Handbook of Autopsy Practice
I dedicate this book to Nicholas J. Hardin, teacher, mentor, colleague, and friend, who instilled in me and many others, an unwavering quest for excellence in autopsy pathology.
Preface

In the twenty-five years of my practice I have seen significant changes, many of which testify to the continued evolution of autopsy pathology. Technologic advancements such as computerized lab information systems, molecular diagnostics, immunohistochemical methods, digital imaging and the Internet have had important applications to autopsy pathology. A less welcomed change is the decline in the autopsy rate in teaching hospitals – a decline that threatens to continue. One reason for this may be the more sophisticated imaging techniques which some believe supplant the need for postmortem exam. Another may be the discomfort that house staff and attendings still experience when asking for permission. Nevertheless, the autopsy remains the diagnostic gold standard. Recent medical literature is rich with articles extolling the diagnostic power of the postmortem exam. Beyond the autopsy’s critical role in transmitting information to clinicians, the postmortem examination procedure provides unrivaled opportunities for pathology residents to hone the essential skills of their trade. These skills include efficient and safe dissection techniques, appropriate handling of unexpected findings, meticulous written and photographic documentation, accurate interpretation of findings, and finally, timely, compassionate, and professional communication with families, physicians and legal counsel. This writer’s view is that the future of autopsy pathology is founded on the perpetuation of these skills. It is with this vision in mind that the 4th edition of the Handbook is offered.

Part I of the 4th edition has six completely new chapters in which the reader will find an assortment of tools that will increase the value of the autopsy. There is a sample next-of-kin letter which is sent to the family member who authorized the autopsy, following distribution of the final report. This letter notifies the person that the report is complete and invites him/her to discuss the autopsy findings with the involved physician. The reader will find a quality assurance worksheet that can be used to check for omissions, discrepancies or insufficiently supported conclusions in the final report. A new discourse on the dissection procedure is accompanied by a worksheet and template for the gross description. There is also a new, detailed discussion of the safe handling of sharps, complete with photographs. The same superb photographs, characteristic of William Edwards, highlight the chapter devoted to the cardiovascular system. The reader will find the updated requirements of the Eye Bank of America and the U.S. Food and Drug Administration for ocular tissue transplantation. Significant advancements in cytogenetic techniques have occurred since the 3rd edition, especially with respect to the application of molecular methods using fluorescent labeled DNA probes. The updated cytogenetics chapter will help autopsy pathologists to decipher when conventional chromosome studies are useful and when molecular cytogenetic methods are more applicable.

Added to the discussion of legal aspects of autopsy practice is material on common law and statute law pertaining to dead bodies and autopsies in general. Many questions that often arise, such as who can view an autopsy, who can receive the autopsy report and how organs or tissues are donated for transplantation, are addressed.

Although a virtual gross specimen museum can be created using digital images, teaching with actual pathologic specimens may still have a role in educating medical students and in inspiring elementary and secondary school students. Therefore, the applied science of long-term organ preservation is discussed with many of the venerable fixatives from the previous editions retained. New items are a step-by-step procedure for paraffin-embedding hearts (courtesy of the Cardiac Registry at Boston Children’s Hospital) and a concise description of the fascinating technique of plastination.

Part II has been updated with new diseases and recent references added. Practicing autopsy pathologists, residents and students are invited to review this alphabetical listing of disorders before each autopsy in order to re-acquaint themselves with what they might encounter.

Part III concludes the book with a series of tables providing organ weights and body measurements for fetuses, children and adults. Many of these are more recent than those of the 3rd edition. The growth charts for children are presented in a larger format to facilitate their use.
I wish to thank all the contributors to this book, past and present, who helped to maintain autopsy pathology as an important and evolving field. I am indebted to Candace LaFreniere for her secretarial help and to Raj Chawla for his expert photographic skills. I wish also to thank my longtime colleague, fellow autopsy pathologist and friend, Dr. Nicholas J. Hardin, who reviewed many of the new chapters and offered much helpful advice. His editorial skills are exceeded only by his skills as a pathologist. His thorough investigative approach to every postmortem exam thankfully rubbed off on me. To him, I dedicate this book.

Brenda L. Waters, MD
## Contents

Preface .............................................................................................................................................................................. vii  
Contributors ........................................................................................................................................................................ xi  

**PART I  AUTOPSY TECHNIQUES AND PROCEDURES** ......................................................................................................................... 1  

1 Ensuring Quality in the Hospital Autopsy .................................................................................................................. 3  
   *Brenda L. Waters*  

2 Principles of Dissection .................................................................................................................................................. 11  
   *Brenda L. Waters*  

3 Cardiovascular System ................................................................................................................................................. 27  
   *William D. Edwards and Dylan V. Miller*  

4 Nervous System ............................................................................................................................................................... 51  
   *Caterina Giannini and Haruo Okazaki*  

5 Eye and Adnexa ............................................................................................................................................................... 69  
   *R. Jean Campbell and Cheryl R. Hann*  

6 Autopsy Laboratory ......................................................................................................................................................... 77  
   *Brenda L. Waters*  

7 Autopsy Microbiology ..................................................................................................................................................... 85  
   *Brenda L. Waters*  

8 Autopsy Chemistry ......................................................................................................................................................... 89  
   *Vernard I. Adams*  

9 Chromosome Analysis of Autopsy Tissue ..................................................................................................................... 93  
   *Gordon W. Dewald*  

10 Postmortem Imaging Techniques .................................................................................................................................. 99  
   *Jurgen Ludwig*  

11 Autopsies of Bodies Containing Radioactive Materials ................................................................................................. 105  
   *Kelly L. Classic*
12 The Hospital Autopsy Report, Death Certification

Brenda L. Waters

13 Medicolegal Autopsy and Postmortem Toxicology

Vernard I. Adams

14 Legal Aspects of Autopsy Practice

Vernard I. Adams

15 Fixation and Transport of Autopsy Material

Brenda L. Waters

16 Museum Techniques

Brenda L. Waters

PART II ALPHABETIC LISTING OF DISEASES AND CONDITIONS

Jurgen Ludwig with Vernard I. Adams (Medicolegal Cases and Toxicologic Disorders)
William D. Edwards (Cardiovascular Disorders)
Caterina Giannini (Neuropathologic Disorders)
Brenda L. Waters (Pediatric and Infectious Disorders)

PART III NORMAL WEIGHTS AND MEASUREMENTS

Hagen Blaszyk, William D. Edwards, Jurgen Ludwig, and Brenda L. Waters

Index
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Ensuring Quality in the Hospital Autopsy

BRENDA L. WATERS

Despite an unceasing stream of publications extolling the value of postmortem examination (1–12), the hospital autopsy rate continues to decline. Estimates, published in the 1990s, of the overall autopsy rate in the United States are as low as 5%, with the rate in academic institutions estimated at 11% (13,14). Several factors contribute to this. One is the notion that the autopsy will not reveal information above and beyond that gained from current sophisticated imaging studies. Another is the clinicians’ concern about resultant litigation. A more fundamental reason, however, is the lack of vigor on the part of the clinician to seek permission from the family (15). The physician attending the death may be too quickly distracted by other competing concerns and responsibilities, or more likely, (s)he is unfamiliar with the family of the deceased. This latter situation is frequent in teaching hospitals, where a house officer with no prior contact with the patient attends the death and feels uncomfortable in requesting permission for autopsy. These obstacles notwithstanding, it this author’s opinion that any academic teaching hospital must make a genuine and persistent effort to achieve a hospital autopsy rate of at least 25%.

PATHOLOGIST’S ROLE IN PROMOTING THE AUTOPSY

Although the chairs of clinical departments must be motivated to help with this goal, autopsy personnel can take a number of steps to encourage hospital autopsy permissions. These steps involve effective and timely communication with the clinician.

Before commencing the evisceration, the prosector should call the clinical resident and/or the attending to discuss the patient’s history. When the prosector is relatively inexperienced, it is preferable to have the pathology attending contact the clinical attending. Either way, this conversation allows the clinician to express any specific questions (s)he may hope to have answered by the autopsy, as well as simply to describe the events that led to the patient’s death. When the initial dissection is completed, the clinicians again should be called and informed of the gross pathological findings. During that conversation, the prosector should invite the clinicians to the morgue to view the findings themselves. The examination of the organs soon after the patient’s death offers a significant learning experience for clinical attendings, as well as house staff and medical students. Any digital photographs of significant abnormalities should be emailed to the clinicians within the same day of the postmortem examination. Generally, the timely receipt of these photographs is much appreciated, because the clinicians will be quickly distracted by their responsibilities to their living patients. Photographs of the gross findings are very effective teaching tools, especially in morbidity and mortality and other clinical conferences. In fact, gross photographs are probably most effective, since both autolysis and the clinicians’ relative inexperience with histology lessen the value of microscopical images. Further discussion on photography may be found at the end of this chapter.

