

## A Clarity Clinic for Surgical Writing

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**Although writing and publishing are key to career development and academic success for surgeons, learning the skills needed to write publishable research reports is an often neglected aspect of surgical training. This report distills several lessons from scientific writing courses for surgeons taught at the University of California, San Francisco, to give a wider audience of academic surgeons tools they can use to write scientific prose more clearly. Drawing extensively on real examples of surgical writing, we cover techniques that are indispensable for achieving clarity, including choosing words carefully, designing well-constructed sentences, building structured paragraphs, and displaying your thinking clearly by using topic sentences and transitions.** © 2007 Elsevier Inc. All rights reserved.

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### INTRODUCTION

Few surgeons set out to become writers, yet writing is essential for a successful career in academic surgery [1]. The assumption that having an advanced degree in science or medicine means one can write effectively has generally proved unfounded [2], and scientific writing continues to come under attack for being dense, unclear, riddled with jargon and abbreviations, and downright unreadable [3–7]. Surgical writing is no exception. When the time comes to put fingers to the keyboard, young surgeons do what other young scientists do—they imitate their elders in a “culture of bad writing” that is self-perpetuating [4].

Although formal instruction in scientific writing could help break the cycle of bad writing [4], few academic physicians report having received any [1, 8–11].

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Over a combined period of 30 years, professional academic biomedical editors in the Departments of Surgery and Neurological Surgery at the University of California, San Francisco (UCSF) have offered formal courses and one-to-one consultation in scientific writing and reporting on a regular basis for department faculty, fellows, and residents, as well as for medical students working with a surgical mentor. This report distills lessons from these programs to give a wider audience of academic surgeons tools they can use to write clear, precise, effective scientific prose.

### WRITE WITH YOUR READERS IN MIND

When polled on the first day of class, surgeons in our scientific writing courses usually say that they dislike reading scientific journal articles. They find that much of what they read lacks a clear message and is densely written and poorly focused. The first lesson they learn that day is the reason, which is that too many scientific papers are written to serve the need to publish rather than the need to communicate with readers.

To write a paper that can be understood—and cannot be misunderstood—you must keep your readers in mind [12, 13]. In addition to your colleagues, these readers may be medical or graduate students and fellows who are just gaining familiarity with your field, as well as scientists and surgeons not working in your field, many of whom are not native speakers of English. With the impact of the Internet, even patients and potential patients may read your work. Among your colleagues, most must fit reading into a hopelessly busy schedule, which means they read quickly and may misinterpret, or simply miss, ideas at any point that slows their reading down.

The second lesson that surgeons in our writing courses learn is that the burden of clarity rests with them, as the author. The reader's job is to follow the author's thinking and assess the author's work—it is



not to decode or reconstruct the paper. Achieving clarity in surgical writing is not a complex process. It rests on several basic skills (Table 1.).

## CHOOSE WORDS CAREFULLY

### Aim for Precision

The words you choose to write about your work should be as precise as your work itself. For example, if you measured an *increase* or *decrease* in a measurement, say so—do not simply say you saw *a change*. In the sentence:

**Large proportions** of even asymptomatic lesions are premalignant or malignant, the phrase *large proportions* is vague. By giving readers the actual percentage or range of percentages instead, there is no doubt about how many asymptomatic lesions are premalignant or malignant; for example:

TABLE 1

### How to Achieve Clarity in Surgical Writing

#### Choose words carefully

Aim for precision: use *increased*, not *changed*.

Use *by*, *when*, *upon*, *resulting in*, not *with*.

Avoid wordiness: replace or delete “*it . . . that*” clauses.

Avoid jargon.

Avoid non-standard abbreviations.

Avoid word clusters.

Choose humane words.

Consistently use the same word for the same thing.

#### Write well-designed sentences

Make the topic the subject of the sentence:

use *Infection rates did not decrease after surgery*,

not *Patients showed no decrease in infection rates after surgery*.

Put the action in the verb:

use *Heart rate increased*, not *An increase in heart rate was seen*.

Write short sentences.

Write comparisons clearly.

