Pathology Findings in Medical School Anatomy Cadavers

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Abstract

With more medical schools in the United States and abroad turning to virtual anatomy instead of gross dissection of actual cadavers, unexpected pathological findings may not be encountered as teaching opportunities. By using real cadavers the cause of death information provided might confirm pathology which is found in the course of routine anatomical dissection. Additional pathology not attributable to cause of death adds further to the experience of the cadaver dissection. Over the course of four academic years, human cadavers at New York Institute of Technology College of Osteopathic Medicine were sampled based on encountered gross pathological findings. Over the four years, there were 64 cadavers sampled randomly and forty two percent of the cadavers had findings related to cause of death. Sixty-six percent of the cadavers had findings which were not related to the cause of death. Thus, not only is pathology abundant in human anatomy cadavers and a source of important medical education but additional pathology outside of cause of death is an even greater source of teaching material. The benefits of human anatomy dissection are good medical educational sources with or without clinical information in the form of cause of death. Having limited clinical information may further enhance the educational value of anatomy dissection.

Keywords: Pathology; Cadavers; Anatomy; Dissection

Introduction

Human anatomical dissection was illegal in ancient Greece and in almost every society until the middle ages (Hayes 2009) although it was reported as early as 300 BC by both Herophilos of Alexandria (circa 335-280 BC) and Erasistratos (circa 304-245 BC) (Wood et al 2005). In 1240, Frederick II, emperor of the Holy Roman Empire allowed for the "sake of public health and training of better doctors" that at least one human body be dissected in his kingdom every five years (Hayes 2009). By the beginning of the 14th century, human dissections were conducted as
often as once a year at the best European universities (Hayes 2009). Dissection became the way to teach medical students around the time of Mondino dei Liucci of the University of Bologna who published his dissection manual, Anathomia, in 1316 which was used for 200 years. (Hayes 2009)

The medical student’s "first patient", the anatomy cadaver, offers opportunities for study of both normal and abnormal findings (Magrill et al 2008; Flynn et al 2010; Wood et al 2010; Zhang and Fenderson 2014; Gopalan et al 2015; Wood et al 2015). Cadaver dissection, used as a means to teach normal anatomy, can lead to unexpected findings in addition to findings which are consistent with the provided cause of death or history (Wood et al 2010; Wood et al 2015). This traditional rite of passage for medical students has been impacted by curricular changes such as reduction in didactic hours or discipline-based teaching, more emphasis on problem-based learning and computer based modalities, and the introduction of virtual pathology (Burton 2005; Chun et al 2010; Wood et al 2010; Wood et al, 2015). Some institutions, notably in the United Kingdom, do little or no cadaveric dissection (Geldenhuys 2016; Wood 2010). However, it has been shown that the pathology which students come across during cadaveric dissection promotes "integrated learning and critical thinking" (Zhang and Fenderson 2014). Cadaveric dissection enhances the integration of anatomy, pathology, and clinical medicine early in the training of the medical student (Wood et al 2010). It can help introduce pathology and be a source of histopathology (Magrill et al, 2008; Gopalan 2015; Wood et al 2015). Team-working skills, observational abilities, self-directed learning, and the concept of comorbidities are also important by-products of cadaveric dissection (Wood et al 2010). The cadaver is also a valuable tool in presenting the topic of death to the medical student and can aid in related topics such as coping mechanisms (Wood et al 2010).

Being able to quantify the amount of pathology helps to confirm the value in medical education and further supports the benefits of anatomy cadaver dissection as an additional medical education tool in teaching both gross and histopathology. Some medical schools incorporate an "autopsy report" as part of the anatomy dissection so that students compare their findings to given clinical history or cause of death, further reinforcing the role of a cadaver as a patient (Geldenhuys 2016). Cause of death pathology findings provide an opportunity to enhance the dissection experience as they are direct clinical correlations (Linsenmeyer et al 2017).