Most hospital autopsy services generate a preliminary report. This report of the major gross findings, preferably organized pathogenetically, should be distributed within 24 hours of the initial prosection. Residents should be inculcated in the importance of sending copies of this and the final report to the patient’s referring physician(s) including those from outside hospitals. Lastly, a short turn-around time between initial dissection and distribution of the final autopsy report will also be much appreciated by clinicians. Many clinicians consider autopsy reports received after one month to be useless and irrelevant, as they have already had their conference with the family. Further discussion of the hospital autopsy report may be found in Chapter 12.

These efforts toward timely communication, eagerness to demonstrate the pathologic findings to the clinicians, provision of gross photographs, and prompt distribution of the final report will help treating physicians understand the value of the service and make them more receptive to seeking autopsy permissions in the future (15).

The permission form for autopsy should be as brief as possible, so that the family can understand it, but be as inclusive as possible to allow the pathologist to gain maximum yield from the procedure. A sample permission form is found as Fig. 1-1. It is the nearest relative who must sign the permission form. Most states have statutes that list the next of kin in descending order of priority. Generally, that list is spouse, reciprocal beneficiary, an adult child, either parent, an adult sibling, a grandparent, the individual possessing a durable power of attorney, the guardian.

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I (Print Full Name) ____ hereby grant permission for a complete postmortem examination, including the removal and retention or use for diagnostic, scientific, educational, or therapeutic purposes of such organs, tissues and parts as the physicians in attendance at (Name of Institution) ____ may deem desirable, on the remains of (Print Full Name of Deceased) _____.

This authority is granted subject to the following restrictions (if none, write “none”): __________________________________________________________________________________________

The following special examinations are requested: __________________________________________________________________________________________

I am the nearest relative of the deceased and entitled by law to control the disposition of the remains.

Signature: __________ Date & Time: __________ Relationship: __________

Mailing Address: __________________________________________________________________________________________

Telephone Number: __________________________________________________________________________________________

Permission obtained by: (Print Full Name): __________ Title: __________

Second witness (required if telephone permission): (Print Full Name): __________ Title: __________ Signature: __________ Date & Time: __________

Fig. 1-1. Proposed text for an Autopsy Permission Form.

of the decedent, or any other individual authorized or under obligation to dispose of the body. The reader is advised to consult local and/or state statutes. In most institutions, obtaining permission over the telephone requires a witness.

Restrictions on the autopsy as set by the next-of-kin may range from “none” to one or several needle biopsies. If there is any uncertainty as to the wishes of the next-of-kin with regard to restrictions, further discussion with the family or the physician who personally obtained the permission must occur, so as to clarify the family's intent. If any doubt remains, the most restricted interpretation of the permission must be followed.

We find that it is advantageous to notify the next-of-kin by mail when the autopsy report is completed and sent to the appropriate physicians. In that letter, sympathy for the loss of the family member is expressed as well as statements made regarding the value of the autopsy to the advancement of medical knowledge. Equally important, the letter invites the family member to discuss the findings with the clinician. An example of such a letter is included as Fig. 1-2. It is advisable not to send the letter to the next-of-kin immediately after distribution of the report, but rather one to two weeks later. This will allow sufficient time for the clinician to receive and review the report. Situations will arise in which the family of the deceased person wishes to discuss the pathologic findings with the pathologist. This certainly should not be discouraged, but courtesy and collegiality compel the pathologist to notify the clinician that such a meeting has been requested. This will minimize animosity and may even help the pathologist in interacting with the family. Further discussion on meeting with the next-of-kin may be found at the end of this chapter.

IN CASES WITH THERAPEUTIC COMPLICATIONS When an autopsy is to be performed on a patient who has possibly died as a result of a medical or operative complication, communication with the clinician is even more important. Given the potential medicolegal implications, the pathology attending must discuss the case with the physician and should invite her (him) to be present during the procedure. Adequate photography is essential in these cases, and the resulting images will then be available for later reexamination and possible presentation in morbidity and mortality conferences. If the complication is of a hemorrhagic nature, photographs should be taken prior to evacuation of the blood, so as to document the extent of the hemorrhage. When a site of bleeding is found, this site must also be adequately photographed. Abnormalities encountered during the prosection should be documented with great attention to accuracy and detail. An excellent array of photographs will promote and enhance such accuracy. Therapeutic complications may be dramatically demonstrated at autopsy, and all personnel must maintain a calm and objective demeanor throughout the prosection, whether clinicians are present or not. Although clinicians may wish to help with the dissection, they should be tactfully dissuaded whenever the pathologist is concerned that tissue relationships may be altered before full understanding of the process is achieved. On the other hand, having a surgeon present during prosection of a complex operative site can be of great help.

When the final report is nearly completed, it is absolutely essential that the clinical attending be invited to review the report before its signing and distribution. This extra step will rectify any differences of opinion that exist between the clinician and
CHAPTER 1 / ENSURING QUALITY IN THE HOSPITAL AUTOPSY

Dear (Next-of-Kin) 

Let me extend my sympathy to you and your family over the death of your (Relationship to deceased) 

The report of findings of the postmortem examination has been completed and will be forwarded to _____, the attending physician, and _____, the referring physician.

We invite you to discuss the report with these physicians. If you wish, you can obtain a copy of the report by contacting Medical Records at ______ (Institution conducting the autopsy).

Knowledge gained from such examinations helps in our efforts to treat other patients with similar problems, and may prolong a life or, someday, lead to a cure or prevention of disease. Your contribution to these efforts is deeply appreciated.

Very Sincerely,

Fig. 1-2. Letter sent to the next-of-kin (i.e., the person who signed the Autopsy Permission Form) on completion and distribution of the Autopsy Report.

pathologist. Not infrequently, these disparities of opinion indicate incomplete understanding of the nature of the complication, either by the clinician or the pathologist or both. With continued dialogue, fuller comprehension of the event is attained. Moreover, it is important for members of the family of the deceased to be spared, if possible, any differences in opinion as to what happened to their family member. To perceive contention between doctors as to the nature of their loved one’s death will seriously impede the family’s grieving process, as well as increase their motivation to seek litigation. Finally, when the clinician is given the opportunity to review the report before it is issued, (s)he will be left with the distinct conclusion that the pathologist is not an adversary, but rather a valued resource.

THE VALUE OF AUTOPSY CONFERENCES The postmortem examination involves, by its nature, dissection and description of a large number of organs and tissues. It is a lengthy procedure, taking up to six hours and is often performed under a time constraint, since funeral home and family may be waiting for the body and a death certificate. Frequently, ancillary activities, such as photography and blood or tissue procurement for chemistry, serologic tests, or culture, are indicated. During these activities, the pathologist may be interrupted by pages, consultations with clinicians, or questions posed by other autopsy personnel. It is not inconceivable then, in this milieu of activities, certain anatomic findings may be overlooked or misinterpreted. This possibility is compounded by the copious amount of blood that one encounters during the dissection. For this reason, review of the major organs during a gross conference is important to any autopsy practice, especially if pathologists-in-training are involved. In our institution, we retain the lungs, heart, urinary system, neck block, esophagus, stomach, proximal duodenum with the extrahepatic biliary tree, the internal genitalia, and rectum for review at Gross Conference. For the liver, spleen, and the rest of the bowel, only representative portions are retained. Following at least a day’s worth of fixation in formalin, the organs are washed and presented at Gross Conference.

In this setting, the prosector and attending on the case, along with other attendings and residents on the autopsy service, review the organs, discuss the findings, and not infrequently, notice lesions that were missed or misinterpreted on the day of prosection. This process has several beneficial outcomes. Residents on the service see the gross pathology of all cases that come through the service and thereby hone their observation skills. Moreover, they are able to see how fixation affects the appearance of different abnormalities, such as acute myocardial infarction, acute bronchopneumonia, and early cirrhosis. The conference provides a forum where any differences of opinion regarding interpretation of the gross findings can be addressed and discussed, to the illumination of all. These interactions cannot help but to increase the value of the final autopsy report.

It is also helpful to conduct a weekly Microscopic Conference, during which selected slides from the previous week’s cases are reviewed. This meeting offers a chance to teach the residents and to discuss differences of opinion regarding interpretation of pathologic findings, with the goal of achieving consistency of diagnoses among pathologists. This type of conference is frequently found in surgical pathology services.
INTRADEPARTMENTAL REVIEW OF REPORTS Unlike the surgical pathology report, the autopsy report involves literally hundreds of datapoints. These datapoints include organ weights, descriptions, and measurements; descriptions and measurements of lesions; histological descriptions; and, finally, dozens of interpretations. Therefore, it is not unusual for even the most diligent attending pathologist to overlook small-to-significant inaccuracies in a multipage report, despite several reviews. These inaccuracies can be typographical or grammatical errors, inadequate documentation of abnormalities, omission of diagnoses, or forming conclusions that are inadequately supported by the pathologic findings. In academic institutions, where residents are the authors of much of the report, inaccuracies may be numerous. Residents are prone to make conclusions that are not adequately supported by the pathologic material to which clinicians, in certain situations, may take umbrage. Such statements must be removed from the report. To catch "errors" such as these, our institution has found it very helpful to have another autopsy pathologist review each final report before signing. With fresh eyes, this pathologist is likely to identify the errors and can bring them to the attention of the original pathologist. In our institution, this step has significantly reduced inaccuracies in the final autopsy report.