Use pronouns effectively:

*This* and *these* are often ambiguous because the noun they refer to is unclear.

Avoid writing flaws:

The subject and verb of the sentence should make sense together;

Do not omit “helping” verbs;

Avoid dangling modifiers.

Use passive voice selectively:

to emphasize the object that is being acted upon, as in describing a method.

Avoid burying key points and important findings by placing all but the most important numerical data in the tables and figures.

#### Write structured paragraphs

Use topic sentences that state your main idea clearly and directly.

Organize supporting details:

e.g., cause and effect, effect and cause, comparison and contrast, definition, illustration, classification, narration, most to least important.

Establish continuity:

Use topic sentences, the same word for same thing, transitions, a consistent point of view.

**Between 3 and 8 percent** of asymptomatic lesions are premalignant or malignant.

### The Use of With

In much medical writing, use of the word *with* is particularly imprecise. Depending on the context, *with* can mean *by*, *when*, *upon*, *resulting in*, *creating*, *plus*, or *containing*. The use of *with* makes it difficult to understand the meaning of the following sentence:

*Measurements of  $L_p$  were taken immediately and then at 5-min intervals up to 20 min **with** continuous perfusion of the test solutions.*

Perhaps the author really meant to use *while*:

*$L_p$  was measured immediately and then at 5-min intervals up to 20 min **while** the test solutions were continuously perfused.*

### Other Common Imprecisions

The word *limited* can create ambiguities because it is used to mean concepts from *low*, to *restricted*, to *partial*. If you mean a *minimal dosage requirement*, say so—or better yet, specify the exact range of the dosage required. Similarly, the word *level* lacks precision—be clear whether you mean, for example, *amount*, *number*, *quantity*, *degree*, *intensity*, *proportion*, or *concentration*. Other common imprecise words are *involved*, *similar*, and *including*. The word *involved* often shows up in a sentence like this:

*Suturing **involved** cannulation of the radial artery for the recording of arterial pressure.*

The more precise word would be *required* cannulation.

The word *similar* does not mean the same thing as the word *same*, as in this example:

*We prospectively collected donor, recipient, and transplant data for 20 consecutive transplants performed during the first year of our program. **Similar** data were retrospectively collected for a historical cohort.*

Were the data only *similar*? If so, the author must go on to tell us how the data collected differed for the historical cohort—but in this case, the data did not differ. Therefore, a more precise alternative would be: *The **same** categories of data were retrospectively collected . . .*

The word *including* is not comprehensive, but authors often use *including* rather than *consists of*, which would be unambiguous. In the following sentence, the use of *including* means there could be additional indications beyond those listed:

*Administration was at the discretion of the transplant surgeon for indications **including** high immunological risk and delayed or slow graft function.*

However, if the indications listed are the *only* ones, the more precise sentence would be:

*The choice of therapy was at the discretion of the transplant surgeon for indications **consisting of** high immunological risk and delayed or slow graft function.*

If the author really did mean that there could be additional indications, then the more precise sentence would be:

*The choice of therapy was at the discretion of the transplant surgeon for indications **including** high immunological risk or delayed or slow graft function, **among others**.*

The word *comprises* means *includes*, but because it is now used more and more often to mean *consists of* or *is composed of*, its meaning has become confused. So that readers do not misunderstand you, consider not using the word *comprises* in your medical writing.

### Temporal Ambiguities

*While* is often used to mean *although* or *whereas*, and *since* is often used as a synonym for *because* or *as*. Because *while* and *since* also have a primary temporal definition, they may trigger conflicting interpretations, momentarily slowing the reader down. In medical writing, they can even be misinterpreted—for example, in the sentence:

*He has been on a restricted diet **since** he was diagnosed with diabetes,* placing a comma before *since* would improve clarity—but because *since* can so easily cause ambiguity, it is better to use *because*, rather than *since*, in medical papers, unless you actually mean *from the time when . . .* In this case, the sentence might be revised to:

*He is on a restricted diet **because** he was diagnosed with diabetes.* It is safe to use *while* rather than *although* or *whereas* when you mean to imply *even as . . .* or *at the same time that . . .*

