Formatting Pathology Reports
Applying Four Design Principles to Improve Communication and Patient Safety
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Context.—Eighty-two million surgical pathology and cytology reports were issued in the United States during 2007; a subset of these reports will be misunderstood by readers. Recent attention has focused on standardizing the content of pathology reports, particularly for common malignancies, to facilitate transmission of required information. Comparatively little attention has been focused on the format of reports—the arrangement of headlines, text blocks, and other report elements to optimize communication.

Objective.—To provide guidance to report designers and authors about how to format reports to maximize the speed, fidelity, and ease of information transfer.

Data Sources.—Review of relevant literature from commercial publishing and aviation and the fields of cognitive psychology and pathology, supplemented with an analysis of 10 000 pathology reports and the author’s personal experience as a practicing pathologist.

Conclusions.—Four evidence-based and time-tested principles can help pathologists format information to communicate more effectively: (1) use of diagnostic headlines to emphasize key points, (2) maintenance of layout continuity with other reports and over time, (3) optimization of information density for readers, and (4) reduction of extraneous information or “clutter.” Practical advice is also provided to help pathologists minimize corruption of formatting as reports are transmitted electronically between medical information systems.

Arch Pathol Lab Med. 2008;132:84–94

In 2007 an estimated 27 million surgical pathology reports and 55 million cytology reports were issued in the United States. The anatomic pathology market in the United States has been increasing at an annual rate of 8.7%, and in 2007 approximately $6.7 billion will be spent to reimburse US providers for the professional and technical services required to produce these 82 million reports. Pathology reports issued in 2007 will be examined by tens of thousands of physicians and will guide follow-up care for millions of patients, often determining requirements for subsequent surgery, hospitalization, chemotherapy, or other treatment.

Recent attention has focused on standardizing the content of pathology reports—the clinical and administrative data elements to be included in reports of various types—to help ensure that required information is transmitted to caregivers. Beginning in the early 1990s, a number of pathology professional societies began issuing recommendations—variously called guidelines, protocols, templates, practice parameters, or checklists—specifying a minimum set of data elements that should be included in pathology reports for particular tissue types or pathologic diagnoses. Attention to the content of pathology reports increased soon thereafter when regulations published pursuant to the Clinical Laboratory Improvement Amendments of 1988 mandated gynecologic cytology reporting using the Bethesda consensus standard. Attention increased further in 2004, when the American College of Surgeons’ Commission on Cancer required as a condition of cancer program accreditation that surgical pathology cancer reports conform to the College of American Pathologists (CAP) cancer reporting protocols. Today, the CAP requires CAP-accredited laboratories to include all report elements specified in CAP cancer protocols in surgical pathology reports.

Several multi-institutional studies of pathology reports have demonstrated gaps between data elements recommended for inclusion in reports and the elements actually included. For example, in a review of 7300 pathology biopsy reports on mammographically detected breast lesions only 62% of reports correlated the mammographic abnormality with the microscopic findings. In only 92% of malignant cases was the margin status reported, and only 77% of reports specified the lesion size. In the course of conducting these studies, investigators identified institutional practices that were associated with production of more complete reports. In particular, the use of checklists to generate surgical pathology reports was significantly associated with production of reports that contained all required data elements.

Comparatively little attention has been focused on the format of pathology reports—the arrangement and configuration of headings, text blocks, and graphic elements on paper or computer screens to optimize communication. This lack of attention is surprising, given the fact that almost all practicing pathologists receive inquiries from...
caregivers who are looking for information that was present in a report but which the caregiver had overlooked. Powsner et al.\(^1\) found that 30% of pathology report information was incorrectly specified by clinicians even when the clinicians were given an opportunity to examine reports as they were answering questions about content. In 1991 Markel and Hirsch\(^1\) first described the synoptic report format, now widely adopted, in which key report elements are arranged in a vertical list. Yet no studies to date have examined whether this format results in speedier transmission of information, better retention of information by readers, or fewer recall errors. Pathologists often embrace formatting conventions without any data supporting their efficacy. I have had discussions with many colleagues who hold strong opinions about the importance of positioning pathology diagnoses at the top or bottom of reports, but the only study that examined whether the position of diagnoses in a report impacted the fidelity of communication was inconclusive.\(^1\)\(^2\)

This review article draws on principles from the publishing, commercial aviation, and cognitive psychology literature to provide guidance to pathologists interested in formatting diagnostic reports to optimize information transfer. Recommendations in this article are evidence-based, but the evidence is found in studies conducted in other industries or academic disciplines. Four principles are described that can help report designers and authors use formatting to more effectively communicate information. This review also discusses tradeoffs that arise among the 4 formatting rules and includes some practical advice to help pathologists minimize corruption of formatting as reports are transmitted electronically between medical information systems. Emphasis is placed on formatting of surgical pathology reports, but the guiding principles elucidated in this review apply equally to cytology, hematology, pathology, and other laboratory reports.

