The Future of Autopsy Reporting: Data Repository and Research Support

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A Brief History of Autopsy Reporting

Over the millennia that postmortem examinations have been conducted, the manner of reporting autopsy findings has no doubt evolved. Little is known about the early history, although extant records from European centers such as Padua and Vienna dating back several centuries provide a glimpse into the western tradition. In a recent review, it was noted that reports were written in *Kurrentschrift* (an archaic form of German language handwriting based on late medieval cursive writing) until the early 1800s and then in Latin script until the 1920s when typewriters revolutionized reports. Their study was possible due to storage of reports in the Vienna Municipal Archives, making the reports available for study and investigation in perpetuity [1].

In the United States, autopsy reporting was impacted dramatically by the "Flexner report" in 1910, which underscored clinicopathologic correlation as a key tenet of modern medical education. Autopsy pathology was a cornerstone of this correlative process, and the formatting of reports made accessible findings that confirmed or refuted physical examination findings and antemortem diagnoses. This was further bolstered by the Joint Commission on Hospital Accreditation requiring that at least 20% of hospital deaths be autopsied (from 1951 to 1970).

In the last quarter of the twentieth century, autopsy reports evolved to follow a fairly standard format with conserved report sections and relatively uniform content across different cases and different institutions. Increasingly, the report assumed the role of a medicolegal document. This was in part the product of standardization

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efforts by the National Association of Medical Examiners, the College of American Pathologists, and other pathology organizations [2, 3]. The reports were entirely narrative, with rhetoric and language finding a balance between the intended audiences of physicians, family members, and their attorneys.

The more recent evolutionary leaps in autopsy reporting have been occasioned by (1) increasing time demands on autopsy pathologists in both the forensic- and hospital-based settings and (2) a data-centered shift across medicine in general. Almost without exception, less time is being allotted to the practice of autopsy pathology, and pathologists are being asked to accomplish more but being given less support and fewer resources. Pathologists have had to be creative and find ways to economize in autopsy reporting. This evolution mirrors what has occurred in surgical pathology reporting, as well. As will be discussed in detail in this chapter, the emphasis is now on producing concise and "actionable" reports that possess the ability to aggregate and search data on a population level. In surgical pathology, this manifests as templated or synoptic (checklist)-based reports. The degree to which this trend will translate into autopsy reporting remains to be seen. Examples of narrative versus synoptic reporting, as applied to autopsy, are shown in Table 3.1.

Essential Elements of Autopsy Reporting

Autopsy reports are unique among all the formal communications issued by pathologists. Distinguished by their length, complexity, and exhaustiveness, these reports are the product of at least as much "art of medicine" as science. Viewed by many as the pillar of prose in the pathology laboratory and a time-honored tradition taught at great pains as part of the initiation of new pathology trainees, the construction of autopsy reports is a serious matter in this field and one invoking no shortage of opinions as to its proper execution.

The autopsy report has not been immune, however, to trends affecting surgical pathology and other reports issued by pathologists. These include a general shift toward brevity (e.g., eliminating microscopic descriptions), at-a-glance readability, and formatting compatible with digital interfaces that connect to electronic health record systems.

What the future holds for autopsy reporting is open to conjecture, but some of the salient issues pertaining to ways the autopsy report may evolve over the coming decades are the focus of this chapter.

Familiarity with the basic structure and content of present-day autopsy reports is assumed here. Readers are referred to recent excellent summaries on this topic by Koponen [3] and Fligner [4] for further contextual information on this subject.

The Narrative Versus Synoptic Report Debate

Over the past decade or so, there has been a movement in surgical pathology reporting (championed by the CAP Cancer Protocols) toward a more tabular format of "synoptic" reporting [5]. The advantages to this approach in terms of