### Which or That?

Some people will tell you it doesn't make any difference whether you use *which* or *that* to introduce clauses within a sentence, but in medical papers the choice can be important. Take this sentence:

*This surgical approach has been particularly useful in the removal of supratentorial brain tumors **which** are cystic.*

The writer should have chosen to use *that* because the use of *which* defines all brain tumors as cystic. Although surgeons know that many brain tumors are not cystic, a patient seeking information, a medical student, or even a physician in an unrelated field may not. How can you tell which word to use? Take the sentence,

*Dr. Smith likes watches that are expensive.*

Not all watches are expensive, and when we use *that*, we mean that Dr. Smith likes only the expensive subset of the set of all watches—the information in the clause *that are expensive* is indispensable to the meaning of the sentence. Now consider,

*Dr. Smith has a Rolex watch, which is expensive.*

As there are no inexpensive Rolex watches, *which is*

*expensive* refers to the whole set of Rolex watches and simply gives you additional information about the set. To increase certainty that readers know you mean to use *which*, and not *that*, always use a comma before *which* in a clause beginning with *which* [14].

### Avoid Wordiness

In addition to being precise, resist the urge to use less familiar words or long words when more commonly used, shorter words will do. Surgeons are not the only authors who have grown conditioned to writing “platitudinous statements with portentous nouns and adjectives” [5]. For example, *constitutes*, *represents*, *exists*, and *serves as* are often used instead of the simplest of words, *is*. One or two inflated words scattered throughout a few paragraphs will not unnecessarily burden your readers, but when you pile them up, the effect is deadening. Do patients do *more poorly* or simply *worse*? Do you really need to use words like *facilitate* for *ease*, *implement* for *do*, *adopt* for *use*, *afford* for *give*, *initiate* for *begin* or *start*, *elevated* or *enhanced* for *increased*, *encountered* for *saw* or *found*, *majority* for *most*, *methodology* for *method*, *modality* for *technique*, *modify* for *change*, *optimum* for *best*, *paradigm* for *pattern* or *example*, *parameter* for *variable*, *perform* for *do*, *prior to* for *before*, *superior to* for *better than*, *target* for *aim*, or *visualize* for *see*? Such inflated language is often confusing or imprecise and should be avoided if you want to communicate effectively with other surgeons, let alone a more general readership.

Examine your writing for wordy phrases such as: *it would thus appear that . . .*, *it is interesting to note that . . .*, and *it is often the case that . . .* These “running starts” can usually be replaced by a single word—*apparently*, *interestingly*, or *often*—or simply deleted. Other typical wordy phrases include *has the capability to . . .*, *is of the opinion that . . .*, and *is unable to . . .* [15], each of which has a one-word equivalent—*can*, *believes*, and *cannot*. Similarly, many phrases used to indicate an amount, for example: *one of the . . .*, *a small number of . . .*, *a majority of . . .*, can be replaced with single words like *one*, *some* or *a few*, and *most* [15]. You can also delete unnecessary adjectives and adverbs, like *fundamentally*, *very*, and *great*. These concepts will be implied by the sentence itself. Can you find the extra words in the following example?

*A vascularized pericranial transposition flap is effective in providing a secure and watertight closure over the dural defect and increasing the blood flow to the region to aid in healing.*

If you chose *is effective in providing*, you are right. The phrase can be replaced with one word: *provides*.

### Help Your Reader Understand You

Whenever possible, avoid making up words, using jargon and nonstandard abbreviations, and creating

clusters of nouns whose relationship to one another is unclear—all of which stand between the reader and the message you are trying to communicate.

### Jargon

Although there may be a grudging consensus that *heparinized patients* means patients who have been given heparin in some form, do not venture further in that abysmal direction by describing your patients as *coumadinized*, *spinalized*, or *thyroidectomized*, or next we will be seeing patients who are *surgerized*. Jargon, such as *living partial grafts*, *cutdowns of the artery*, *the patient was obstructed*, and *cord boost to bulky disease*, for just a few examples, is comprehensible to only a subset of your potential readers. In this sentence:

*The suture was **left tightened** for 45 min, constituting the ischemic period of the procedure,*

what does *left tightened* mean? It could be interpreted to mean *tightened from the left side of the artery* rather than *was tightened to occlude the artery*.