**METHODS**

**Information Sources**

MEDLINE (National Library of Medicine, Bethesda, Md) and Google (Google Corporation, Mountain View, Calif) searches were conducted using the search terms “pathology” + “report” + (“formatting” or “layout”), and the first 500 documents returned from each search were reviewed. In addition, a review was conducted of formatting, data presentation, and layout literature from the newspaper industry, the cognitive psychology literature, and literature from the human factors division of the Federal Aviation Administration, which regulates flight systems and their displays in aircraft flight decks. A convenience sample of 10,000 sequential surgical pathology reports, stripped of patient and physician identifiers, was downloaded from a shared laboratory information system that supports 6 distinct pathology departments that include a total of 32 pathologists who serve 10 hospital-based clinical laboratories. These reports were examined for examples that adhered to or violated the 4 layout principles culled from the literature review. Additional background information about how pathology reports are formatted in practice was obtained from a “show of hands” to questions I posed during lectures I delivered in various venues about pathology report formatting, from a review of the handout materials for the most recent 150 hours of anatomic pathology continuing medical education workshops I attended, and from my 22-year experience as a practicing pathologist.

**Definition**

The term format is used to indicate the arrangement of headlines, other text elements, and graphical elements on printed documents and computer screens. In this sense, format is synonymous with the term layout as used by the publishing industry. For the purposes of this review, format also includes selection of text font, color, size, and other text effects that add information to the literal (semantic) meaning of words, as well as decisions pathologists make to group words together in a single line of text or to break textual information into separate lines. Thus, format includes elements specified by report designers when the layout of reports is programmed into medical information systems and also elements specified by practicing pathologists, pathologist assistants, and transcriptionists when words or pictures are inserted into and arranged within predefined data fields such as the “diagnosis” or “gross” sections of a surgical pathology report.

**Measures of Effective Communication**

Information sources were reviewed to determine whether there was any evidence or industry-wide consensus that a particular type of formatting impacted communication effectiveness. This assessment required an operational definition of “communication effectiveness.” For the purpose of this review, communication was considered to be more effective if any of the following conditions were met: (1) improved reader memory of content, demonstrated either by better “recognition” of content on multiple-choice questions that tested an ability to recognize key facts or by better “recall” of content as demonstrated by an ability to spontaneously bring up key facts without the prompting inherent in a multiple-choice question; (2) fewer task errors in either of the 2 types of memory tasks—recognition or recall; (3) less time required by a reader to examine a document or computer screen, provided there was no concurrent loss of content memory or increased task errors; (4) increased likelihood to take a correct course of action in response to the same information being presented using a different format; or (5) increased subjective measure of satisfaction with the communication experience. This last effect was considered important because less satisfying communication experiences were presumed to require more mental effort that, in turn, might lead to decreased inclination to absorb additional information or diminished cognitive capacity.

**Annual US Pathology Activity**

The 2007 surgical pathology volume for the United States was estimated from the total surgical pathology market size in 2006,\(^1\) indexed for inflation (7%, Medical Care Services Consumer Price Index, series CUUR0000SAM2, US Department of Labor), and divided by average global reimbursement (115% of Medicare reimbursement for Current Procedural Terminology [CPT] 88305), which equaled $102.82 in 2007. A correction factor was applied for the average number of CPT codes per accession (1.2), and the product was then multiplied by the proportion of surgical pathology expense attributable to CPT 88300-9 (81%, CAP analysis of 2006 Medicare claims files obtained from the Centers for Medicare Services). Cytology activity was obtained from reference 1 and indexed by the annual growth rate specified in the same reference.