Table 3.1 Synoptic vs narrative autopsy reports using the heart as an example

Narrative	*Heart* The heart weighs 485 g (expected 280–480 g). The pericardium is smooth. The coronary arteries are widely patent without evidence of atherosclerosis, except for focal grade 3 (of 4) narrowing in the proximal LAD with plaque calcification. There is also focal narrowing (grade 2) of the RCA. The left ventricle is mildly hypertrophied (1.7 cm, septum 1.8 cm). The right ventricle is normal thickness (0.4 cm). Cut surface shows no evidence of scar, fibrosis, or hemorrhage. The tricuspid (12.5 cm), pulmonic (7.7 cm), mitral (10.3 cm), and aortic (7.9 cm) valves are all unremarkable. The oval foramen is fused.
Synoptic	**Heart**
	Weight (in g): *485* Expected weight (in g): *280–480*
	Chamber sizes:
	Right atrium: *normal*
	Right ventricle: *normal*
	Left atrium: *mild enlargement*
	Left ventricle: *mild hypertrophy, no dilatation*
	Ventricle wall thicknesses (in cm)
	Left (freewall): *1.7*
	Septum: *1.8*
	Right: *0.4*
	Myocardial scarring: *none*
	Myocardial mottling: *none*
	Coronary stenosis (grade, out of 4) (extent, location):
	LMA: *1*
	LAD: *3 (focal, proximal)*
	LCX: *1*
	RCA: *2 (focal, mid)*
	Coronary calcification: *focal, LAD*
	Coronary stents, grafts: *none*
	Valve circumferences (in cm):
	Pulmonary: *7.7*
	Aortic: *7.9*
	Mitral: *10.3*
	Tricuspid: *12.5*
	Valve leaflets:
	Thin and pliable
	No vegetations
	Oval foramen: *fused*

communicating key pathology findings include standardization, consistency, completeness, and clarity. These translate into more "user-friendly" reports that, for example, improve oncologist efficiency in finding the parameters in the report that may guide their decision-making. They also are a boon to the creation and maintenance of registries and other clinical databases, improving the reliability and accuracy of data entry from pathology reports and even enabling the automatic export and querying of data fields, obviating the need for manual data entry altogether.

While autopsy reports are fundamentally different from surgical pathology reports, drawing analogies to this kind of transformation to a synoptic reporting style is almost unavoidable in considering the future of autopsy reporting.

Still, there are proponents of the narrative reporting style, and their arguments are sound. In contemporary (synoptic era) surgical pathology, pathologists already lament the constraints of synoptic reporting in terms of the ability to convey nuance and nonstandard aspects of a given pathology specimen. Furthermore, it is easy for important information to become buried in the "sea of data," especially when synoptic reports are lengthy, dense, and juxtapose minor/trivial and more impactful pathology findings. Both of these limitations are amplified tremendously in the extrapolation to autopsy reporting.

Truly, no two autopsies are the same, and a synoptic reporting approach to autopsy findings could jeopardize the pathologist's ability to characterize the idiosyncrasies and potentially important interplay of synergistic disease processes in a given patient. There is also the fact that it may not be possible to capture the entirety of the spectrum of possible pathologies affecting any given organ in a tidy list that is amenable to synoptic reporting. Moreover, by canonizing a list of potential common findings, pathologists may over time either forget or lose the ability to recognize other rare conditions not included in the list. Overarching this argument is a general (and justified) concern that the role of the pathologist in synoptic reporting more closely resembles that of a technician rather than a physician.

Striking the balance between efficiency gains afforded by synoptic reporting and the need for a mechanism that allows for clear communication of subtlety and complexity will be the central challenge for future autopsy reporting.

Trend Toward Uniformity Within Institutions

Like it or not (for better or worse), there has been an "organic" movement in pathology programs across the country toward adoption of dictation templates, macros, and boilerplate language in autopsy reporting. This may be an effect of the premium placed on time in pathology training, as expanding rotations and increased elective time often come at the cost of time on the autopsy service in many programs. Residents have more to do and more to learn but less time for either task. So, whether in a standardized fashion (such as macros built into information systems or official dictation templates) or through a more ad hoc approach (macros, copy-paste files, or unofficial dictation templates passed from one trainee to another), there is clearly a move toward repetition and abbreviation and away from free text or real-time narrative dictation through a microphone in the autopsy suite.

Electronic Health Records and the Drive to Data

Part of the efficiency and utility realized by electronic charting, besides eliminating illegible penmanship, is the capacity for automated note authoring assistance including prepopulating certain fields with data from other electronic health information sources. Coding and documentation of medical necessity can also be facilitated by

building certain rules into report authoring and allowing digital extraction of information entered into appropriate data fields.

The possibility and potential for the future of autopsy reporting in this context is discussed in a separate heading below, but needless to say, the move toward next generation Electronic Health Records (EHRs) must be part of any conversation about the autopsy report's future.