Some autopsy pathologists may find it helpful to use a quality assurance worksheet to review the autopsy reports prior to signing. Such a worksheet may be found as Appendix I-I. This worksheet was patterned after the CAP Checklist for Autopsy Pathology (16). Note that questions 8 and 9 on this form generate data that will be useful for quality assurance programs in other departments, such as surgery, medicine, and radiology.

PHOTOGRAPHY

A well-composed photograph of an autopsy specimen conveys significant and clear information to experienced clinicians and medical students alike. Digital photographs have an advantage in that they can be disseminated to clinicians within hours of the autopsy and can be readily stored and, later, incorporated into presentations for teaching. Although photographs of fresh specimens are ideal, very good images of fixed specimens are equally informative. Either way, excellent photographs that are shared with clinicians in a timely manner will further convince the clinicians of the value of their autopsy service. It is, therefore, imperative that every photograph intended for review at clinical conferences be of the highest technical quality. The sole intent of the photograph is to convey pathologic information. With a good photograph, the viewer's eye will not be distracted by puddles of blood or body fluids in the background, lack of focus, a soiled label, or an unclear presentation of the pathologic process. A good photograph is dramatic, but not lurid. The viewer quickly becomes oriented as to what he/she is viewing. A good photograph will rouse a weary intern into a moment of curiosity and attention.

A sturdy, durable and easily accessible photography stand is essential (Fig. 1-3). The camera, ideally a digital camera with a zoom lens, should be firmly attached to a sturdy vertical pole upon which the camera may be raised and lowered. To reduce the amount of blood or tissue fluid on the support stage, we find it very useful to set a clear plastic pan~ with small risers under each corner, on the support stage. This allows the specimen to be properly positioned beneath the camera without actually moving the specimen on the plastic. This avoids the formation of pools of blood or tissue fluid around the specimen.

Following the guidelines below will result in a good photograph:

1. The specimen should be thoroughly washed of blood. This critical step enhances the impact of the photograph by allowing the various colors of the tissues to be fully visible.
2. The camera should be close enough to clearly demonstrate the abnormality, but be far enough away so that the viewer can recognize the identity of the surrounding tissues. Certainly, landmarks may be pointed out by the presenter,
but following such an introduction, the viewer should be fully oriented as to what was being photographed and at what vantage point. Fig. 1-4 demonstrates a close up image of a portal vein thrombosis. The opened gallbladder serves to orient the viewer.

3. The glass or plastic on which the specimen sits must be completely free of blood or body fluid. Puddles of fluid are distracting and thus pull the viewer’s eyes away from the reason for which the photograph was taken.

4. A label should be placed in the photograph, so that no important detail of the pathologic process is obscured. The “up-and-down” orientation of the label should coincide with the generally perceived “up and down” of the organ being photographed. For instance, if one is photographing a tumor in a lung, the superior region of the lung should be positioned in the upper part of the image and the label should be placed at the bottom of the image, with the upper edge of the label being closest to the upper region of the image. Ideally, the labels should be typed, not handwritten, and should include a ruler.

A camera should also be available to take in situ pictures. In situ photographs may be necessary when a lesion would be significantly disrupted by the evisceration. Examples include pleural or peritoneal abscess, lung collapse, hemopericardium, and epidural hemorrhage. These photographs are much more challenging because they may, by their nature, require various machinations on the part of the photographer to get the photograph appropriately framed. Labels must be included in the framing and retracting fingers should be excluded. Finally, it is important that the unavoidably lurid nature of the autopsy be minimized by excluding skin flaps, structures not directly involved by the pathologic process and blood and body fluid accumulations from the photograph. Fig. 1-5 is an example of a good in situ picture: The rib cage serves to orient the viewer; no skin flap or retracting hands are included and the empyema is readily seen.

In some instances, it may be appropriate to include photographs in the autopsy report. Regardless, a note should be entered into the autopsy report, stating that photographs were taken and that they are on file.

**MEETING WITH THE NEXT-OF-KIN** In most institutions, the clinical attending physician reviews the autopsy findings with the family. Since the autopsy report is never automatically sent to the family, this conversation is of great importance. Inevitably however, there will be an occasion when the next-of-kin wishes to discuss the autopsy findings with the pathologist. The pathologist should see this request as an opportunity to provide detailed information about the autopsy findings to help clear up any miscommunications that may have occurred between the family and the clinicians, as well as to facilitate the family members in their grieving process. As mentioned earlier in this chapter, the pathologist must notify the clinical attending physician that such a meeting is planned. The clinician may be able to provide further information about the family and/or about events leading up to the death.

Before meeting with the family, carefully review both the clinical history of the deceased as well as the autopsy report. A thorough knowledge of the patient will better prepare the pathologist for any questions that may arise and, thus, allow him/her to be more relaxed during the exchange. Provide a quiet room for the meeting so that privacy will be assured. This may be the pathologist’s office or a conference room. Do not meet in or near the autopsy laboratory. It is strongly recommended that, during the meeting, the pathologist make him/herself unreachable by phone or pager, so as to avoid momentary or prolonged distractions from the meeting at hand. Such a concerted effort

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**Fig. 1-4.** This close-up image of a portal vein thrombosis dramatically demonstrates the pathology, while including enough of the surrounding tissue so that the viewer can readily discern the anatomic site.
to give the family undivided and empathic attention cannot help but promote better communication between the pathologist and the family. It is essential that the pathologist relay information to the family in layperson’s terms and to make sure that the family understands what is being said. Simple explanations of human physiology may be required. The pathologist should not hurry this conversation, as it may take the family minutes to digest what is being said and then more time to formulate questions. When adequate time has elapsed for these exchanges to occur and the family members appear satisfied with the information, the meeting may come to a close. At this point, it is very helpful to give the family a phone number by which they may reach the pathologist with further questions. This will have a comforting effect, as they will understand that the pathologist remains available to them should new questions or concerns arise.

Finally, the reader is directed to the recommendations for quality assurance and improvement in autopsy pathology from the Association of Directors of Anatomic and Surgical Pathology. These recommendations have been published in three major pathology journals (17–19).

REFERENCES
5. Gibson TN, Shirley SE, Escoffery CT, Reid M. Discrepancies between clinical and postmortem diagnoses in Jamaica: a study from the University Hospital of the West Indies. J Clin Pathol 2004;57:980–985.
APPENDIX 1-1 QUALITY ASSURANCE DOCUMENT, AUTOPSY SERVICE AUTOPSY NO. ____

1. Are all appropriate components of autopsy report included? (major diagnoses; case discussion; clinical summary, gross, micro, cultures, smears, photos, x-rays, results of special procedures, neuropathology) YES NO

2. FRONT SHEET:
   a) Major diagnoses in logical (pathogenetic) sequence? YES NO
   b) Results of special studies (micro, chem, etc.) reported and interpreted in front sheet or final note? YES NO NA
   c) Major neuropath diagnoses in appropriate places in front sheet? YES NO NA
   d) All major diagnoses or disease processes included on front sheet (examples: hypertension, diabetes, all previous cancers)? YES NO

3. GROSS DESCRIPTION:
   a) Consistent with and supports each diagnosis on front sheet? YES NO

4. MICROSCOPIC DESCRIPTION:
   a) Consistent with and supports each diagnosis on front sheet? YES NO
   b) Previous surgicals and cytologies reviewed and recorded? YES NO NA
   c) Consultant opinions documented in report? YES NO NA

5. NEURO GROSS AND MICRO:
   a) Consistent with and supports diagnoses on front sheet? YES NO NA
   b) Major neuropathologic diagnoses addressed in final note? YES NO NA

6. CASE DISCUSSION:
   a) Does case discussion, in combination with front sheet, adequately address clinical questions and autopsy findings? YES NO

7. CAUSE OF DEATH:
   a) Cause of death clearly stated on front sheet or final note? YES NO NA
   b) Death certification appropriate and accurate (or amended)? YES NO NA

8. Did autopsy identify discrepancies between autopsy and clinical diagnoses? YES NO

   CLINICAL DIAGNOSIS: ____________________________
   AUTOPSY DIAGNOSIS: ____________________________
   COMMENT: ____________________________

9. Did autopsy reveal (or confirm) complications of therapy or surgery? YES NO
   If yes, was the complication suspected or diagnosed clinically? YES NO

   SURGERY OR THERAPY: ____________________________
   COMPLICATION: ____________________________
   COMMENT: ____________________________

<table>
<thead>
<tr>
<th>Date</th>
<th>Prosector's Signature</th>
<th>Attending Signature</th>
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PRINCIPLES OF DISSECTION

BRENDAL. WATERS

TECHNIQUES TO ENSURE SAFETY

The principle of “Universal Precautions” is predicated on the assumption that all autopsies carry a significant risk of transmitting disease, either by aerosols or through the use of sharp instruments. To prevent exposure, the prosector is now mandated to wear surgical scrubs over which (s)he dons mask, head protection, apron, sleeve covers, and cut-resistant as well as latex (or rubber) gloves.