**FOUR FORMATTING PRINCIPLES**

1. **Use Headlines to Emphasize Key Findings**

Newspapers and pathology reports share communication challenges. Both have a story to tell, although it can be argued that the type of stories that appear in a newspaper are more wide-ranging than the stories included in pathology reports, and the educational level of the newspaper audience is more varied than the audience for a pathology report. Nevertheless, in both cases it is reasonable to assume that readers will not be able to assimilate all of the information contained in a story.\(^10\) How does the newspaper industry use layout techniques to increase the likelihood that key facts will be successfully communicated?
The top half of the front page of the New York Times from September 12, 2001 (Figure 1) illustrates a basic formatting technique that is so common as to be taken for granted—a headline. The headline, which precedes the story, conveys the key message in large bold typeface and is set off from the body of the story by visual “white space.” The headline is often followed by a cascade of progressively smaller subheadings that convey important sub points. This type of layout is termed an inverted pyramid style. The text of the story follows the headline and subheadings, often beginning with recapitulation of the key points. Headlines describing particularly newsworthy events, such as the September 11 attack on the United States, frequently span 2 or more related stories.

Is the inverted pyramid newspaper layout adaptable to the diagnosis section of pathology reports? Figure 2, A, shows a specimen-centered diagnosis section, the most common pathology reporting format used today, in which each specimen receives its own diagnosis. Figure 2, B, shows a patient-centered diagnosis section with a newspaper-style “diagnostic headline” that spans the “stories” told by each of the biopsies. At the time these 2 reports were created, both contained all elements required by the CAP cancer protocols for prostatic adenocarcinoma. Both reports are adequate for billing purposes, because individual specimens are identified in each report. Both are adequate for cancer staging purposes.

When the diagnosis of cancer in a multi-biopsy report is buried in the middle of an unformatted string of diagnoses, it may be more difficult to find cancer in the pathology report than in the biopsy itself. Given the fact that clinicians often fail to correctly recall information contained in pathology reports, which of the 2 examples in Figure 2 is more likely to faithfully communicate the key finding from this series of biopsies—that the patient has cancer? Given the fact that in the outpatient setting, non-physician office staff often triage paper pathology reports before they are reviewed by physicians, which example is more likely to be routed correctly by office staff? Does the format in Figure 2, A, present an increased risk to patient safety, relative to the format in Figure 2, B? Whether or not the rest of the report is in synoptic format or in narrative format, the conventional wisdom of the publishing industry suggests that the use of a headline with offsetting white space will result in increased recall of key points and fewer recall errors.

Experimental evidence from the newspaper industry supporting the use of headlines as a communication tool is scanty, as almost all of today’s newspapers rely heavily on headlines and sub headlines. In the early 1800s, however, many periodicals contained almost no white space to set off headlines from text, and headlines were formatted in the same typeface as text. Controlled eye tracking studies of subjects examining newspaper Web sites show that headlines are the first item to be viewed on a Web page, underscoring their importance.

The information within most pathology reports is not sufficiently complex to require subheadings analogous to those found in newspapers, but unusual findings (eg, synchronous neoplasms in the same specimen) or particularly lengthy reports often benefit from indentations and white space that visually creates subheadings and groups related information. An example is shown in Figure 3.

Sometimes the most important finding in a biopsy is the absence of disease. Following the analogy to newspaper formatting, this negative finding should become the diagnostic headline. For example, the diagnostic headline in a report about a reexcision breast lumpectomy without residual cancer might read: “BREAST (LEFT): NO RESIDUAL CARCINOMA,” followed by a comment mentioning the identification of a healing biopsy site and residual fibrocystic changes. In my experience, pathologists are un-
comfortable emphasizing negative findings when they have something positive to report, even if the negative findings are the most newsworthy and most in need of clear communication.

Many pathology reports contain unrelated diagnoses for multiple separate biopsies, with no single diagnosis being particularly newsworthy. For example, a patient may undergo upper endoscopy for epigastric pain that leads to a normal gastric biopsy, followed immediately by screening colonoscopy that leads to the biopsy of a hyperplastic polyp. It is difficult to construct an overarching diagnostic headline for these 2 diagnoses that enhances communication. In cases such as this, conventional sequential delineation of each specimen's diagnosis seems preferable. A single diagnostic headline is not appropriate for every report.

2. Maintain Layout Continuity

Shortly after World War II aircraft cockpit instruments were standardized in the so-called 6-pack configuration, in which an array of 6 essential gauges are arranged in 2 rows of 3, directly in front of the pilot (Figure 4). In clockwise order from the upper left are found the airspeed indicator, artificial horizon, altimeter, vertical speed indicator, heading display, and turn coordinator. Uniform positioning of instrumentation eased pilot transition from one type of aircraft to another and minimized the amount of time required for airborne flight crews to obtain situation awareness in dynamically changing environments. Even in modern commercial aircraft equipped with "glass cockpits" (computer displays instead of gauges), a computer-generated representation of these 6 gauges is often displayed on one of the screens.