Capturing Clinical History

Certainly, a trying aspect of autopsy report writing is the accurate portrayal of the patient's past medical history and clinical events preceding death (including vital signs, imaging findings, and laboratory values [both baseline and antemortem]). This portion of the autopsy report is typically informed by other notes and reports in the patient's chart but is presented as a more concise synopsis. Because there are so many variables in play, this is also perhaps the greatest challenge in devising a synoptic or tabular format for these data in the autopsy report.

The clinical summary serves as a critically important lens through which the more objective organ-specific findings at autopsy are interpreted. For example, a history of hypertension leads to certain expectations about cardiac and renal findings, and a history of alcoholism anticipates certain potential changes in the liver, brain, and portal circulation. So, uncoupling the clinical history data from the autopsy findings data would be problematic to say the least.

At the same time, in constructing a list of possible conditions to include in the clinical history summary, it is hard to avoid redundancy with ICD-10 and other clinical coding schemes already developed for this purpose. In some future state of EHR integration, it may be possible to rely entirely on clinical documentation and ICD coding for the information that would otherwise be re-summarized in the autopsy report clinical history section. In this scenario there may no longer be a need for a separate clinical history summary as part of the autopsy report but tying this data to the autopsy findings would still be considered critical to autopsy reporting.

One additional feature captured in some hospital autopsy reports is the explicit indication for autopsy and specific questions to be addressed. This information helps shape the clinicopathologic correlation section (if included in the report). This kind of data is theoretically amenable to codifying, since the reasons for requesting postmortem examination are relatively finite. Tracking trends in these indication data could be incredibly valuable to hospital quality programs and understanding hospital autopsy trends at a macro level.

External and Internal Autopsy Findings

Organ weights and measures are easily captured in data fields, and perhaps the most direct application of templated reporting deals with these data. As mentioned before, there is a generally conserved set of descriptive gross and histologic findings, organ by organ, that could be captured in a synoptic autopsy template. Likewise, the

possible findings on external examination (similar to physical examination in living patients) could be reduced to a checklist of options. Indeed, the existing templates and dictation scripts in frequent use as part of clinical progress reports across the country reflect efforts at achieving this simplification.

Almost invariably, there is a need for an "other" category or natural language text field to capture the rare exceptions. This is important for accuracy and "free expression" of pathologists even though it may also be a potential liability to the data-oriented utility of tabular reporting, especially in the creation of registries.

Adding complexity to this is the fact that for any given gross or microscopic descriptive finding, there also exists a severity hierarchy. That is, when a finding is present, how is it best quantified? This has major implications for determining which processes were likely to be clinically significant (i.e., contributing to the mechanism of death).

While the order in which autopsy findings are reported may not be important (ultimately arbitrary and customizable in a digital environment), there may be conventions ingrained in institutions that would be important to maintain in the descriptive section of the autopsy report. These approaches include organization (1) by anatomic compartment (often in the order in which they are encountered during the postmortem procedure, for example, head and neck, thorax, abdomen, pelvis, brain, and spinal cord); or (2) by organ system, for example, neurologic, circulatory, respiratory, digestive, genitourinary, endocrine, etc.; or (3) from cranial to caudal, for example, brain, head-eyes-ears-nose-throat, neck, breast, lungs, mediastinum, heart, etc. Further details of new templates for autopsy reporting are discussed in a separate section below.

The Future of Autopsy Reporting: Why Change?

If autopsy examination is to remain an important source of data for clinicians, next of kin, communities, and institutions, it is clear that change is mandatory. Preservation of the autopsy may need a perception change as fundamental as that following publication of Morgagni's treatise "De Sebidus et causis morborum per anatomen indagatis" [6, 7]. This publication is credited with establishing modern medical practice through the identification of anatomical cause of disease and introducing anatomic-clinical correlation.

Declining Autopsy Rates

Decreased interest in this previously groundbreaking advance in medical thought and practice (the autopsy) is attributed to many factors: ability of noninvasive imaging methods to identify anatomic and some physiologic alterations, clinician confidence in these tools, elimination of minimum autopsy rate for hospital accreditation (1971), fear of litigation among clinicians, and lack of pathologist and family interest [8]. Current hospital autopsy rates are variable but average less than 10% [8].