The elimination of cutting injuries is not guaranteed by the use of cut-resistant gloves; it requires conscious and continuous attention to the safe handling of knives and scalpels. Multiple approaches may be employed. First, the morgue should have a policy in place stipulating that all long knives be routinely sharpened. When a prosector is forced to apply excessive pressure to cut tissue, the likelihood of the knife slipping with injury resulting is increased. A serviceably sharp long knife can readily incise all the large organs, such as the lungs, kidneys, and liver, with only a modicum of pressure. The prosector will find that incising with long strokes, using as much of the length of the knife as possible, and pushing the knife through with as little pressure as possible will result in smooth slices. This type of knife is preferable to the disposable blades that are nearly as sharp as a scalpel. In addition, disposable blades are very flexible and require a handle. Both of these characteristics increase the chances of injury. Microtome blades are also undesirable because of their extreme sharpness. These blades contribute to a disproportionate percentage of cutting injuries when used at an academic pathology department (1). The prosector will find that the great proportion of the dissection procedure can be done safely with simply a pair of sharp, blunt-tipped scissors. These scissors will also require careful, intermittent sharpening.

With regard to the handling of scalpels, pathology trainees should be instructed in the inherent potential of sharps to transmit a chronic and life-threatening disease, such as hepatitis or acquired immune deficiency syndrome. The trainee should develop the habit of using a scalpel only when absolutely necessary, such as while taking sections for histological examination or incising small organs, such as adrenals. The scalpel should always be set down in clear view, away from pools of blood, organs, and other instruments, preferably at the far corner of the cutting board. The scalpel blade should be used for cutting only. It should never be used to point out an item of interest or to gesticulate in any way. As a corollary, one should be vigilant in not placing one’s hand in the vicinity of another hand that is wielding a blade. “Mid-air collisions” have occurred in these situations.

Insufficient data is available to determine whether using scalpel blades without handles poses a greater risk than using them with handles. Certainly, attaching a scalpel blade to and removing a blade from a handle require additional manipulation of the blade. On the other hand, using a blade without a handle may increase the risk of injury, because the blade is in close proximity to the cutting hand.

When arming a handle with a scalpel blade, the prosector should point the sharp edge away from the hands and use a minimum of force to accomplish the task. Disarming a blade handle is more dangerous, because the blade may be contaminated with blood. The handle should be held firmly in the nondominant hand, with the blade facing up. With the dominant hand, the prosector grasps the blade at its base with a sturdy pair of forceps or clamp and applies a force perpendicular to the long axis of the handle (Fig. 2-1A). This will lift the base of the blade away from the bevel. Then, with the base of the blade lifted away from the bevel, a controlled force is applied toward the end of the handle, thereby slipping the blade off the end of the handle (Fig. 2-1B). Figure 2-1 demonstrates the procedure as performed by a right-handed person. Notice that the thumb of the hand holding the handle can be used to gently push the blade off the handle by pushing on the forceps. A left-handed person would accomplish the same task with the blade facing down toward the cutting board and using the dominant hand to pull the blade off to the left. Rarely, the blade has been witnessed to inadvertently be “ejected” with a good deal of velocity, while it is removed from the handle. Thus, one must always face the tip of the blade away from people when removing it from a handle.

EVISCERATION TECHNIQUES

There are several techniques by which the organs are removed at autopsy. These have been amply discussed in previous editions of this book, as well as in other books devoted to the subject (2,3,4). Briefly, many forensic pathologists use the Virchow
method, by which organs are removed one at a time. In the Letulle method, the entire organ block is removed in its entirety and the dissection proceeds on the prosector's table (5). This technique has a disadvantage in that the removed organ block is very heavy and may not fit on standard cutting boards. In academic settings, where pathology residents perform the autopsies with the help of a diener, the modified Letulle technique may be employed. In this approach, following removal of the anterior chest plate, the heart is removed and given to the resident to begin dissecting, while the diener removes the bowel from the region just distal to the ligament of Treitz to the distal sigmoid-proximal rectum. Then, the diener removes the cervical, thoracic, abdominal, and pelvic organs in one block. This method allows the body to be prepared for the funeral director in a timely manner, independent of the extra time needed by an inexperienced pathology resident to complete the dissection. The Rokitansky method is poorly described in the literature, but involves in situ dissection in combination with organ block removal. The technique of Ghon involves removal of the thoracic and cervical organs, the abdominal organs, and the urogenital system as three separate blocks.

Discussion of the various organ systems below will be predicated on the modified Letulle evisceration technique, as described above.

CARDIOVASCULAR SYSTEM

For a discussion of the cardiovascular system, see Chapter 3.

RESPIRATORY SYSTEM

In only the rarest of adult cases need the prosector remove the tongue, soft palate, and tonsils. In those instances, the prosector must use caution to avoid cuts through the skin of the face. To gain access to the nasal cavities and adjacent sinuses, remove the brain first so that the nasal and perinasal bony structures may be separated from the rest of the base of the skull with an oscillating saw. This must be done with meticulous attention to preservation of the contours of the face.

Generally, the larynx, trachea, and proximal esophagus are removed as one block, using a transverse cut through the esophagus and trachea 2–3 cm below the inferior margin of the thyroid gland. After the parathyroid and thyroid glands are examined, as described below in Endocrine System, the cervical esophagus is opened posteriorly. Following that, the trachea is also opened posteriorly, along the midline. The lateral portions of the larynx are pulled apart to better expose the mucosa. In adults, this maneuver may require breakage of the ossified hyoid and laryngeal cartilages. In forensic cases, where fractures of the hyoid bone are a possibility, this maneuver should not be performed.

The lungs and bronchi are then approached posteriorly, with removal of the aorta, followed by removal of the esophagus and stomach, the last two as one block. In some institutions, the heart will already have been removed, as described above. If not, the heart is removed by cutting the inferior vena cava close to the diaphragm, the pulmonary veins close to the lungs, the superior vena cava well above the right atrium, and the great vessels above the semilunar valves. The heart may then be set aside for dissection later. For dissection of the heart, see Chapter 3. The lungs are dissected from the diaphragm. Any pleural adhesions must be carefully transected as close to the parietal pleura as possible. If adhesions are extensive, then the prosector may find it advantageous to remove the lungs with portions of adherent parietal pleura attached. Remnants of the pericardial sac and mediastinal soft tissue are also removed. The lungs are then separated from each other by transverse cuts across the mainstem bronchi and weighed. If the lungs are to be perfused, it is advisable that the transverse cuts in the mainstem bronchi be as close to the tracheal bifurcation as possible. This will allow enough length of bronchus in which to wedge the perfusion tubing. Before perfusing the lungs, be sure that the lungs have indeed been weighed and that all cultures have been taken.

Pathologists have debated the pros and cons of lung perfusion for decades. One faction claims that a perfused lung is easier to slice and that parenchymal abnormalities, such as pneumonia, emphysema, and fibrosis are better demonstrated with perfusion. The other side states that perfusion obscures pulmonary edema. The accumulation of experience will help the prosector to resolve...
this dilemma. A compromise can be that only one lung is perfused or that sections of lung are taken before perfusion. It should be noted here that even in perfused lungs, pulmonary edema can still be seen histologically. Edema fluid appears as pale eosinophilic proteinaceous material that is pushed (by the formalin perfusate) against the alveolar walls. It is distinguished from the hyaline membranes of diffuse alveolar damage (adult respiratory distress syndrome), in that the edema fluid is not as condensed or as deeply eosinophilic. Pulmonary edema is very likely to be present if foamy fluid is noted to exit the bronchi prior to perfusion.

When perfusing lungs after weighing (Fig. 2-2), it is helpful to employ one clamp to hold the bronchus as the perfusate tube is inserted. Another clamp may be used to cross-clamp the bronchus when the perfusion appears to be complete. The lungs should expand fairly briskly. If there appears to be a delay, slight repositioning of the tube may help. If there is copious exudate, mucin, blood, or tumor in the bronchial tree, perfusion may be sluggish, in which case one can perfuse the arterial system instead. Although it may be convenient to set the lungs aside at this juncture, for dissection later, they may be sectioned immediately, if desired. Although rents in the pleural surfaces due to excision of pleural adhesions or procurement of lung tissue for culture will hamper lung perfusion, they do not negate the advantages of perfusion. These rents may be closed with clamps. Remember to weigh the lungs prior to perfusing. It may be a good idea to post such a reminder on the carboy that holds the formalin perfusate.

The commonly used planes of sectioning for lungs are transverse and parasagittal. The transverse plane may be preferable if the pathologist is trying to correlate the autopsy findings with the CT or MRI images. In most cases the parasagittal plane works well. The prosector begins with the hilar region facing up and the lateral pleural surface on the cutting board (Fig. 2-3A). A long, serviceably sharp knife is best. The lung sections should be no thicker than 2 cm (Fig 2-3B). When the slices are this thick, reconstruction of the lungs will not be difficult. The prosector should use long strokes of the knife, keeping the knife parallel to the cutting board. This will ensure that the slices are of uniform thickness. A succession of long back-and-forth strokes with the knife, using as little force as needed, will minimize uneven cutting. As the slices approach the hilar region, the prosector may encounter difficulty cutting through the larger branches of the

Fig. 2-2. Perfusion of a lung. The resident is holding the lung by way of a clamp attached to the mainstem bronchus and is keeping the perfusion tubing wedged into the bronchus.