Jargon is often used to describe steroid use, as in this example:

*All patients received corticosteroids intravenously beginning in the operating room followed by **an oral prednisone taper**.*

The clear phrase would be *a tapering dose of oral prednisone*. Similarly, a *steroid-sparing strategy with rapid taper to off . . .* could be revised to say, *a steroid-sparing strategy in which the dose was rapidly tapered before being stopped*. In this example:

*There was a trend toward more patients in the historical cohort's being **discharged on sirolimus** (24% versus 5%,  $P = 0.094$ ), most often as a **bridge to delayed initiation** of calcineurin inhibitors,*

*discharged on sirolimus* and *bridge to delayed initiation* are jargon—the sentence is confusing. Why not opt for being simple and clear, as in:

*More patients in the historical cohort were taking sirolimus when they were discharged (24% versus 5%,  $P = 0.094$ ), in most cases to delay their having to take calcineurin inhibitors.*

### Abbreviations

Readers become numb to what they're reading when bombarded with abbreviations. Nonstandard abbreviations are clear only to those who already know what they mean, so bear in mind two essential points [13]:

- Readers can handle no more than two or three abbreviations per paragraph.
- An abbreviation should be used often enough in the paper—preferably more than 10 times—so that the reader does not forget the meaning.

Abbreviations definitely detract from clarity. If you find yourself creating alphabet soup to make your paper meet a journal's word limitations, remember to

look for the extra words and phrases in the text you have written and cut those instead.

### Word Clusters

Clusters of nouns used as an adjective, as in the term, *0 antigen mismatched deceased donor kidney*, are a lot like unfamiliar abbreviations. There are too few words used to make the meaning clear to readers who are not already familiar with the term. Unlike so much scientific writing that is verbose to a fault, such clusters are too telegraphic. What words are generally missing from a cluster? Tiny words like *of* and *in*—the prepositions. Prepositions indicate how the nouns are related to each other. To unravel a cluster like this, reorganize terms to make the meaning clear and add any prepositions that are missing. Doing so results in *a kidney from a deceased donor with no (zero) antigen mismatches*. Likewise, unraveling would turn *small polypeptide/medium chain triglyceride enteral diets* into the much more accessible *enteral diets containing small polypeptides and medium chain triglycerides*. Like an abbreviation, a cluster may be permissible when necessary because the more lengthy term is used often in the paper—and like an abbreviation, the shortened cluster is defined clearly by the unraveled cluster the first time it is used and is introduced, for example, by saying, . . . *which in this paper, we term zero antigen mismatched kidney*.

### Choose Humane Words

Choosing your words carefully also means being inclusive, not being sexist, and not blaming the patient when therapy fails. Sexist references often can be avoided easily by using a plural subject:

*The surgeon can do much to encourage his patients to be optimistic,*

can be revised to:

*Surgeons can do much to encourage their patients to be optimistic.*

Although it may be convenient shorthand to talk about patients *failing therapy*, in medical writing avoid blaming the patient for what surgery cannot accomplish. Patients earn respect as the focus, the support, and the sustaining force of biomedical research. With respect for the patient in mind, then, how would you revise this sentence?

*Patients who fail surgical resection, radioiodine ablation, and thyroid-stimulating hormone suppression have no other proven treatment alternatives.*

One solution would be to say,

*When treatment with surgical resection, radioiodine ablation, and thyroid-stimulating hormone suppression are unsuccessful, there are no other proven treatment alternatives.*

In many examples of surgical writing, patients not only *fail* treatment, they also *resist* it. Here is one example:

*Notably, in patients resistant to treatment, the urocortin 1 level never changed.*

To avoid dehumanizing the patient, revise the sentence so that the *disease* is the culprit:

*Notably, in patients who had disease resistant to treatment, the urocortin 1 level never changed.*

An important exception is if you are writing about genetic testing to isolate people who may not respond to certain types of therapy because of their genetic makeup. In such a case, saying that patients *are not responsive to treatment* or *do not respond to therapy* would be correct.