However, the value of autopsy has not declined, with studies demonstrating that at hospital autopsy rates of even 5%, a major pre- and postmortem diagnostic discrepancy rate of almost 25% is identified. In almost 7% of these cases, identification of the missed diagnosis prior to death would have changed management and perhaps prolonged survival (class 1 missed diagnosis – Goldman criteria) [9, 10]. These data derive from reviews of 53 autopsy series over a 40-year period.

From studies like this, the statistical value of a nationwide database compiling uniformly and accurately codified autopsy data becomes readily apparent. Such data could and should drive nationwide healthcare quality metric data and research funding. In the era of quality-based medical care, the role of autopsy cannot be overemphasized. Graber argues that although autopsy is capable of identifying diagnostic errors, and indeed the impact of diagnostic errors (identification of class I errors), it is not always capable of identifying why the error was made [11]. One could argue, however, that the autopsy as a trigger for root cause analysis in cases of class I missed diagnoses should be able to supply such data at least in a significant subgroup. Performance of such a root cause analysis should be included as part of any autopsy quality assurance plan and plays a key role in patient safety.

Advancing Information Technology

For all of the aforementioned to happen, autopsy data needs to be of high quality (quality controlled), temporally relevant, and reported in a manner compatible with electronic medical records and data management systems. The narrative portable document format (pdf) files copied into a patient's electronic medical record at some temporal distance following death are not providing the ability to search relevant data fields, use data to more globally measure quality, and regionally and nationally share data [8]. Synoptic reporting using standardized and accepted formats as described in preceding paragraphs will clearly facilitate such processes.

The ADASP (Association of Directors of Anatomic and Surgical Pathology) recommends quality metrics for surgical and autopsy pathology [12]. Pre- and postanalytical and analytical variables are noted, as is the importance of having a quality assurance/quality improvement (QA/QI) plan with assessment of minimum quality standards as well as benchmarks set for improvement and a committee to oversee its implementation. It is imperative to emphasize the application of such practice to autopsy pathology. However, in the modern era of decreased autopsy rate and lack of direct monetary support for autopsy performance, many institutions do not even have a designated Director of Autopsy Pathology who can ultimately be tasked with such responsibility. National standards and synoptic reporting of autopsy would facilitate coordination of quality improvement measures across larger hospital systems as well as perhaps even nationally, in part addressing this problem. One can envision peer review of autopsy reports happening more readily in the situation of a synoptic reporting system with a separate, non-charted synoptic field dedicated to this purpose.

Impact on Education/Quality Metrics

Improving quality autopsy performance and reporting is mandatory to facilitate clinician, resident, and medical student education. Part of the decrease in autopsy rate is attributed to a decrease in pathologist interest in autopsy [8]. Some of this relates to resident autopsy exposure and education during training. The American Board of Pathology (ABP) mandates that a resident wishing to take the certification examination in anatomic pathology or anatomic and clinical pathology performs a minimum of 50 autopsies. Residents must report age group, gender, primary pathologic diagnosis, and the postgraduate year (PGY) in which they completed the autopsy [13]. This oversight assures 50 unique autopsy exposures of differing age groups (and presumably with a large enough exposure to many diagnostic categories), but the quality of such autopsy experience is much more difficult to ascertain. Nationally adopted uniform reporting standards should at least help to begin to set the minimum standard for autopsy performance and reporting and might be one way that certifying agencies such as the ABP can begin to survey quality. In addition, this move to future templated reports lends itself nicely to a coordinated and stepwise progression in assessing competency, helps clearly define the scope of what skills are necessary for residents to show independence, and documents milestone progression as residents gain more autopsy experience.

Another way to envision templated reports facilitating nationwide autopsy performance standards is to potentially tie them to quality metrics for practicing pathologists. CAP-derived physician quality measures for Medicare reimbursement incentives recommend adherence to synoptic reports as one of their quality metrics. One could envision a time when such adherence to synoptic autopsy reports is similarly proposed [14].

Development of New Templates for Autopsy Reporting

Logistical Considerations

A detailed description of the intricacies of designing database architecture is beyond the scope of this chapter, but some basic principles are helpful to review. In an electronic synoptic reporting system, a number of data field types would be needed to capture the relevant parameters. These would include defined lists (as in drop-down menus), free numeric data, free alphanumeric data, and binary selections (present/absent). The data entry interface must be customized with an eye toward ease of use and have built-in quality checks. This interface may be separate from the main report structure or may be integrated into the report itself. An example of one possible design for capturing gross data from kidney examination is presented in Table 3.2. This is constructed following principles of autopsy reporting set forth by Hanzlick et al. [2].