The aim of this study is to show the prevalence of the number of findings both specific and not specific to the cause of death information and the prevalence of cadavers with these respective findings. While pathology has been shown to be present in human anatomy cadavers (Magrill et al 2008; Wood et al 2010; Zhang and Fenderson 2014 Gopalan et al 2015; Wood et al 2015), this study compares the chance findings by medical students of pathology related to cause of death versus not related to cause of death. This study hopes to further establish the importance of human cadaver dissection in the anatomy laboratory as a rich source for pathology and medical education. By using anatomy cadaver dissection to discover abnormal findings, active learning is incorporated in medical education to teach pathology. Rather than describing and reading about gross and microscopic findings in books or electronic resources, the students discover findings themselves or under the guidance of professional anatomists and pathologists to solidify the knowledge. This allows introduction of human disease as a real experience before students are ready to encounter live patients.

Anatomy is part of the first year curriculum at NYITCOM in the first course of the first term known as Foundations of Osteopathic Medicine. In this course, concepts in biochemistry, physiology, microbiology are taught in lecture. Anatomy lectures are also given and anatomy labs are conducted in parallel with the lectures. In addition there are osteopathic manipulative medicine lectures and labs and physical diagnosis lectures and labs. Later in the term, pharmacology and pathology are introduced. The course, including all of the anatomy, runs nineteen weeks. Pathology itself is then integrated in a Systems approach over the first two years in Neuroanatomy, Musculoskeletal system, Hematology/Immune system and Dermatology, Cardiopulmonary and Renal, Endocrine and Reproductive.
The anatomy laboratory for the medical school generally consists of approximately forty cadavers per year with about eight students per table (there are approximately 300 students in each class). Most years, the back is dissected first, followed by thorax, then abdomen, then pelvis, limbs, head and neck, and finally brain. The cadavers tend to be an older age group (greater than 50 years), mostly white, and mostly well preserved. All cadavers are obtained in the state of New York. A few come locally (Long Island) from a funeral home that embalms the cadavers. These are received through a body donation program. The large majority come from other medical schools in the state which are members of the Association of Medical Schools of New York. Anatomy faculty are present at dissection as well as upperclassman "Academic medical scholars" who also act as mentors for the students.

At the New York Institute of Technology College of Osteopathic Medicine the cause of death information is provided to the medical students after dissection is completed. When bodies are donated for anatomical study at the medical school, information taken from the death certificate, age, and sex are provided. There is no additional history. If there are pathological findings which are consistent with the cause of death, this serves as a strong clinical pathological correlation. When cause of death is the only information known this correlation helps enhance the dissection experience not just by finding pathology but by finding relevant pathology in the form of a "mini-autopsy". Other unexpected findings would be additional pathology material for education. Cause of death findings may not be discovered in all cadavers because of limitations of dissection. For example, if myocardial infarction is listed as the cause of death, the medical students do not routinely see gross changes consistent with this and would not sample it. Also, coronary arteries are not routinely sampled. Therefore without knowing this information beforehand, this cause of death may not be confirmed in the cadaver.

Materials and Methods

Over the course of four years human anatomy cadavers at the New York Institute of Technology College of Osteopathic Medicine were randomly sampled for interesting gross findings noted during dissection. Incidental abnormal or unusual findings were brought to the attention of the pathologist or the anatomist by the student or discovered by the anatomist. Some of the students did have guidance. All were initially gross findings. By this method, not all pathology was identified and not all cadavers were sampled. Therefore, the students found pathology both through self-direction and also through some guidance. Teaching faculty did not review each dissection to ensure that as many pathologies as possible were noted because the aim was to see what could be found without active searching, that is, the minimal yield of pathology when not actively seeking pathology. All of the samples were recognized grossly and there was no random sampling of normal tissue. Devices such as stents or artificial valves were not considered in this study.

If, for example, a nodule was identified in the liver it would be brought to the attention of the anatomist or pathologist and when possible, depending on the pathologist’s availability (there are only two pathologists available at this institution) a discussion on possible differential diagnosis would take place. Without given history or cause of death information this would be quite a large differential but if, for example, the thorax had already been identified and a lung mass was revealed, a metastatic lung lesion would be highly considered. Confirmation would be made by microscopy.