Fig. 2-3. Slicing the lung. (a) The lung is placed hilum up and close to the edge of the cutting board, so that the prosector can use the entire length of the knife without her hand bumping into the cutting board. (b) If attention is directed to keeping the knife parallel to the cutting board, uniform slices will be the result.
bronchi. Instead of adding more force to the knife, (s)he may cut the bronchi with a heavy pair of scissors and then continue with the knife. Finally, all the large vascular and bronchial branches should be opened with scissors. A good autopsy pathologist is reluctant to leave a tubular structure unopened. Pulmonary tumors and emboli can be well visualized and photographed using this parasagittal slicing method.

Most normal lungs at autopsy are quite congested and, therefore, have a bright-to-dark red color. This is especially notable in the posterior regions of the lungs, where blood settles after death. A characteristic postmortem artifact occurs when gastric contents enter the bronchial tree and settle into the pulmonary parenchyma. This generally occurs during transportation of the body to the morgue. Because of the strong acidity of the gastric fluid, the involved portions of lung are literally digested. They will appear dark gray to black but will not feel consolidated. The mucosal surfaces of the bronchi supplying these areas will often be darkened and brown-black. When actual aspiration of gastric contents occurs, the tracheobronchial mucosa will be hyperemic and thus red in the fresh state.

Useful axioms in gross lung pathology include the following: Acute pneumonia is characteristic in that its gross appearance is more pronounced after fixation. This can be of help diagnostically. Also, in lungs involved by centriacinar emphysema, acute pneumonia may not be as evident grossly. Fixation may bring out the gross features of acute infection, but the reduction in parenchyma as a result of emphysema may still obscure its presence or extent. Finally, pulmonary hemorrhage may often be differentiated from severe pulmonary congestion by its associated consolidation and by the continuous outpouring of blood from the lung slices, even after fixation.

Common, clinically inconsequential abnormalities of the lungs include mild artherosclerosis of the pulmonary arteries, subpleural fibrosis of the posterior aspect of the lower lobes and focal fibrosis of the apices. These generally occur in older individuals. However, in patients with pulmonary hypertension, the atherosclerosis may be accentuated.

The diaphragm need not be retained in its entirety, but it is a good idea to carefully examine it and retain a small portion of it in a “stock jar.” Such containers are used to store small sections of all the major organs and are kept for a year or longer if necessary. Further comments on these jars are found in Chapter 6. Common gross abnormalities of the diaphragm include hyaline plaques on the thoracic side (due to asbestos exposure) and small foci of anthracotic pigment.

**SPECIAL PROCEDURES**

**DEMONSTRATION OF TENSION PNEUMOPTHORAX** Once the skin and subcutaneous tissue is dissected laterally from the initial Y-shaped incision, water is poured into the recess lateral to the rib cage and medial to the skin flap. Then, a scalpel is placed below the surface of the water and inserted into the pleural space between two ribs. The scalpel is rotated slightly. Exiting of air bubbles establishes the diagnosis of tension pneumothorax. Another approach to observe this abnormality is to view the domes of the diaphragm from the abdominal cavity. In a tension pneumothorax, the dome may be pushed downward.

**PREPARATION OF PAPER-MOUNTED SECTIONS** This method was pioneered by Gough and has undergone several modifications (6). The technique yields very instructive, detailed, and extremely durable views of pulmonary abnormalities. Following perfusion fixation with formalin and sodium acetate, 2-cm slices of the lungs are washed and embedded in gelatin mixture that contains a disinfectant. After the gelatin has penetrated the tissue, the block is frozen and large 400-μm sections are cut, refixed, and transferred to another gelatin mixture. They are then mounted on paper. Routine stains can be applied without difficulty. Readers will find that paper-mounting requires both skill and patience. The original method Cough required 11 days, although other authors have achieved comparable results in 2 days (7). Despite this method’s didactic and esthetic appeal, it has been largely replaced by photography of perfusion-fixed specimens.

**PULMONARY ANGIOGRAPHY** These injection procedures require inflated lungs. Therefore, careful removal of the lungs and sealing of accidental lacerations of the pleura are essential.

For arteriography, tubing is tied with glass or plastic cones into the pulmonary artery and the bronchus, respectively. The lung is inflated through the bronchus with air at a pressure of approximately 20 mm Hg. The barium-gelatin mixture is warmed to about 60°C and injected into the pulmonary artery at a pressure of about 70 mm Hg to 80 mm Hg. Some experimentation may be necessary since required injection pressures vary depending on the viscosity and the temperature of the mixture. This method should result in filling peripheral artery branches down to vessels with an internal diameter of about 60μm. The study of smaller vessels requires very low-viscosity gelatin or nonconsolidating contrast media. For the average-sized lung, about 150 mL of medium are needed. The injection takes 5–10 minutes. When the vascular tree is filled, the pressure increases sharply, indicating that injection is completed. The lung should be kept warm during the injection so that the gelatin does not set too quickly. A lung processed this way is depicted in Fig. 2-4. This method may be adapted to infant lungs (8). Another approach is to perfusion-fix the lungs with formalin, using the pulmonary arteries and then perfuse the arteries with white contrast medium (see Fig. 2-5).

The injection technique for venography is similar, although the filling of the pulmonary veins must be accomplished from the left atrium. Thus, if this technique is planned, the heart should not be separated from the lungs, or the pulmonary veins should be kept as long as possible on the lungs. Injection pressures may vary between 20 and 70 mm Hg.

Lymphangiography requires the use of sodium tritirzoate and a no. 30 lymphangiography needle, while the lung is kept at an inflation pressure of about 18 cm H₂O (9).

Bronchial arteriography may be accomplished by tying a 30-gauge polyethylene catheter to the isolated bronchial vessels. The left lung usually has two bronchial arteries, and the right lung usually has one. The left bronchial arteries arise from the anteromedial surface of the aortic arch. The superior artery ostium is just lateral to the carina and posterior to the left main bronchus. The inferior left bronchial artery ostium is just inferior to the left main bronchus. The right bronchial artery arises from the right third posterior intercostal artery or rarely...
CHAPTER 2 / PRINCIPLES OF DISSECTION

Fig. 2-4. Arteriogram of left lung. The lung was inflated with carbon dioxide and the pulmonary artery was injected with barium sulfate-gelatin mixture. Note the blunting of the arterial tree in this emphysematous lung.

Fig. 2-5. Perfusion-fixed lung with advanced destructive centrilobular emphysema, photographed underwater. Note the pulmonary artery branches containing white contrast medium (arrows).

Fig. 2-6. Bronchial arteriogram.

from the thoracic aorta via the superior left bronchial artery. The path of these arteries continues to the upper esophagus, and runs along the posterior wall of the main bronchi to penetrate the lung parenchyma. The lung is first inflated with air. Then, the contrast medium, usually barium sulfate, is injected through the catheter. The injection pressure is 150 mm Hg. An example of a bronchial arteriogram is shown in Fig. 2-6.

PARTICLE IDENTIFICATION Many particles can be readily identified if they are within the resolution limits of the light microscope. The *Particle Atlas* is most helpful in such a situation (10). Inorganic particles can be isolated and concentrated for morphologic study by holding an unstained, uncovered paraffin section over a flame, such as a Bunsen burner, until the organic material has been incinerated.

In most cases, light microscopic observation with polarizing lenses provides sufficient semiquantitative information. However, for research purposes, mineral particles in lung tissue can be quantitatively analyzed with macroanalytic techniques, such as X-ray diffraction, X-ray fluorescence, neutron activation analysis, atomic absorption spectroscopy, or proton-induced X-ray emission spectroscopy. Microanalytic techniques include energy dispersive X-ray spectroscopy and wave-length dispersive X-ray spectroscopy. Excellent descriptions of these methods are found in the references (11,12,13).

For the quantification of asbestos, ferruginous bodies are harvested from the fixed or unfixed lungs by digesting the tissue in 5.25% sodium hypochlorite. The solid residues are collected on membrane filters. The characteristic features of asbestos bodies allow reasonably accurate counts. For a detailed description of
current digestion and counting strategies, see reference (14). For the semiquantitative demonstration of asbestos bodies, dried scrapings from lung sections are often studied. Ferruginous bodies also can be viewed using electron microscopy (15,16).

HEMATOPOIETIC SYSTEM, SPLEEN, AND THYMUS

In patients with hematopoietic disease, the prosector should procure multiple sections of bone marrow. Sites of procurement include ribs, sternum, vertebrae, and iliac crest. Bone marrow smears may also be very useful, although they inevitably show autolysis when obtained postmortem. It is best if a hematology technician can come to the morgue to obtain the smears, as he or she is most experienced in this procedure.