Once the data fields are established and populated, they may be reassorted in customized report (output) formats. These would include stylistic preferences and

Table 3.2 Synoptic data design model for autopsy gross kidney findings

Kidneys
Right kidney weight: [Numeric] g; *Size*: [Numeric] × [Numeric] × [Numeric] cm
Left kidney weight: [Numeric] g; *Size*: [Numeric] × [Numeric] × [Numeric] cm
Kidney capsule strips: [Defined list] easily/with difficulty/others: [Free text]
Kidney surfaces show: [Defined list] persistent fetal lobulation/depressed infarcts/coarse granularity/smooth granularity/smooth texture/others: [Free Text]
Kidney cut surface cortex is: [Defined list] brown/red-brown/pale brown/others: [Free Text], and [Numeric] cm thick
Kidney cut surface medulla is: [Defined list] light brown/red-brown and the corticomedullary junction [Defined list] distinct/indistinct/others: [Free Text]
Pelvicalyceal system: [Defined list] normal/others: [Free Text]
Cysts: [Binary] present/absent; [Defined list] medullary cysts/cortical cysts/both; [Defined list] right/left/bilateral; ranging from [Numeric] to [Numeric] cm in greatest diameter
Stones: [Binary] present/absent; *Stone Location*: pelvis/ureter/others: [Free Text]
Tumors: [Binary] present/absent; Description: [Free Text]
Renal artery and vein: [Defined list] Single/Dual/Multiple artery system; [Defined list] Renal artery patent bilaterally/ostial stenosis/atherosclerosis/fibromuscular dysplasia/others: [Free Text]
Ureters: [Defined list] Slender and patent bilaterally/other: [Free Text]; [Defined list] Single/Dual ureters; [Defined list] right/left/bilaterally

perhaps grouping findings by organ systems or anatomic compartment, as mentioned previously. Reports compiled solely for quality efforts, research, or monitoring purposes could also be developed using autopsy data fields. Examples could include trending lung weights (normalized to body weight) in intensive care unit deaths over time, or tricuspid valve annular diameters in patients with pulmonary hypertension compared to a reference group (or untreated cohort).

Another critical consideration for electronic autopsy reporting is the potential alterations to the report structure and format that may occur as data pass through an electronic interface to the EHR. There are generally established standards that help ensure successful passage through this process, but some validation of that protocol and careful examination of reports as viewed through the clinical EHR portal are important in ensuring success in this aspect of autopsy reporting.

One novel approach to "next-generation" autopsy reporting is detailed by Wittekind et al. [15]. They propose restructuring the elements of a conventional autopsy report into a modular format, making each section self-contained and separate. An example of how such a report might look is shown in Table 3.3. Although not their initial intent, this approach could lend itself well to database architecture.

Potential Benefits to Pathology Departments

Autopsy reports are labor intensive. The time involved in collecting and organizing the necessary information, and then in dictation, transcription, and proofing, is considerable and costly. The potential for ease of data entry and time efficiency for