The end result was various grossly abnormal sampled tissues from 64 cadavers, 24 male and 40 female, ranging in age from 50 to 105 years. The tissue was placed in formalin and then processed and embedded in paraffin wax. Standard 6 um thick sections were cut and stained with Hematoxylin and Eosin (H and E). Two board certified pathologists reviewed each of the slides for diagnosis. At the time of examination, the cause of death information was not known by the pathologists. At the end of the term, the cause of death (obtained from the death certificate)
was revealed and no additional medical information was provided.

The histology varied from good to poor depending on the preservation of the cadavers but overall architecture was recognizable. No grading of carcinomas could be made but general diagnoses such as adenocarcinoma, small cell carcinoma, acute inflammation, abscess, etc. were feasible given the material.

Findings were tabulated by year and then totaled. All individual findings by organs were recorded and an Excel spread sheet was created listing each cadaver, the organs sampled, and the findings in each organ. Because of the great number of results, a partial sample is shown in table 1. Organs sampled per each cadaver ranged from 1 to 5. The number of total findings was the number of total organs sampled and each diagnosis associated with it. However, within one cadaver, several organs could have the same finding (e.g., metastatic carcinoma – liver, lung, etc.), therefore, a separate category for "distinct" findings was created to represent the true number of findings related to separate diagnoses.

The number of cadavers which did reveal findings consistent with what was provided as cause of death was counted and the number of cadavers with other additional findings was also counted. These were not additive since cadavers with findings related to the cause of death might or might not have additional pathology. Since the cause of death was not known until after dissection, finding the cause of death pathology was not a given.

This project was exempt from the Institutional Review Board because it complied with the category of "research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects."

Results

The results were separated by year and totaled (Tables 2 and 3). There were a total of 64 cadavers over four years. There were a total of 88 distinct organ findings. For example, a finding of metastatic carcinoma in one cadaver that involved the liver and lung would be considered one distinct finding, i.e. metastatic cancer. The histopathological findings included various types of carcinomas, benign cysts, reactive lymphoid hyperplasia, benign tumors, atherosclerosis/arteriosclerosis, emphysema, pneumonia, chronic renal injury, steatosis, skin lesions, accessory spleen, and silicon reaction to breast implant rupture. There were a total of 27 cadavers out of 64 (42%) in which there were found pathology findings consistent with cause of death and 42 out of 64 which showed other findings (66%) (Table 2). Note that some cadavers could show both but this was not tallied. Of the total of 88 distinct organ findings, 40 showed cause of death findings (45%) and 62 did not show cause of death findings (70%) but rather other pathological findings (Table 3).

In a population of randomly sampled autopsy cadavers without knowledge of cause of death before hand, 42 percent had pathology consistent with cause of death when dissected for anatomy. Even more (66%) had other pathological findings. These results were obtained without prospective knowledge of any pathology and simply because of use of anatomy cadavers for dissection.

Although the total percentage of cadavers with cause of death findings (42%) was less than those with other findings (66%), this did not happen for each year. In fact in one academic year, 2015-2016 the percentages were equal at 54% (Table 2). In addition, though the total percentage of distinct findings which were related to cause of death was less than those that were not (45% vs. 70%, Table 3), this was also not consistent between the years. In 2013-2014,
94% of the distinct findings were not related to cause of death and only 14% of the distinct findings were related to cause of death. Therefore, no distinct trends or statistical significance was seen between years.

For each academic year the percentage of cadavers in which cause of death findings were seen ranged from 22% to 69% and of all the distinct findings in each year 50% to 94% were additional to cause of death.

Discussion

Human anatomy cadaver dissection offers medical educational opportunities for pathology. When the cause of death is known, either before or after dissection, findings can be compared to what are expected. Cadavers which show pathological findings related to cause of death may further add to the clinical dimension of the experience.