Federal aviation regulations, Part 25 (14 CFR 25), empower the Federal Aviation Administration to review aircraft flight deck instruments, and systems that change the manner in which information is presented are carefully evaluated to determine if the benefits of the novel display format outweigh the risks created when continuity with other flight decks is disrupted. Authorities examine flight displays for continuity with other displays on the same instrument panel and with the flight deck on other types of aircraft a pilot is likely to encounter.
In the newspaper industry, periodicals predictably place certain types of information in the same position in each issue. For example, *The New York Times* has positioned a synopsis of the weather in the upper right-hand corner of the first page for more than 150 years. Business news predictably begins in the second section of the *Times* and opinion pieces in the right-most column of the *Times* home page on the Internet. Even the format of this article has been altered to bring it into conformance with the journal’s standard layout, to preserve formatting consistency with other articles.

Consistent use of position improves communication for 2 reasons: (1) consistent positioning speeds information transfer because attention can be quickly focused on a small “spotlight” within the visual transfer because attention can be quickly focused on a small “spotlight” within the visual field without requiring mental evaluation of all the information within the field of view; and (2) consistent use of position reduces the risk of confusion. If a caregiver knows the patient name always appears in the upper left-hand corner of a report and the physician name in the upper right-hand corner, the caregiver is less likely to confuse the two.

The pathology profession does not place as much emphasis on layout continuity as the commercial aviation industry. Within an individual clinical laboratory, report layout is reasonably standardized. The same data field tends to appear in the same position on a sheet of paper or computer screen from report to report (Figure 5). Yet, the degree of standardization within the clinical laboratory industry as a whole is poor, to the detriment of effective communication. An office-based physician required to use several laboratories by different health maintenance organization contracts will find little similarity in the way each laboratory formats results. In some reports, the patient name appears in the upper left corner; others use this same space to list ordering and “copy-to” physicians. Some laboratories report the date and time of specimen collection in a location that other laboratories use to show the date and time of result verification. When I have informally polled pathologists about where diagnoses appear in their institution’s surgical pathology reports, approximately half have indicated that the diagnosis appears at the top of the report and the remaining half indicating the diagnosis appears at the bottom. Evidently, institution-to-institution continuity of pathology reporting format is not a priority for laboratory directors, and there is no regulatory authority or professional society that has attempted to standardize the layout of pathology reports.

Similarly, little effort is typically expended to bring pathology report formats into conformance with the other types of reports clinicians examine. Vigorous debates erupt among pathologists about whether diagnoses in pathology reports belong at the top or the bottom, but rarely are radiology, specialty consultation, or cardiac catheterization reports examined to ascertain where diagnostic impressions and management recommendations are positioned in these reports, even though these reports appear alongside of pathology reports in paper charts and electronic medical records. Many pathologists who advocate placing diagnoses at the top of the page appeal to newspaper layouts. Yet examination of any newspaper reveals that the name of the paper—not the headlines—appears at the top (eg, Figure 1). In business what is arguably the most important information about a company—its profitability—is predictably found the world over at the proverbial “bottom line” of financial statements. It seems that the consistency with which information is positioned is more important than the particular location it is assigned, although subjects do show a slight tendency to first examine the upper left corner of computer screens before they move on to other areas.

In addition to stressing continuity of flight deck instrumentation systems with one another, the Federal Aviation Authority stresses the importance of maintaining continuity over time, particularly with previous flight decks the
Figure 6. A through D. Diagnostic headlines with 4 different densities of information.

A
ENDOMETRIUM: WELL DIFFERENTIATED ENDOMETRIOID ADENOCARCINOMA (FIGO I), ARISING IN A BACKGROUND OF ATYPICAL HYPERPLASIA. ENDOCERVIX FREE.

B
ENDOMETRIUM: ENDOMETRIOID ADENOCARCINOMA (FIGO GI).

Atypical hyperplasia is present.
Endocervix not involved.

C
ENDOMETRIUM: ADENOCARCINOMA.

Histologic type: Endometrioid
Histologic grade: Well differentiated (FIGO I)
Non-malignant endometrium: Atypical hyperplasia
Endocervix: Not involved

D
ENDOMETRIUM: CANCER.