The ribs are ideal sources of marrow. First, they are readily available in cases in which the autopsy permission allows examination of the thorax and, second, marrow taken from them requires little to no decalcification. With a scalpel in hand, the prosector instructs the deiner to compress the rib just below the cut end. This can be accomplished with the use of a pair of pliers, or similar tool. What generally follows is an extrusion of bone marrow from the end of the rib. The prosector uses the scalpel like a spatula and carefully gathers the marrow up and places it onto previously moistened tissue paper that lines a cassette. This method of bone marrow collection results in a beautiful display of the cytology of the hematopoietic cells, since decalcification is not required. Patients with aplastic anemia often have very watery marrow that resembles hemorrhagic serous fluid. Patients with multiple myeloma or other myeloproliferative disorders frequently have copious amounts of thick, dark brown marrow retrieved by this method.

In addition, small samples of bone from the vertebral bodies should be taken. There is a tendency to take too large a section of bone marrow for histologic section. In actuality, multiple small sections, the size of a small pea, taken from several different sites, require less decalcification and allow for greater preservation of cells. Overdecalcified bone marrow sections appear smudgy, with the basophilia of the nuclei blending with the eosinophilia of the cytoplasm. This problem may be mitigated by rehydrating the section, immersing it in a lithium carbonate solution and then restaining with Harris hematoxylin. See the decalcification procedure under Skeletal System, at the end of this chapter.

The size of the spleen varies greatly in hematologic diseases, so it is important to record the spleen weight. The spleen may be sectioned in the coronal, parasagittal, or transverse planes. The choice of plane should be made with the intent of demonstrating the largest diameter of the organ. Because of the high content of blood in the spleen, the organ should be sliced thinly, so as to maximize fixation. The spleen may be perfused with formalin, using the splenic artery, however it is beneficial to first perfuse with normal saline so as to wash out much of the blood. In fact, the splenic reticulum can be well demonstrated by that perfusion method. If the injection pressure is about 100 mm Hg, the splenic pulp will turn white after about 1 hour. The perfusion is then continued with 10% formalin. Splenic arteriography may also be accomplished using the splenic artery.

In the fetal life and in childhood, the thymus is a prominent multilobed organ, situated partly in the neck and partly in the thorax. It rests on fascia over the great vessels and on the anterosuperior region of the pericardium. It may extend into the neck to the level of the lower border of the thyroid gland. It reaches its maximum size at puberty, weighing up to 35 grams. It then gradually decreases in size and may weigh only 6 grams at the age of 70. If it is important to examine thymic tissue at autopsy, such as in a patient with a history of thymoma.

Although formalin fixation is adequate for hematopoietic tissue, we find that B-Plus Fixative™ (BBC Biochemical) minimizes cytoplasmic retraction, and provides excellent cytologic preservation.

ENDOCRINE SYSTEM

NECK BLOCK

The thyroid and parathyroid glands are part of the “neckblock,” a traditional term that refers to the larynx, the proximal esophagus, and the proximal trachea extending “two fingers” (about 2-3 cm) below the inferior margin of the thyroid gland. This inclusion of the trachea below the thyroid insures that the inferior parathyroid glands will remain with the block. The dissection begins with steps to view the thyroid and parathyroid glands before opening the esophagus or trachea/larynx. The most anterior fascicles of the strap muscles may be removed. Overtrimming of muscle and connective tissue from the neck block should be avoided, since this may result in inadvertent removal of one or more of the parathyroid glands. Multiple incisions are made no more than 0.5 cm apart in the soft tissue between the esophagus and the posterior margin of the thyroid gland. In that region, using an astute and patient eye, the parathyroid glands will be found. The glands will be slightly flattened, like a lentil bean, and have a homogenous tan to golden color. With age, they become a brighter yellow. The lower glands are generally larger than the upper. Lymph nodes of comparable size will have a gray or pink hue and small nodules of the thyroid will have a glassy, brownish-red hue. Fixing the neck block will stiffen the tissue and make the task of identification of the parathyroid glands easier.

In the great majority of patients coming to autopsy, there is no clinical suspicion of parathyroid disease. This may lull the inexperienced pathologist to erroneously conclude that it is unnecessary to search for these glands on a routine basis. In our practice, we encourage first-year pathology residents to submit all the parathyroid glands for histologic confirmation. This provides them with feedback for their developing eye. When the clinical history of the patient raises the question of parathyroid disease, then the glands should be assiduously sought out. All possible contenders for parathyroid tissue should have their location documented before they are removed from the neck block. A simple drawing or “map” is sufficient, designating each nodule with a different letter. Each possible parathyroid gland should be trimmed of fat, and individually weighed in a balance that records a weight in grams to three decimal points. Such a scale may be found in the histology or chemistry laboratory. The normal weight for four parathyroid glands is 120 mg in adult males and 142 mg in adult females. Finally, each of the specimens is separately submitted for histologic examination.

When the search for parathyroid glands is completed, the thyroid gland is either removed, weighed, and incised or just incised while...
still attached to the neck block. The slices should be spaced no more than 0.5 cm apart. The normal thyroid has a rich brown-gold color and a glassy sheen. The latter characteristic is the result of the colloid. Nodules of hyperplastic follicles are frequently present, as are foci of dystrophic calcification. Neoplasms are less frequent, and generally have a more tan and less glassy appearance. They may seem to be well circumscribed and may readily bulge up from the cut surface. In any of these neoplastic nodules, it is prudent to include in the histologic section both the tumor and the surrounding thyroid tissue, since issues of capsular invasion should still be dealt with in autopsy material. Regional lymph nodes need to be sampled in cases of thyroid neoplasia.

ADRENAL GLANDS The adrenal glands in most individuals may be found within the retroperitoneal fat above and/or medial to the superior poles of the kidneys. It is generally a good idea to remove them as soon as possible, as they autolyze and soften quickly, resulting in fragmentation. Also, they can be very difficult to locate later, when surrounding organs, such as the kidneys, have been removed. First, the posterior leaves of the diaphragm are cut along each side of the aorta and reflected upward and out of the way. Then, by using blunt dissection and careful palpation, the prosector should be able to locate the adrenal gland. When the borders are discerned by palpation, the prosector can begin to remove the gland by taking a cuff of fat around it. At this point, the adrenal gland may not be visualized directly, but rather palpated. If the prosector cuts into the adrenal, he or she will recognize it by its golden-to-dark brown red color. The adrenal artery may be conspicuous. Once the adrenal is removed, as much of the periadrenal fat is removed as possible. This is accomplished by holding the scissors flat and parallel to the cortical surface. Once trimmed, the organ is weighed. The average weight of a well-trimmed adrenal gland is 4-6 grams. The right adrenal is more triangular and is also flatter, as it resides between two solid organs, the right lobe of the liver and the right kidney. The left adrenal is more elongated and usually features a superior, midline upfolding of its cortex, forming a longitudinal ridge. The adrenal cortex ranges in color from yellow gold, to brown red, depending on the content of lipid and the degree of congestion in the deeper areas. The medulla, characterized by gray more solid tissue beneath the cortex, can be mistaken for metastatic cancer. Normally, the medulla is present only in the body and head of the gland.

PITUITARY Removal of the pituitary is discussed in Chapter 4.

THE GASTROINTESTINAL TRACT

ESOPHAGUS Dissection of the gastrointestinal tract begins at the esophagus, the proximal portion of which is part of the neck block. This segment of esophagus on the neck block is opened posteriorly. In most adult autopsies, the esophagus may be removed prior to opening, because there is no suspicion of any fistulous connection between it and the bronchial tree. If there is any history of pathology in the esophagus, it should be opened, examined, and fixed immediately. In cases of infiltrating carcinomas arising from or involving the esophagus, the esophagus should be opened prior to removal from the thoracic organs so as to identify and preserve any fistulae. With minimal autolysis, the mucosa will be white to gray and may show islands of acanthosis, characterized by mucosal thickening and gray-white opacification. Moderate to severe autolysis will cause areas of the mucosa to slough, leaving a darkened reddish surface. This change can be mistaken for ulceration or Barrett's esophagus if it is near the gastroesophageal junction. Early fixation, followed by procurement of a longitudinal section of esophagus containing both grossly normal and abnormal areas will allow the correct interpretation in most instances.

Esophageal varices that have eroded through the mucosa and have bled are readily seen as hyperemic ulcerations often with thickening of the wall. On the other hand, unruptured varices may be difficult to see. Even in normal patients, the submucosal veins may appear quite dilated when incised in transverse section. One strategy for improving the demonstration of varices entails turning the esophagus inside out with the aid of a long clamp prior to opening. This may be quite successful in some cases. Formalin fixation may further accentuate the varices. Injection with barium sulfate-gelatin mixture may also highlight the varices (see Fig. 2-7).
Although the lower end of the esophageal wall is normally thicker, some patients with a history of dysphagia may have an accentuation of this wall thickness and may appear to have stenosis of the lumen. Comparing the internal circumference of the area of suspected stenosis with that of other regions of the esophagus may help to quantify the degree of stenosis. To confirm the presence of lower esophageal rings (Schatzki rings), remove the lower half of the esophagus with the upper half of the stomach and an attached ring of diaphragm. Clamp the stomach across the corpus. The viscus is then slightly distended with a mixture of barium sulfate and 10% formalin with clamping of the esophagus. Roentgenograms should be prepared as soon as possible. Subsequently, the specimen should be fixed in the distended state in formalin until it is to be cut. This method can be used for other types of stricture of the esophagus.