Table 3.3 Complete example of a modular autopsy report format with content

<table>
<tr><td>Module 1: Patient demographic information
Autopsy accession #:
AU18–0024
Name: Jane Q. Doe
Birthdate: 01/02/1934
Date/Time of Death:
07/30/2018/23:14
Place of Death: Thoracic ICU
Date/Time of Autopsy:
08/02/2018
Ordering Physician:
D. Doctor, MD
Autopsy Pathologist:
R. Virchow, MD</td><td>Module 2: Clinical cause of death determination and clinical history
1a. Acute pneumonia
b. Etc.
This 84-year-old woman was admitted from her care center with dyspnea and increasing oxygen demands. Sepsis protocol was initiated, but she became progressively unstable hemodynamically and died later that evening</td></tr>
<tr><td colspan="2">Module 3: Autopsy cause of death and sequence of events leading to death
1a. Pulmonary embolism
b. Hypercoagulable state
c. Pancreatic carcinoma
2. Hypertension
The cause of death in this case is pulmonary embolism from a deep venous clot in the left leg. The underlying cause of death was pancreatic carcinoma, which is often associated with a paraneoplastic hypercoagulable state (“Trousseau” phenomenon). No evidence of acute pneumonia was seen.</td></tr>
<tr><td colspan="2">Module 4: Final autopsy diagnoses
1. Acute pulmonary embolism:
(a) Multiple thromboemboli, distal artery branches, bilateral lungs
(b) Adherent nonocclusive thrombus in left femoral vein
2. Pancreatic adenocarcinoma, poorly differentiated:
(a) Spiculated 3.2 cm mass in the pancreatic head
(b) Multiple liver metastases, all lobes, 0.2–2.3 cm
(c) Multiple peripancreatic lymph nodes
3. Right ventricular enlargement (etc.)</td></tr>
<tr><td>Module 5: Tissue sections taken
Lungs – RUL, RML (triangular) (A1), LUL LLL (A2)
Heart – LV-I (A3), RV-L (A4), LAD (A5)
Esophagus and stomach – stock bottle (etc.)</td><td>Module 6: Ancillary test samples taken
Blood (R groin) – red top, filter spot, freezer
Urine (aspirated) – freezer (etc.)</td></tr>
<tr><td colspan="2">Module 7: Summary of microscopic findings
<table>
<tr><td>Block</td><td>Stains</td><td>Findings</td></tr>
<tr><td>A1–2. Lung</td><td>H&E, Gram</td><td>Thromboemboli, congestion, no inflammation</td></tr>
<tr><td>A3. Heart</td><td>H&E</td><td>Mild myocyte hypertrophy, no ischemic changes (etc.)</td></tr>
</table></td></tr>
</table>

Adapted from Wittekind et al. [15]

pathologists and autopsy staff in a future state of electronic autopsy reporting is great. Savings would also be realized by eliminating transcription costs and potentially integrating images into reports (rather than handling them separately).

Quality efforts could also be bolstered by the potential for standardization and uniformity in autopsy reporting across providers as well as across different case types. The error reduction that could result from this would also save downstream time and expense correcting reports and clearing up confusion. Peer review would also be easier to perform.

Potential Benefits to Hospitals, Providers, and Families

Error prevention (or at least reduction) has been mentioned as a benefit to pathology departments already, but this also translates to improved clarity in the communication of autopsy findings to clinicians. Of course, the foremost concern of most clinicians, turnaround time, could also be improved by more real-time electronic and synoptic autopsy reporting.

Data availability for quality efforts based on autopsy report parameters could also be of tremendous benefit to clinical programs and hospital quality teams. These could be diagnosis-specific or procedure-based (e.g., complication rates). As institutions make the move toward becoming high-reliability organizations, such data could become part of a templated autopsy report under quality assurance (diagnostic error classification, safety event classification) that may or may not be a chartable component of the report but could also be searchable. Another potential benefit to institutions would be to include the results of root cause analyses and interdepartmental presentations (e.g., morbidity and mortality conferences) in portions of an electronic autopsy report that may be searchable but not reportable.

Potential Benefits to Society

Autopsy reports, collectively, contain a wealth of information that could augment and dramatically improve public health statistics, disease trend tracking, and other measures in the interest of societal good. Most current data is based on death certificate reports only and therefore is deeply flawed due to the variability and inaccuracies inherent to those resources. Death certificate data are used, despite their flaws, because they are easily accessible through computer registries. If future autopsy reporting practices were more amenable to digital codification and registry construction, the quality of information available for public health analysis would be remarkable and have potential for remarkable societal good. Some specific examples are provided in the next section and summarized in Table 3.4.

Table 3.4 Potential benefits for stakeholders from synoptic/searchable autopsy data