Cancer type: Adenocarcinoma
Histologic subtype: Endometrioid
Histologic grade: Well differentiated (FIGO I)
Non-malignant endometrium: Atypical hyperplasia
Endocervix: Not involved

Figure 7. A. Ungrouped digits. The average subject will be able to recall 7 digits. B. Grouped digits. When the same digits are “chunked” into 4 familiar numbers, the average subject will be able to recall all 12 digits. C. When digits are chunked into unfamiliar groups, recall is comparable to the presentation in A.

3. Optimize Information Density for Readers

A common problem facing the diagnostic pathologist creating a report is determining how much information to include in a single report line and how much to include in subsequent lines. Figure 6, A through D, illustrates 4 options for reporting an adenocarcinoma of the endometrium, each providing progressively less information in the diagnostic headline and progressively more information in the text that follows. Which format communicates most effectively?

The cognitive psychology literature provides a perspective to help pathologists frame this problem. In a classic article, Miller described the now-familiar inability of an average experimental subject to store more than 7 bits of unrelated information in short-term or “working” memory. For example, the average subject presented with the string of numbers in Figure 7, A, will only be able to recall 7 of the 12 digits shown. Yet when the same digits are grouped or “chunked” into 4 familiar numbers (Figure 7, B), the average subject can recall all 12 digits, because the subject need remember only 4 “numbers.” Assembling digits into unfamiliar groups (Figure 7, C) does not significantly extend the capacity of working memory.

The remarkable ability of the human mind to extend the capacity of working memory by “chunking” information into groups has direct implications for pathology report formatting. When readers of pathology reports are already familiar with grouped pathology diagnostic terms, such as endometrioid adenocarcinoma (FIGO GI), they

7A
1 1 7 7 6 9 1 1 1 9 8 4

7B
1 1 7 7 6 9 1 1 1 9 8 4

7C
1 1 7 7 6 9 1 1 1 9 8 4

pilot is likely to have encountered. In what I believe to have been the only controlled experimental study of pathology report formatting, a change in report format (to either of two arguably better layouts) resulted in a 17% to 54% increase in recall errors by clinicians. Change creates confusion. This finding should sound a note of caution to pathologists who wish to “tinker” with local report formats. Changes should be carefully considered, implemented infrequently, and explained to caregivers in advance. In some circumstances, it may be advisable to train caregivers with the new format prior to implementation.
will mentally “chunk” these terms into a single “unit” and store the entire sequence of terms in working memory as a single “bit” of data. On the other hand, when a reader is not familiar with the grouped terms, each term becomes a separate unit of information that must be stored individually. When too much ungrouped information is packed together in a single line, some information is apt to be forgotten, and without the benefit of a headline key facts may be as vulnerable to loss as less important data. In fact, research has shown that terms in the middle of a list of ungrouped words (such as “adenocarcinoma” in Figure 6, A) are the least likely to be correctly recalled.16

Pathologists use diagnostic pathology terms on a daily basis and can be expected to be highly practiced at grouping these terms together. The diagnosis in Figure 6, A, might be the most effective approach to formatting information for other pathologists. On the other hand, Figure 6, B, might be a more appropriate level of information density for a gynecologist, because gynecologists usually have less experience in grouping pathology terms and are more at risk for overlooking a key finding if too much information is placed on a single diagnosis line. Figure 6, C, might be optimal for a general internist, whereas the format in Figure 6, D, might be best suited for a patient or for a physician’s office assistant who has been tasked with sorting pathology reports into “benign” and “malignant” stacks.

Admonishments to “write with the reader in mind” are nothing new. Nevertheless, cognitive psychology research illuminates some of the tradeoffs that underlie decisions to include more or less information in a single line of text. Organizations that wish to rigidly standardize pathology report formatting, such as requiring use of a synoptic report format, are advised to consider the different backgrounds of the many readers of pathology reports before developing synoptic style sheets. Readers of pathology reports include pathologists, other specialists, generalists, pathologists, tumor registrars, public health officials, office staff, and patients.17 With the emergence of electronic reporting, it is not difficult to envision a future in which pathologists are asked to record 2 or 3 diagnostic headlines of progressively increasing complexity, with different headlines being displayed for users of different backgrounds. In the interim, pathologists who are communicating with nonpathologists should keep in mind that their audience is likely to be less familiar with pathology terminology than other pathologists. The optimal information density in a diagnostic headline intended for nonpathologists should be less than in communications intended for other pathologists.