Some studies, mainly from outside the United States, have reported the prevalence of pathology in cadavers in medical school (Wood et al 2010; Zhang and Fenderson 2014; Wood et al 2015; Geldenhuys 2016). Wood looked at the prevalence of pathology in 12 donor cadavers at the Medical School of St. Andrew’s University in Scotland (Wood et al 2010). Several years later his team looked at the histopathology of 17 cadavers from the same medical school (Wood et al 2015). In both cases brief clinical histories were obtained by consulting with their primary physicians, referring to hospital notes and death certificates prior to dissection. In both studies findings were tabulated and a considerable amount of pathology was discovered. (Wood et al 2010; Wood et al 2015). Our study looked at cause of death information after dissection so there was no bias to sample any particular organ and organs were randomly sampled.

An American study in 2008 looked at intra-abdominal pathology on 36 cadavers and found a total of 70 different pathologies (Magrill 2008). One of the most recent studies from South Africa in 2016 was one of the largest, examining 127 cadavers to gauge whether sufficient pathology lesions representative of all organ systems were present to justify using cadavers as an additional pathology learning tool (Geldenhuys 2016 ). They found that the most common organ system was the respiratory system with 76% of cadavers showing pulmonary tuberculosis lesions (Geldenhuys, 2016 ).

Geldenhuys (2016) showed many pathology lesions in different organ systems. This is not only important in integration of pathology in the anatomy curriculum, but also optimizes the use of cadavers (Geldenhuys 2016 ). Our study confirmed this with 88 distinct findings out of 64 cadavers. These findings included cause of death findings and other unexpected pathological findings not related to cause of death. Forty-two percent of the cadavers had cause of death findings while sixty-six percent had other findings which were unrelated to the cause of death.

It is interesting to note that 70% of our distinct organ results showed findings not related to what was stated as the cause of death which is a significant amount of extra pathological material above and beyond what might be expected if only cause of death is taken into consideration. When the human anatomy cadaver is used for dissection it not only provides opportunities for learning various pathologies but it also can be used as a way to clinically correlate with what is noted as cause of death if the cause of death is well delineated. In cases where more than the cause of death is known, i.e. clinical history, the anatomy cadaver would become an even more important source of clinically relevant material and quantifying that experience might be helpful.

We found that without knowing any history or cause of death information of cadavers prior to anatomy, dissection still yielded a good percentage of findings consistent with cause of death and additional pathological findings in a random sampling of cadavers and their organs. Though there was no particular trend or pattern, it appears that the
anatomy cadaver is a rich source of pathology medical education with or without clinical correlation. With clinical correlation, this would add more relevance to the experience but there is still ample opportunity to gain pathology knowledge.

Since there is no separate Pathology course at this institution, it is difficult to say whether students who participate more actively perform better, but anecdotally, those who show interest do tend to gravitate toward Pathology. This has not been measured statistically and would be an interesting trend to follow. This is a large medical school class and only a handful eventually enter Pathology but even an increase of one or two students a year would have an impact.

As discussed in the introduction, reading about pathologic findings in books or electronic resources is a different experience than encountering them in a cadaver in the same way as taking care of a patient with a disease is different than reading about one in a book. This study is limited in that there is no outcome measure of how medical students feel they benefit from dissection of pathology in anatomy versus reading pathology text and this would be the subject of another study.

Additionally, there is no mechanism in place to allow for family to be notified of other findings. If the finding is a benign lipoma, the significance may not be important. However, family members may want to be aware, for example, of a carcinoma that was not diagnosed prior to death. In the extremely rare case of a death missed by the coroner this may also be an issue. In the case of cadavers obtained from other institutions, the institution would have to be contacted first. But a formal procedure may need to be put in place for follow-up to inform next of kin. This may occur at some institutions already but is not currently practiced at this medical school.