**STOMACH** In most cases, the stomach may be separated from the pancreas and opened along the greater curvature. When penetrating ulcers or infiltrating tumors are anticipated, the stomach should remain attached to the adjacent organ involved and a plane of sectioning chosen to best demonstrate the pathologic process.

The gastric rugae stretch out and flatten soon after death. For this reason, early examination and fixation of this organ should be a priority, especially in patients with any kind of gastric disease. The pyloric region of the stomach has a characteristically flattened mucosa, as compared to the regions proximal. The muscular wall is also thicker in this region, which may resemble the gastric wall thickening in limitis plastica. The proximal duodenum should be severed about 4 cm (two prosector’s finger-widths) distal to the pylorus such that any peptic ulcer of the anterior surface parallel with the longitudinal axis of the organ, spread out on an X-ray cassette and radiographed.

**Celiac Arteriography** For gastric arteriography, the organs supplied by the celiac artery should be removed en masse. The splenic and hepatic arteries are tied as far distally as possible. A barium preparation is injected through the celiac artery. After injection, the stomach is isolated, opened along the middle of the anterior surface parallel with the longitudinal axis of the organ, spread out on an X-ray cassette and radiographed.

**SMALL AND LARGE BOWEL** The greater omentum should be examined prior to discard. In clinical situations where there is a history of abdominal malignancy it should be fixed and retained for possible future reexamination, such as at Gross Conference.

The C-shaped proximal segment of the duodenum will be covered in the section pertaining to the hepatobiliary tree and pancreas.

The intestines autolyze quickly and thus should be examined and fixed promptly, especially in patients with intestinal disease. Opening of the bowel is greatly facilitated when the mesentery has been cut close to the wall of the intestine. Having minimal attached mesentery also allows for pinning of the bowel segments to a corkboard so as to have a flat surface for excellent, close up photography.

The color of normal bowel varies widely at autopsy. It may be tan-pink as seen in surgical specimens, or it may be dark pink, red, green, yellow, or black, the latter if the bowel was adjacent to a postmortem rupture of the gastric fundus. Despite its length, the small bowel infrequently manifests pathology at autopsy. Submucosal lipomas may be found as well as dilated lacteals. The latter are whitish and may be slightly raised as they appear through the overlying normal mucosa. When incised, they sometimes quickly collapse and spilt out a milky fluid. The most common malignancy to involve the small bowel at autopsy is intraperitoneal metastatic carcinoma. This may appear as multiple rounded to flattened deposits of white, firm tissue in the bowel serosa, submucosa and/or mesentery.

Ischemic bowel, especially in its early stages, may be a difficult entity to distinguish from autolysis. The colors of ischemic bowel may resemble those of normal postmortem change. Subtle characteristics of early bowel ischemia include hemorrhage or hyperemia in the submucosa and muscularis, fine roughening of the mucosa and finally, an odor. The odor of ischemic or necrotic bowel is most characteristic and once perceived, is well remembered by alert prosectors. Any section of bowel that is suspected to be ischemic or infarcted should be fixed immediately and processed for histologic examination.

More advanced bowel necrosis is typified by a dusky blue serosal surface often with fibrinous exudate, bowel dilation, and/or darkening of the mucosa by hemorrhage or severe hyperemia. The wall may be thickened and the odor of dead bowel may permeate the room.

Small polyps frequently reside in the large bowel. They autolyze so quickly that the prosector may not consider them worthy of histologic examination. However, if the bowel is examined soon after removal, these polyps will be surprisingly well preserved such that histologic examination will allow them to be properly categorized. The diagnosis of colonic polyps is of importance to family members of the deceased.

Carcinomas of the large bowel should be photographed prior to obtaining sections for histologic examination. Careful attention should be paid to looking for mesenteric lymph nodes in the region of the carcinoma.

A modification of the placental “membrane roll” method may be employed to obtain long sections of intestinal wall for histologic examination (Fig. 2-8A–F). Following fixation, a long rectangular strip of bowel wall is cut from the organ. With the
use of two wooden sticks, the strip is rolled up and pierced by a straight pin between the sticks so as to hold the roll in place. Following removal of the sticks, the roll is cut on both sides of the pin to a thickness appropriate for placement in a cassette. The section is submitted to the histology laboratory, accompanied by a written warning that a pin is present in the block. What results is sampling of a large area of mucosa and muscularis.

Preparation for Study under Dissecting Microscope Inevitably, autolysis will cause flattening of the mucosal plicae. To obtain the best results, immediate processing of the tissue is essential. Opened segments of the bowel should be rinsed in saline, pinned to corkboard, mucosa side up and then fixed in 10% formalin for at least 24 hours. The tissue is then immersed in 70% alcohol for two hours and then

Fig. 2-8. (a) A rectangular strip of bowel is cut away. (b) With two wooden sticks, the strip is wound into a roll. (c) A pin is placed through the roll. (d) The sticks are pulled out, leaving the pin in place. (e) The roll is sliced on both sides of the pin to obtain a section thin enough to fit into a cassette. (f) The pin remains in the roll. The requisition accompanying the cassette, should have a notation warning the histology technician that there is a pin present.
immersed in two changes of 95% alcohol for 2 hours each. The tissue may then be stained with 5% alcoholic eosin for 4 minutes and subsequently immersed in two changes of absolute alcohol for 2 hours each. The fixed and dehydrated intestinal wall is then placed in xylol. The preparation is now ready for examination (17).

Mesenteric Angiography  The celiac, superior mesenteric or inferior mesenteric artery can be injected with a barium sulfate-gelatin mixture, either in situ or after en block removal of the abdominal viscera. If all three vessels are injected (Fig. 2-9), the abdominal organ block must be partitioned so that the three vascular compartments can be displayed properly (18).

Fig. 2-9. Partitioned abdominal viscera for celiac and mesenteric arteriography. Celiac trunk specimen: Note the rotation and upward sweep of the duodenum. The root of the superior mesenteric artery remains with the celiac artery but is hidden behind the pancreas. Superior mesenteric artery specimen: This includes the intestine from the middle of the first jejunal loop to the middle of the transverse colon. Inferior mesenteric artery specimen: This extends from the middle transverse colon to the anus. Adapted from ref. (18).
HEPATOBLIARY TREE AND PANCREAS

The hepatobiliary block comprises the liver, gallbladder, pancreas, and the retroperitoneal “C” loop of duodenum. This block is approached from its posterior surface. Extraneous fat is removed as well as the mesentery of the small intestine. Although the mesentery may be discarded during most autopsies, multiple cuts should be made into it to reveal the luminal patency – or lack thereof – of the mesenteric arteries and portal veins. The duodenum should then be opened along its anti-mesenteric border. At this point, firm, sustained pressure on the gallbladder should express bile through the bile duct and ampulla. This maneuver does take a bit of patience. The inferior vena cava is examined and removed. Next, a superficial transverse incision across the hepatoduodenal ligament is made with the intent of entering the portal vein. Using scissors, open the portal vein toward and away from the liver to establish its patency. If it is free of pathology, then it may be transected. Then, a deeper transverse incision into the hepatoduodenal ligament uncovers the hepatic artery, on the left side. This vessel should also be opened to determine its patency. Finally, the common bile duct will be encountered to the right of the hepatic artery, with a third and deeper transverse incision. It is opened along its entire length, from porta hepatis to its entry into the duodenum. If stones are present, the prosector should document the degree of duct dilation, if any, proximal to the stone. A simple method to roughly quantify the caliber of any tube is to measure its internal circumference. Simple arithmetic calculation ($D = C / \pi$, where $D$ = diameter, $C$ = circumference), will approximate the luminal diameter.

Opening the cystic duct is fraught with difficulty because of its semicircular valves. However, the task can be completed with patience and a small pair of blunt-ended scissors. The gallbladder is then extricated from its bed against the liver, but left still attached to the pancreas and duodenum. It is advisable to open the gallbladder near the edge of the cutting board, toward the sink or into a container, such that the bile is does not stain the rest of the organs. However, the prosector should closely inspect the gallbladder’s contents, so that any stones may be recognized, quantified, and characterized.

To maximize the exposure of the parenchyma, the pancreas may be incised along the frontal (i.e., coronal, plane). When there is suspicion that the pancreatic duct is dilated, then sagittal sections are preferred. Commonly, autoysis causes the pancreas to demonstrate a blotchy, dark red pattern. This may be confused with hemorrhagic pancreatitis by inexperienced pathologists. However, the abnormality frequently accompanying hemorrhagic pancreatitis, that is fat necrosis, is conspicuously absent. Routine sections from the pancreas should come from the tail, since a higher concentration of islets is found in that region.