The phenomenon of chunking also informs some of the debate about the use of illustrations and graphics in pathology reports. Cognitive psychology research indicates that 2-dimensional representations of spacial data will be more accurately communicated and stored in working memory than 1-dimensional representations. Pictorial displays allow information to be visually chunked and increase the storage capacity of working memory.18 For example, experimental subjects will take significantly less time to acquire and be better able to recall information about the anatomical location of positive prostate biopsies when the information is presented pictorially instead of in a 1-dimensional textual array (Figure 8).

Of course, the advantage of using 2-dimensional pictorial representations to transmit spacial information is predicated on the assumption that information in the picture is important to communicate in the first place. When data contained within a picture are not important to communicate, the picture constitutes a form of visual “clutter” that competes for readers’ attention with more important information. Reduction of clutter is the final formatting principle discussed in this article.

4. Reduce Clutter

There is ample experimental evidence in the cognitive psychology literature that inclusion of distracters in a visual field interferes with a subject’s ability to acquire information. Distracters also interfere with short-term memory. Working memory decays rapidly (in tens of seconds) without mental maintenance rehearsal—repeating items to oneself.18 Distracters inhibit the rehearsal required to retain information.

Distracters can take the form of nontextual inputs (symbols, pictures, or text effects such as font changes or colors) that draw attention away from the information of interest. Distracters can also take the form of text that conveys unneeded information beyond the information that the subject is required to acquire. A particularly salient example of distracters inhibiting data acquisition is the Stroop effect, illustrated in Figure 9.19

The Human Factors Division of the Federal Aviation Authority recognizes the potential dangers posed by distracting information presented by cockpit avionics and poses the question “What does the pilot need to know?” when
reviewing instrument display prototypes. The potentially deleterious effects of providing unnecessary information in laboratory reports are known to microbiologists. In the past, antimicrobial susceptibility results were often provided for antibiotics that were inappropriate for the patient's site of infection, which caused physicians to write inappropriate prescriptions. Contemporary standards prohibit this sort of reporting; antibiotics with hepatic excretion, for example, are not reported for urinary tract isolates.20

Reporting checklists have advanced the practice of pathology by specifying a minimum set of data elements that must be included in pathology reports, but little attention has been paid to the cognitive burden placed on readers when unnecessary additional information is provided, such as descriptions of tumor attributes that do not influence management or have well-established prognostic value. Human executive capacity is limited. When formatting information, less is often more. There are many examples of extraneous or redundant information in pathology reports. For example, it is common practice to repeat the name of the procedure in the diagnosis line (eg, "COLON (RIGHT, BIOPSY); TUBULAR ADENOMA") even though the procedure is a potential distractor, particularly to the less experienced reader. Many pathology reports contain codes required for billing or other purposes (eg, CPT, International Classification of Diseases, Ninth Revision [ICD-9], SNOMED) that are distracters to the clinical reader. In our age of electronic reporting it is not difficult to produce different types of reports for different types of audiences (caregivers, billers, agents, tumor registrars, etc), reserving specialized codes for those who need them. Even disclaimers required by regulation to be included in reports (eg, "Immunoperoxidase tests utilized in this report were developed and performance characteristics determined by . . .") can be relegated to ancillary screens so as not to distract busy clinical readers from more pertinent information they must acquire. When deciding what to include in a report, the possibility that some reader might use a piece of information must be balanced against the possibility that the information will distract another reader and result in a cognitive error.

When the same type of information is positioned consistently from one report to the next, it is often unnecessary to precede the information with an explanatory label (such as "PATIENT NAME:" ). In these cases, position alone is adequate to define content and visual clutter produced by labels can be reduced. Determining when labels are necessary and when they constitute clutter is not always straightforward and may require validation by testing a group of report readers. Personal preference is not always synonymous with good design.

Pathologists are cautioned against blaming readers when reports are misunderstood because they include too much information. Although many pathologists will admit privately to harboring the view that physicians who cannot understand their reports "should not be practicing medicine," frustration is more profitably redirected to eliminating the clutter that caused the caregiver to misunderstand the report in the first place. No one would feel much sympathy for an aircraft instrument manufacturer who responded to a fatal aircraft accident with a quip that "a pilot who cannot understand our display should not be flying an airplane." Sharing examples of actual reports in continuing education forums may help practicing pathologists develop an eye for layouts that are less cluttered. This sort of sharing is not currently the norm. The handouts from my last 150 hours of anatomic pathology continuing medical education did not contain a single example of an actual pathology report and contained only 2 examples of actual diagnosis lines or comments used in reports.

