathol*. 2011 Jun; 1(2):194-201. https://doi.org/10.23907/2011.025.

21) Gill J, Lange R, Azar O. What is sudden cardiac death. *Acad Forensic Pathol*. 2011 Jun; 1(2):176-86. https://doi.org/10.23907/2011.023.

22) Bove KE. Practice guidelines for autopsy pathology: the perinatal and pediatric autopsy. Autopsy Committee of the College of American Pathologists. *Arch Pathol Lab Med*. 1997 Apr; 121(4):368-76. PMID: 9140305.

23) Laskey AL, Haberkorn KL, Applegate KE, Catellier MJ. Postmortem skeletal survey practice in pediatric forensic autopsies: a national survey. *J Forensic Sci*. 2009 Jan; 54(1):189-91. PMID: 19040665. https://doi.org/10.1111/j.1556-4029.2008.00922.x.

24) Parham DM, Savell VH, Kokes CP, et al. Incidence of autopsy findings in unexpected deaths of children and adolescents. *Pediatr Dev Pathol*. 2003 Mar-Apr; 6(2):142-55. PMID: 12481231. https://doi.org/10.1007/s10024-002-0016-y.

25) Naso C, Jenkins AJ, Younger D 3rd. A study of drug detection in a postmortem pediatric population. *J Forensic Sci*. 2008 Mar; 53(2): 483-90. PMID: 18284528. https://doi.org/10.1111/j.1556-4029.2007.00646.x.