#### Consistently Use the Same Word for the Same Thing

If surgeons can be relied on to remember one rule from high school composition class, it is to use different words for a thing because repeating the same word is boring or uncreative—for example, a *ghost* may then be called a *spirit*, and then an *evanescent being*. But in scientific writing, the same term for an idea or element in a paper—whether it is a technical term like *G protein* or a nontechnical term like *increase* or *function*—should be repeated consistently from sentence to sentence throughout the paper. This repetition is the strongest technique for providing continuity. Whatever you can do to keep readers from having to work to figure out what you mean will help them understand your work more clearly while reading quickly. If a key term is not repeated exactly, and instead another term is used, readers need to do a mental manipulation to be certain whether the two terms mean the same thing, thereby forcing them to divert their attention from the scientific content.

#### WRITE WELL-DESIGNED SENTENCES

Imprecise, inflated, or superfluous words are a big problem in surgical writing, but *how words are arranged in sentences* causes additional problems. Sentences are clearest, most forceful, and easiest to understand if they are simple and direct [13]. Complicated sentences are hard to follow, slow the reader down, and are often confusing. For example, in the following sentence:

*Elimination of genomic DNA was performed,*

the writer used a weak verb, *was performed*, but the true action of the sentence, *eliminate*, is in the subject instead of the verb. The sentence can be revised to be simpler and more direct:

*Genomic DNA was eliminated.*

Not expressing the action of the sentence in the verb is just one of several common problems surgeons have in constructing sentences. The following techniques,

which we have adapted from Zeiger's excellent textbook [13], have helped surgeons in our scientific writing courses learn to write simple and direct sentences and avoid making grammatical mistakes.

#### Make the Topic the Subject of the Sentence

One important technique for writing a simple and direct sentence is to make the topic the grammatical subject of the sentence. In the following sentence:

*Patients showed no decrease in infection rates after surgery,*

the grammatical subject and apparent topic of the sentence is the patients—but then the core meaning of the sentence is *patients showed no decrease*, which doesn't tell you much. The actual topic of interest in this sentence is the *infection rates*. To make the topic the subject, you can revise the sentence as follows:

*Infection rates did not decrease after surgery.*

This revision communicates the message.

#### Put the Action in the Verb

In English, verbs are where the action is. If the action of a sentence is expressed by the main verb, the sentence is natural, direct, and easy to understand, as in this sentence:

*Oxygen levels decreased.*

If the action winds up in the subject, object, or a prepositional phrase, the reader has to stop to decode the message, as in this sentence:

*A decrease in oxygen level was seen.*

The phrase *was seen* is a red flag that the true action is not in the verb.

To put the action in the verb, you need to liberate verbs that are "imprisoned" elsewhere in your sentence. Look for weak verbs, such as *was performed*, *occurred*, *was achieved*, *was observed*, *was noted*, and *was seen*. Look for nouns made from verbs, such as nouns ending with: *-tion* (prolongation, formation), *-ment* (measurement, assessment), *-ence* (occurrence, existence), and *-al* (removal, disposal). Also look for *increase* and *decrease* used as nouns.

Once you make the topic the subject and put the action in the verb, you can revise the following sentence:

*Isolation of cells and microsomal membranes was carried out as described previously.*

First, replace the abstract noun *isolation* with the active verb form, *isolated*. When you do that, you no longer need the weak, passive verb *was carried out*, and the result is:

*Cells and the microsomal membranes were isolated as described previously.*

Now try one more for good measure:

*Imaging of the symptomatic breast was performed in the sagittal orientation.*

The tipoff is the weak passive verb *was performed*. That is your cue that the real verb lies imprisoned

elsewhere in the sentence—in this case, in the subject. As the real action is *imaging*, revise the sentence so that *image* is the verb:

*The symptomatic breast was **imaged** in the sagittal orientation.*

#### Write Short Sentences

As many of us write a first draft, we tend to pack several ideas into long sentences to get our thoughts out on paper. Sentences that go on for more than two or three lines can often be broken into shorter sentences that will make the paper easier to read and the ideas easier to understand. The following sentence is overloaded:

*The other six rats per group were followed serially by laser Doppler perfusion imaging and then were studied at 30 days after gene delivery for a clinical ischemia index and angiograms before sacrifice.*

Breaking it into two sentences makes it easier to understand:

*The other six rats per group underwent laser Doppler perfusion imaging at several time points. Thirty days after gene delivery, a clinical ischemia index and angiograms were obtained before the rats were humanely killed.*

Note that the ambiguous phrase, “*were followed serially*” has been replaced with the more precise “*underwent . . . at several time points.*” The awkward “*studied for an ischemia index and angiograms*” has been replaced by the simpler phrase “*a clinical ischemia index and angiograms were obtained.*” In addition to breaking up overlong sentences, remember that shorter sentences have more impact and should be used to express your most important points.

#### Write Comparisons Clearly

Although scientists compare things all the time, they often don't do so clearly. One problem is the comparison of unlike things [13]. The sentence, *These **results** are similar to previous **studies***, compares apples (*results*) to oranges (*studies*). The revision is simple: *These **results** are similar to **the results** of previous studies.* Now results are compared with results. You could even shorten the sentence by saying: *These **results** are similar to **those** of previous studies.*

Ironically, another problem with writing comparisons is the use of *as compared to*, as in this example: *Treated animals will show improved body weight gain, decreased bloody diarrhea, and decreased pro-inflammatory cytokine production **as compared to** control animals.*

This wording leaves ambiguous whether control animals will not show these changes at all, or whether treated animals will show greater decreases in these variables than will controls. A revision might be:

*Treated animals will have greater body weight gain, less severe bloody diarrhea, and lower pro-inflammatory cytokine production **than** will control animals.*

By using the word *than* in comparisons containing a comparative term like *higher*, *greater*, *lower*, or *less*, you will avoid this problem, especially when you are talking about an increase or a decrease.

#### Use Pronouns Effectively

Pronouns—for example, *he*, *she*, *it*, *they*, *them*, *this*, *that*, *these*, and *those*—are words that replace or refer to a noun. If it is not clear, in a sentence, which noun a pronoun refers to, the reader may have trouble understanding the sentence. Particularly when *this* and *these* are the pronouns used, the usual reason the sentence is unclear is that there is no noun for the pronoun to refer to. In the following sentence, *this* is ambiguous:

*Candidates who are assured of receiving a kidney donated by a standard criteria donor can be removed from the expanded criteria donor list. **This** is currently a provision of our Expanded Criteria Donor Program.*

Does *this* refer to periodic reconsideration of candidacy, or to removal of such candidates? To make the meaning of *this* immediately clear, repeat a word from the previous sentence after *this*, for example: *This removal is currently a provision . . .*, or *This periodic reconsideration is currently a provision . . .*

#### Avoid Writing Flaws

When any of several writing flaws appears in a paper, the reader has to slow down and may need to reread the sentence to decode the intended meaning. One such flaw is that the subject and verb of the sentence do not make sense together—for example, saying that *negative controls were performed* when you mean that *negative controls were created*. Similarly, in the sentence, *The laparoscopic approach was performed in six mice*, is it correct to *perform* an approach? A clearer statement would be to say that the *laparoscopic approach was used*.

Another flaw is omitting what are called *helping verbs*. In the following sentence:

*Cells **were stimulated** with each compound and the amount of heat shock protein production **measured** after 24 h,*

the word *cells* is plural, so *were stimulated* is correct, but the word *amount* is singular, so carrying over the helping verb *were* is not correct. Instead, the helping verb *was* must be included. Omitting helping verbs is especially common in the Methods section.