Stakeholder	Expectations from autopsy data (select examples)	Potential benefits of synoptic/searchable reports
Next of kin	Identify COD	COD in separate field
	Understandable identification of disease important to NOK	Decrease autopsy TAT, highlight COD and NOK in understandable lay language
Clinicians	Identify COD in timely fashion	COD in separate field, decrease autopsy TAT
	Identify patient safety issues/sentinel events	Separate portion of report from EMR but searchable
	Highlight clinically unsuspected findings and clinical relevance	Clinically unsuspected findings in separate field and codified as to patient impact
Pathology residents/pathology departments	Education	Facilitates resident competency/milestone assessment
		May lead to increase in autopsy rate and increased educational opportunities for residents
		Ease of searching may promote clinical research projects by residents
		Increases resident exposure to informatics
	Quality	Ease of peer review
		Clinically unsuspected findings help identify cases for RCA/M and M
	Cost	Potential cost savings
Institutions/healthcare systems	Timely reports	Decrease TAT
	Identify sentinel events for interdisciplinary investigation	Separate portion of report from EMR but searchable
	Highlight clinically unsuspected findings as quality metric	Clinically unsuspected findings in separate field and codified as to patient impact, trends followed over time
	Identify trends in healthcare-associated infections	Easier to do with searchable fields
	Ensure accurate final diagnosis coding for billing purposes	Final diagnoses can be linked to ICD10 coding for billing purposes
Researchers/biobanks	Searchable diagnoses/demographics	Links to ICD10
	Searchable PMI/tissue storage	Separate fields for PMI/tissue storage easy to implement
Public health	National statistics for accurate COD (research funding)	Searchable COD statements make statistics in a national registry easier to create
	Patient safety (accurate identification of sentinel events and trends)	National database of sentinel events highlights trends and national measures to improve patient safety
	Quality care	Autopsy reporting can be linked to physician quality metrics

Templated Reporting and Cross-Institutional Research

Accurate and Up-to-Date Normal Organ Weight Data

The use of templated, high-quality autopsy data in a searchable format has many advantages for institutional as well as national health quality. Even something as apparently simple as normal organ weights in any given population at any given period of time may be difficult to define with certainty. Most autopsy reports cite references that are decades old and in need of updating [16, 17]. A national database of high-quality data would be invaluable for this as well as other vital quantitative measures.

Public Health/Patient Safety

Even more importantly, qualitative data such as cause of death and vital statistics are more easily validated using easily searchable data fields such as cause of death. Variable interpretation of narrative reports has been demonstrated as a cause for error in death certification. Clear and concise communication of cause of death is a vital component of any autopsy report. Similarly, disease burden statistics, which help guide national research funding, can be made more precise with searchable fields.

The autopsy plays a vital role in our national movement toward patient safety. Since the Institute of Medicine report in 1999 *To Err is Human* citing a potential 98,000 patient deaths per year related to safety errors, the emphasis on error reduction has become a major focus at all healthcare institutions, promoted by the Joint Commission [18]. The Joint Commission is focused on patient safety and making hospitals highly reliable organizations, as well as learning organizations in which individuals learn continuously, enhancing creativity and innovation. Five components of a learning institution include team learning, shared visions and goals, similar models of thought, systems thinking, and individual commitment to lifelong learning [19]. Highlighting patient safety events as opportunities for learning and process improvement is a vital part of healthcare institutions becoming learning institutions. Autopsy examination plays a vital role in the identification and classification of the most severe category of patient safety event, a sentinel event. Patient safety events are defined as an event, incident, or condition that could have resulted in or did result in harm to a patient. A sentinel event is a subcategory: a patient safety event (not primarily related to the natural course of the patient's illness or underlying condition) that reaches a patient and leads to death or permanent harm. By definition, autopsy plays a vital role in the identification of such events, and these events may only come to light following a complete autopsy. The autopsy report can assist in identifying sentinel events and should contain enough information to facilitate the multidisciplinary investigation that should follow such an event, and it should also promote institutional learning from the event. Formalized reporting that directs pathologists to think along the lines of patient safety events and to immediately recognize and report such events is vital to public health. If we do not

accurately codify such events and gather precise institutional and national statistics on them, it will be impossible to identify the effects of patient safety measures at institutional and national levels. This can only be done with uniform searchable reporting models.

Translational and Other Research

Translational research can be augmented with the use of well-annotated, searchable, de-identified autopsy reports linking to tissue resources. Collaboration for access to tissue resources for rare diseases will be easier. Use of de-identified but searchable high-quality autopsy data in support of tissue repositories will be an unprecedented resource for research.

The use of standardized autopsy data when evaluating clinical trials will augment the quality of the clinical trial data. A collective review of treatment-related mortality (serious adverse events) from Europe revealed clinical-pathologic discrepancy in 46% of autopsied cases. The autopsy rate was only 10% of treatment-related deaths, attributed in large part to the lack of requirement for autopsy following death of a patient in a clinical trial [20]. Renewed interest in obtaining autopsy on study patients, combined with well-performed, searchable autopsy-derived data, should increase the quality of clinical trial data.