**Conclusion**

The human anatomy cadaver has been with medicine for many centuries and though attempts to replace it with virtual dissection and other methods are on the rise, it would seem that given the great amount of pathology that can be learned we might be throwing out the baby with the bath water. The best words of advice come from the first edition of Gray's Anatomy in which the editors issued a warning: "No book, however ably written and accurately illustrated, can ever enable the student to dispense with the necessity of the actual dissection of the human body, and the study of disease at the bedside… The student who trusts solely to books, however excellent they may be, will find himself, in the hour of trial theoretically learned but practically inefficient" (Hayes, 2009). And, of course, since books are being replaced by virtual media, it stands to reason the same holds true for the latter.

**Take Home Messages**

1. Traditional anatomical dissection in medical school may be replaced in time by virtual methods.
2. Real cadavers offer the opportunity to discover human pathology in situ.
3. Clinical information, such as cause of death, can enhance the pathology findings but is not required to discover important findings.
Notes On Contributors

Plummer, Maria M. M.D., is an associate professor in the Department of Clinical Specialties, Division of pathology at the New York Institute of Technology College of Osteopathic Medicine. She is involved heavily in teaching pathology and is interested in using cadavers in research.

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### Appendices

#### TABLE 1 – ORGAN FINDINGS AND CAUSE OF DEATH IN ANATOMY CADAVERS - SAMPLES

| YEAR    | Cadaver | ORGAN       | FINDINGS                                      | AGE/ SEX | COD                                      |
|---------|---------|-------------|----------------------------------------------|----------|------------------------------------------|
| 2012-2013   | 1       | Lung        | Non-small cell carcinoma (large, pleomorphic) | 76 yrsF  | cardiopulmonary failure/non-small cell lung ca (tobacco use) |
| 2012-2013   | 2       | Thoracic duct | Benign Cyst ?S/P chest surgery iatrogenic v. congenital | 73 yrsM  | Metastatic lung adenocarcinoma of lung (brain, bone, soft tissue) |
| 2012-2013   | 3       | Pancreas    | Poorly differentiated adenocarcinoma (primary) | 84 yrsF  | Acute MI, Coronary artery disease        |


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TABLE 2 – PERCENTAGE OF CADAVERS WITH CAUSE OF DEATH FINDINGS V. OTHER FINDINGS

|        | Total Cadavers | Cadavers with Cause of death findings | Percentage of cadavers with Cause of death findings | Cadavers with additional findings | Percentage of cadavers with additional findings |
|--------|----------------|---------------------------------------|----------------------------------------------------|----------------------------------|-----------------------------------------------|
| 2012-2013 | 13             | 9                                     | 69%                                               | 8                               | 62%                                           |
| 2013-2014 | 23             | 5                                     | 22%                                               | 18                              | 78%                                           |
| 2014-2015 | 15             | 6                                     | 40%                                               | 9                               | 60%                                           |
| 2015-2016 | 13             | 7                                     | 54%                                               | 7                               | 54%                                           |
| Total    | 64             | 27                                    | **42%**                                           | 42                              | **66%**                                       |

TABLE 3 – PERCENTAGE OF CAUSE OF DEATH FINDINGS VERSUS ADDITIONAL FINDINGS

|        | Total findings | Total Distinct Organ findings | Cause of death findings | Percentage of distinct findings which were Cause of death | Additional findings | Percentage of distinct findings which were not Cause of death (additional findings) |
|--------|----------------|------------------------------|-------------------------|----------------------------------------------------------|--------------------|-----------------------------------------------------------------------------------|
| 2012-2013 | 23             | 18                           | 14                      | 78%                                                       | 9                  | 50%                                                                               |
| 2013-2014 | 38             | 35                           | 5                       | 14%                                                       | 33                 | 94%                                                                               |
|       | 2014-2015 | 2015-2016 | Total |
|-------|-----------|-----------|-------|
| Count | 22        | 19        | 102   |
| Hits  | 19        | 16        | 88    |
| Misses| 10        | 11        | 40    |
| Hit % | 53%       | 69%       | 45%   |
| Miss %| 47%       | 31%       | 55%   |
| Total | 12        | 8         | 62    |
| Miss %| 63%       | 50%       | 70%   |

Declarations

The author has declared that there are no conflicts of interest.

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