The liver may be sliced in the coronal or the transverse planes. The latter approach yields the most recognizable shape of the liver, with both lobes well seen and with the porta hepatis clearly shown in at least one slice. However, the best demonstration of a pathologic process must remain the primary goal when choosing the plane of sectioning. It is best to section liver in slices that are no more than 2 cm thick. This will ensure adequate examination and proper fixation of the slices that are reserved for demonstration at a later time. To avoid leaving telltale marks of the knife, the prosector should use a long, sharp knife, with as minimal downward force as possible. The knife should be drawn in long sweeps, using the entire length of the blade, as if playing a cello. One is reminded of the adage, “Let the knife do the work.” In this way, not only will the surfaces of the slices be smoother, but the prosector will reduce the risk of a cutting injury.

This author finds it useful to push the tip of her index finger through a slice of unfixed liver in every autopsy to roughly assess the degree of fibrosis. Normally with this maneuver, the liver will tear easily. In situations of chronic congestive heart failure, where there is centrilobular fibrosis, the liver will resist tearing. In cases of cirrhosis, the task is nigh impossible. This so-called “finger test” can be applied to fresh slices of liver only, no more than 2–2.5 cm thick. With consistent use of this test, the pathologist may be able to recognize early hepatic fibrosis grossly.

In situations of a tumor involving the porta hepatitis or of cirrhosis with a portosystemic shunt, the prosector must use ingenuity to choose the dissection approach that will best demonstrate the relationships between the pathologic process and the adjacent organs. This may require that the biliary connections be preserved and that the organ block be sliced in the coronal, transverse or even sagittal plane. Patience and possible conference with other pathologists may help to decide on which plane to use. The result will be a specimen that is dramatically instructive to both clinicians and other pathologists.

Up to 10% of patients undergoing upper GI endoscopy or radiography have a duodenal diverticulum. These diverticula are seen at autopsy at generally the same frequency. They characteristically have a large opening, are thin walled, and project into the mesentery of the proximal portion of the retroperitoneal duodenum. They are considered developmental in pathogenesis, rather than secondary to obstruction.

Gross Demonstration of Liver Staining for Iron This method (19) is particularly useful in cases of hemochromatosis. It can be applied to other organs, such as pancreas and myocardium. The actual staining procedure is described in Chapter 16.

Quantitative Assessment of Hepatic Iron or Copper Iron load may be quantified from fresh or paraffin-embedded tissue, using atomic absorption spectroscopy (20). This method may also be applied to measure copper in tissue, such as in Wilson’s disease.

Pancreatic Angiography and Duct Roentgenography Arteriograms require injection of the celiac and superior mesenteric artery system, as described earlier. The retrograde injection of radiopaque medium from the papilla of Vater provides excellent roentgenograms of the pancreatic duct system. The pancreatograms show stones and other duct abnormalities quite clearly (21).

Hepatic Angiography Remove the liver together with the diaphragm, the hepatoduodenal ligament, and a long segment of the inferior vena cava. Vessels can be injected with contrast medium either before or after perfusion fixation. Fig. 2-10A shows the equipment that is needed for the infusion of the contrast medium. Fig. 2-10B shows such a nozzle in place.
Fig. 2-10. Preparation for angiography and cholangiography. (a) Straight and bifurcated nozzles for hilar vessels and bile ducts; rubber hose for attaching specimens to perfusion apparatus; cotton was for plugging hepatic veins; ligature with needle to secure nozzles. Two identification tags are also shown. (b) Cirrhotic liver with nozzle tied into portan vein. Adapted from ref. (22).

Fig. 2-11. Postmortem specimen cholangiogram. Note that in this case, the gallbladder has been left in place and is filled with contrast medium.

After the vessels have been cannulated, blood and blood clots are flushed out with saline. Perfusion can be performed with the contrast media. Barium sulfate gelatin mixtures give excellent results. Lowering the viscosity of the barium will enhance the filling of smaller vessels.

**Cholangiography** Cholangiography is easier if a sufficiently long sleeve of the common hepatic duct remains attached to the liver, so that a cannula can easily be tied into the lumen. Removal of the gallbladder prior to cholangiography may lead to leakage of contrast medium. Therefore, it may be substantially easier and more elegant to fill the gallbladder, still attached to the liver, along with the bile ducts (Fig. 2-11). Lowering the viscosity of the barium will enhance the filling of smaller ducts.

**URINARY TRACT**

**RENAL ARTERIES** Dissection and examination of the urinary tract are preceded by opening of the aorta and renal arteries and by removal of the adrenal glands. The inferior vena cava will be encountered on the right side and assessment of its patency can be performed at this time. Any renal artery stenosis, whether at the aortic ostium or along its length, should be searched for and documented. Then, the renal arteries may be transected either close to the renal hilum or midway along their length, with the proximal portions left attached to the aorta. The aorta may then be removed, starting at the iliac bifurcation and extending through to the aortic arch.

**KIDNEYS AND BLADDER** It is wise at this juncture to locate the ureters so that they are not inadvertently cut. Once they are located, removal of excess fat around the kidneys may be done. The kidneys are then dissected down towards the pelvis, with care taken not to transect the ureters. The prosector will note that the retroperitoneal ureters course anterior to the rectum, to enter the posterior wall of the bladder. Any retroperitoneal tissue that is still attached medial to the kidneys and ureters may be removed. With the organ block facing down, the rectum can then be removed. There is no easy fascial plane to guide the prosector along the anterior margin of the rectum, but if he removes the rectum by keeping the plane of dissection close to the rectum, no ureter will be cut. Once removed, the rectum is opened, rinsed, and examined.

The perirenal fat and the renal capsules are then removed and the kidneys are bivalved, leaving the anterior and posterior
halves connected at the hilum. In patients with renal tumors, hilar nodes should be sampled. If each half of the bivalved kidney is thick, then each may be incised again. The next task is to open the ureters. The easiest approach for many is to orient the urinary block such that the posterior aspect is resting on the cutting board, kidneys nearest to the prosector, and bladder farthest away. The smooth, peritoneum-covered posterior wall of the bladder should be lying against the cutting board. With a pair of blunt-tipped scissors, enter the renal pelvis and cut down each ureter to enter the anterior wall of the bladder. When this has been accomplished, the two openings are connected by a transverse cut in the anterior bladder wall. Finally, an anterior cut is made out the urethra and up the midline to the dome of the bladder.

Removal of the renal capsules will reveal the most common gross abnormality of the kidneys, that of arterial sclerosis. This is manifested by a diffuse, fine granularity of the renal cortical surface. When severe, this disorder will also feature small cortical cysts. The cut surface will often show thinning of the renal cortex. The normal thickness of the cortex is about 1.5 cm. Large areas of ischemic atrophy or old pyelonephritis will appear as broad areas of cortical thinning, surrounded by raised, more normal parenchyma. It is common to find one to several small tubular adenomas in scarred kidneys. Small, well-circumscribed tan nodules in the cortex characterize these neoplasms. Fibromas, angiomyolipomas and myelolipomas are not uncommon. Heterotopic adrenal cortex will appear as flattened foci of yellow-tan tissue on the cortical surface. Many diabetic patients at autopsy will have characteristic deep orange noncalcified atheromas in their renal artery branches. Acute tubular necrosis may be suggested when pallor and swelling of the renal cortex or obscuration of the corticomedullary junction is seen.

The bladder frequently contains slightly thick, milky fluid. This material may be mistaken for an inflammatory reaction, such as severe pyuria, but is actually just sloughed urothelium suspended in urine. A Gram, Papaniculau, or hematoxylin-eosin stained smear of this material will reveal innumerable urothelial cells. This finding is a postmortem artifact. The bladder mucosa normally has a pale tan color at autopsy. Mucosal hyperemia or hemorrhage may be found, and may be the result of bladder catheterization, severe cystitis, or profound hypotension.

**Renal Perfusion Fixation** In this method, a length of renal artery is left attached to the kidneys. A cannula is then tied into this vessel and the kidney is perfused first with normal saline and then with 10% formalin.

**Renal Angiography** Arteriograms (Fig. 2-12A and B) and venograms (Fig. 2-13) may be performed either in situ or after en bloc removal of the abdominal aorta and kidneys or on isolated organs. Clinical contrast media or barium sulfate gelatin mixtures give excellent results. A catheter is tied into the celiac artery in situ or after removal of the organ block and all nonrenal arteries are ligated and both ends of the aorta are clamped. Venography is conducted by injection of contrast medium into a segment of the inferior vena cava that was sealed off by ligatures. By moving the ligatures higher, excellent hepatic venograms can be prepared.

**Urography** Retrograde urograms are easy to prepare with any of the conventional contrast media. The ureter is cannulated either from the urinary bladder or through the wall of the distal ureter.

Urethral valves may be demonstrated by injection of radiopaque material into the urinary bladder. The valves will prevent contrast from entering the urethra. The urethra should then be opened along the anterior midline opposite to the direction of flow of urine (Fig. 2-14). This will prevent laceration of the delicate valves.

**FEMALE AND MALE REPRODUCTIVE SYSTEMS**

Following removal of the rectum, the vagina, uterus, fallopian tubes, and ovaries may be examined. Separation of the uterus/vagina from the back of the bladder is not routinely required. The vagina may be opened, using scissors, with a midline posterior cut, extending to the cervix. Since the uterus and cervix are