**PRESERVING FORMATTING OVER ELECTRONIC INTERFACES**

The pathology profession is at a watershed with respect to the method used to distribute reports. Informal polls I have conducted suggest that at the time of this writing more than 75% of pathology reports for inpatients are now being first viewed on hospital information system computer screens instead of paper, whereas the great majority of outpatient pathology reports continue to be printed on paper that is physically distributed to caregivers. Given the increasing reliance on electronic transmission of reports from laboratory information systems to other computers, maintaining the integrity of formatting during transmission from one system to another deserves consideration.

The vulnerability of formatting to degradation over interfaces depends on the capabilities of the sending and receiving systems and the interface protocol in use. Today, the interface protocol most commonly used to transmit pathology reports between information systems is HL7 (Health Level 7, Ann Arbor, Mich). HL7 supports lower and uppercase text and commonly used punctuation characters but in most implementations does not allow the sending system to specify text characteristics (font, bold, size, color, etc) or sophisticated formatting commands (columns, tables). For this reason, reliance on text effects to focus readers' attention is discouraged in environments where electronic interfaces are likely to be used. Use of UPPERCASE characters is generally sufficient to draw readers' attention to diagnostic headlines.

Figure 10, A, illustrates one of the most common formatting problems created by interfaces. Pathologists who attempt to align text that is displayed in a fixed width font in a pathology information system (eg, Courier) often do not realize that alignment is lost when text is printed or
displayed in a proportional font (eg, Arial or Times Roman) because the ‘‘space’’ character in a proportional font is accorded less width than most other characters. Similar problems arise when aligned lines created in a proportional font are printed or displayed using a fixed width font. A simple solution to this problem is shown in Figure 10, B: Use a separate line to introduce the text, and align the next 2 lines using an equal number of ‘‘space’’ characters that will be compressed equally when rendered in proportional fonts.

Tables are extremely sensitive to garbling when transmitted over an interface using the most commonly used release of the HL7 protocol because the protocol contains no formatting command for tables and alignment relies on character spacing that can vary as fonts change. Figure 11 shows a report from an institution that constructed an elaborate table to concisely display prostate cancer prognosticators. The information contained within the table has been rendered unintelligible after transmission from one information system to another. Use of the synoptic format illustrated in Figure 2, B, provides a more robust approach to transmitting data over an interface, although a synoptic report is often less compact than a tabular report.

Many interfaces are programmed to strip leading spaces or blank lines from textual reports, in an effort to conserve visual space. This practice should be discouraged because properly formatted ‘‘white space’’ improves readability. Figure 12 illustrates what happened to a well-formatted pathology report when leading spaces and blank lines were removed, carriage returns were added to the ends of lines, and the report was displayed on a system that could not accommodate 80 characters per line, causing irregular wrapping of text. Although still interpretable, the resulting report requires considerably more effort on the part of the reader. Most staff responsible for managing electronic interfaces will deactivate this type of editing if asked.

Finally, use of certain characters can cause erratic behavior when reports are transmitted over an interface because interface engines interpret these characters as record or field separators, memory variables, or encapsulation sequences. Limitations vary from system to system, but at the time of this writing 4 characters are particularly apt

10A

**Specimen margin:** Free of invasive carcinoma by 5 mm
Free of in-situ carcinoma by 1 mm

10B

**Specimen margin:**
Free of invasive carcinoma by 5 mm
Free of in-situ carcinoma by 1 mm

11

**MICROSCOPIC DIAGNOSIS:**

1. Prostate, left base, biopsy (JS05-23240): Adenocarcinoma of the prostate, Gleason score 3+3=6. Please see template.

2. Prostate, right base, right mid, right apex, left mid and left apex, biopsies (JS06-25240): Benign prostatic tissue.

**PROSTATE CORE BIOPSY**

<table>
<thead>
<tr>
<th>Site</th>
<th>Positive Carcinoma volume</th>
<th>Gleason(1)</th>
<th>Gleason(2)</th>
<th>Gleason PNI cores/</th>
<th>score (Yes)</th>
<th>Total</th>
<th>Total Greatest pattern %</th>
<th>pattern %</th>
<th>/No</th>
<th>Others % of Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>L base</td>
<td>1/2</td>
<td>Less than 5%</td>
<td>5%</td>
<td>3/50</td>
<td>3/50</td>
<td>6</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Slide labelled D**
12A

LIVER: CHRONIC HEPATITIS WITH MODERATE ACTIVITY AND CIRRHOSIS.