When national organizations, institutions, and individuals see the benefit of high-quality, uniformly reported, and searchable autopsy data, there is hope for a new era of excitement for autopsy performance similar to that precipitated by the work of Morgagni in the 1700s.

Biorepository Partnering

Laboratories faced with logistic impediments to archiving autopsy materials (slides and blocks) beyond 10 years may consider partnering with local or regional tissue biorepositories. The potential value of these materials, including to family members with possible heritable diseases, extends well beyond the 10-year regulatory time frame for storage. While preservation of nucleic acid and proteins in autopsy tissue is a valid concern (addressed elsewhere in this text), most autopsy tissues are amenable to research assays. A highly annotated tissue source (tissue linked to comprehensive autopsy reports, especially with templating) would be an attractive resource to biorepositories.

Thoughts on Next-Generation Autopsy Reporting

Utilizing information technology to take autopsy practice and reporting to the next generation is vital to the preservation of autopsy practice in the modern healthcare system. Templates/synoptic reporting/EMR linking/searchability and database

sharing are all important means to this end. Templates that are well-vetted and uniformly utilized can help direct the focus of modern autopsy practice to include *patient safety/public health* (sentinel events, patient safety issues), *quality of care* (COD statements, codified clinically unsuspected findings, peer review of autopsy findings), *multimodal resident education* (system-based education/informatics education/scholarly activity, ease of competency assessment/milestone progression), and *research* (shared databases, tissue storage data).

The modern autopsy report needs to incorporate the rules of the R's to maintain its viability in the current healthcare system; it needs to be *rapid*, *reliable*, and *relevant*. Rapidity is imperative to maintain the relevance of the individual report and to maximize the usefulness of the results to institutional learning models. Reliability of reports is vital to maintain the status of autopsy results as the "gold standard." Autopsies performed superficially without an understanding of the wealth of vital information that can be shared with all stakeholders do not promote family, clinician, or institutional interest in autopsy performance. Autopsies need to be of relevance to all stakeholders. Modifying how cases are reported, with what language, and what vital data is included can be directed via nationally vetted and shared autopsy synoptic reports and databases. Considering autopsy in this fashion is also vital to maintaining its role in resident education. With so many demands on resident educational time, creatively using an autopsy service to give residents experience in informatics, system-based practice, quality assurance, and synoptic reporting is a way to increase the *relevance* of this practice to these younger practitioners, hopefully creating a group of forward-thinking practitioners who continue to take autopsy practice and reporting to the *next generation.*

As alluded to earlier, "modernizing" the autopsy report, particularly with an eye toward synoptic formatting and data extraction, represents a double-edged sword. Potential advantages are clear, but there is clearly also potential to dilute the value and utility of these reports in the practice of medicine.

Autopsy reports are inherently subjective. Standardization using templated or synoptic fields may help improve the completeness of reporting, but autopsy findings entered by pathologists are still subject to their own medical judgment. Given their length and complexity, autopsy reports are also inherently prone to errors (particularly typographic and clerical). Limiting input to a predetermined set of options has potential to improve the overall error rate. However, since there may still be a reliance on manual entry the possibility of miscoding or inadvertently selecting the wrong option also remains.

In terms of efficiency, opportunities should be sought to streamline the reporting process and eliminate barriers to its timely and accurate completion. As an example of this, the autopsy program at Seattle Children's Hospital has published their experiences using a "LEAN" approach. Not surprisingly, given the focus of this kind of analysis, they identified delays in transfers (getting tissue to histology lab, getting slides to pathologists, etc.) as well as document approvals (signing permissions or reports). Importantly they also addressed "finding time for the autopsy" by providing dedicated schedule time to pathologists and set milestone deadlines for completing provisional diagnoses, examining the brain, reviewing slides, and producing a

clinical-pathologic correlation [21]. Finding additional time may not be possible in every department, but through their approach they were able to eliminate extra steps, improve report timeliness, and enhance communication with clinical teams. "Next-generation" autopsy reporting will need to be streamlined and efficiency-focused. Finally, there is valid concern that in a synoptic format report, there is no opportunity to convey the "big picture" or overall message to the family and care team. This is particularly critical when the findings could affect the health of surviving relatives or possibly alter a practice or policy in the healthcare system. There are certainly other ways for this panoramic view to be communicated besides the autopsy report, but this implication is important to consider in the future of autopsy reporting.

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