Histologic activity index (HAI) score: 11
- Lobular injury: 1
- Piesemeal necrosis: 3
- Portal infiltrate: 3
- Fibrosis (Trichrome): 4

There is mild macrovesicular steatosis, scattered Mallory’s hyaline, ballooning degeneration, and pericellular fibrosis typical of steatohepatitis. In addition, characteristic features of HCV are present, including focal nodular lymphoid portal infiltrates and a sinusoidal pattern of mononuclear inflammation. At this stage it is difficult to ascertain the degree to which each contributes to ongoing injury.

12B

LIVER: CHRONIC HEPATITIS WITH MODERATE ACTIVITY AND CIRRHOSIS.

Histologic activity index (HAI) score: 11
- Lobular injury: 1
- Piesemeal necrosis: 3
- Portal infiltrate: 3
- Fibrosis (Trichrome): 4

There is mild macrovesicular steatosis, scattered Mallory’s hyaline, ballooning degeneration, and pericellular fibrosis typical of steatohepatitis. In addition, characteristic features of HCV are present, including focal nodular lymphoid portal infiltrates and a sinusoidal pattern of mononuclear inflammation. At this stage it is difficult to ascertain the degree to which each contributes to ongoing injury.

to cause difficulties. The vertical bar (|) character (sometimes called the ‘pipe’ character) and the caret (^) character should generally not be used in reports because they can be confused with field separators that are part of interface protocols. The ampersand (&) and ‘at’ (@) characters may also be translated as field separators by certain data parsers. In some implementations the ampersand character may additionally produce erratic displays on computer screens or erratic printing behavior. This can occur when the ampersand is followed by certain letters, because a data parser may interpret specific ampersand + letter combinations as memory variables or an encapsulation sequences. Prudence discourages use of these 4 characters in pathology reports.

COMMENT

The patient safety movement has identified handoffs as a vulnerable step in the continuum of care. When responsibility to care for a patient is handed off from one provider to another without transfer of important clinical information, patients are placed at risk. Laboratory directors and consulting pathologists have an interest in ensuring that information emanating from the pathology service is accurately handed off to caregivers. Knowledge accumulated in the publishing and commercial aviation industries and cognitive psychology research can help pathologists present information in a manner that facilitates timely acquisition and minimizes the potential for confusion.

This review has highlighted 4 report design principles that improve the fidelity of communication. These are (1) using diagnostic headings; (2) maintaining layout continuity from report-to-report, between departments, and between institutions; (3) formatting report text so that it has an information density appropriate for the reader; and (4) eliminating clutter that can distract attention and create confusion. Because the research supporting these 4 principles was conducted outside the field of pathology, readers should remain open to the possibility that factors unique to pathology may cause some of these principles to be less applicable within our specialty. Well-controlled studies are required to give us a sense of the relative importance of these 4 principles in our work. Several additional limitations of this review should be kept in mind. Each of the 4 principles described in this article involve tradeoffs. None can be applied ritualistically. Some biopsy findings do not lend themselves to an overarching “diagnostic headline” format. Excessive zeal to eliminate “clutter” may deny some readers access to information they require. No one format is suitable for all pathology reports, just as no one newspaper format is suitable for all news stories or all types of readers.

Several specific issues related to pathology report formatting have not been addressed in this review because I have not been able to identify guidance that has reasonable experimental support. In particular, I have not discussed the best way to format preliminary, corrected, or addendum reports; the inclusion of photomicrographs as a communication tool; how (or whether) to document in a report that consultations have been obtained or time-sensitive results have been called; issues surrounding the use of advanced electronic formatting techniques; and issues that arise when presenting quantitative data.

Finally, I have not stressed the importance of communicating the correct diagnosis, although it hardly needs emphasis. Using exquisite formatting techniques to more effectively communicate inaccurate information will not advance patient care. Good formatting should be considered an adjunct to accurate diagnostics, not a substitute.

These limitations notwithstanding, the principles and...
caveats contained in this review should promote speedier, more complete, and less error-prone transmission of information. Clinicians examining pathology reports may not understand how different reporting formats can speed data transfer or make communication more certain. The absence of complaints about reports from caregivers does not relieve pathologists of our affirmative responsibility to communicate clearly, using techniques proven to improve the transmission of important information.

References