A third writing flaw to avoid is the dangling modifier. Dangling modifiers abound in the Methods section. A modifier describes, clarifies, or gives more detail about a person, place, or thing named in a sentence. The following is a typical example:

*Before making each port site incision, a 5–0 prolene suture was placed around the planned site in a “purse-string” fashion to help maintain a sealed pneumoperitoneum.*

The way this sentence is constructed, the suture will be making the incision, as *suture* is the noun modified by the introductory phrase. This sentence needs revision to make it clear who is making the incision:

*Before making each port site incision, we placed a 5–0 prolene suture . . .*

Equally correct is to recast the sentence: *Before each port size incision was made, a 5–0 prolene suture was placed.*

In the example, *Using a direct entry Hasson technique, a 1.9 mm, 30°, rigid fiberoptic camera was introduced through a 2.5 mm incision*, it is the camera using the Hasson technique. You could revise this to say, *Using a direct entry Hasson technique, we introduced a 1.9 mm, 30°, rigid fiberoptic camera . . .* Also acceptable would be to say, *A direct entry Hasson technique was used to introduce a 1.9 mm, 30°, rigid fiberoptic camera . . .*

Although none of these particular examples is a major crime against scientific clarity, they make readers work harder to understand your meaning and will slow their reading down. More important is that these flaws can sometimes cause confusion and even misunderstanding, and they are sometimes a source of unintentional humor. In the following example,

*After making the midline skin incision, the patient has self-retaining retractors placed to retract his scalp, the patient makes his own incision—inadvertently referencing a real crisis in surgical care.*

#### Use Passive Voice Selectively

We just used examples of sentences written in passive voice—for example, *Before each incision was made, a suture was placed*. Passive voice is probably the most ubiquitous marker of conventional medical scientific style. Many scientists use passive voice because they think that it is objective or that it would be somehow unscientific or immodest to name the agent of action in a sentence. In any type of writing, though, the active voice is more precise and less wordy than the passive voice.

Active voice energizes your writing because the subject is *doing* something. In contrast, the passive voice can obscure your true meaning and compound your chances of producing inflated prose and grammatical errors, like the dangling modifiers we reviewed earlier. The key in scientific writing is not to overuse the passive voice. Clauses that begin with “it” and end with “that,” such as *it is thought that . . .* usually indicate that passive voice is being used. You have no doubt come across phrases like *it is clear that . . .*, which means *clearly*, and *it is worth pointing out that . . .*, which means *note that . . .*. The following is a typical example of passive voice:

*The prolene suture was tightened, occluding the su-*

*perior mesenteric artery until cessation of flow in the study venule was visualized.*

The phrase *until cessation was visualized . . .* is needlessly wordy, not to mention the problem of using *visualized*—which means “to form a mental image”—instead of *see*, which means “to perceive with the eye” [16]. A more straightforward revision would be:

*The prolene suture was tightened, which occluded the superior mesenteric artery until flow in the study venule ceased.*

You do not need to avoid passive voice altogether. A good rule of thumb is to use passive voice to emphasize the object that is being acted upon, as in describing a method—for example, *Cells were washed . . .*—but to use the active voice to focus on the person, animal, or thing performing the action. When stating a goal, intention, or hypothesis, for example, say, *We hypothesized . . .*

#### Emphasize What Is Important

A simple, direct sentence conveys a clear message. A long, complicated sentence that is peppered with numbers and *P*-values often obscures the actual message the sentence is meant to convey. Like many scientists, surgeons often cannot resist including lots of data in the sentences they write to describe their results, even if they have provided a table or figure that presents the data in detail. To avoid burying key points and important findings, place all but your most important numerical data in the tables and figures. As for the numerical data that must stay in the sentence, subordinate them so they appear where they most clearly and concisely relate your findings. The following example includes the study data without conveying the finding they represent:

*Mean recipient wait time was  $1.8 \pm 0.9$  years for transplant recipients versus  $4.1 \pm 1.4$  years for historical controls ( $P < 0.001$ ).*

It is more meaningful for readers if a sentence describes a result in practical terms, gives an indication of magnitude, and subordinates all of the data, often at the end of the sentence:

*Transplant recipients waited less than half as long as historical controls ( $1.8 \pm 0.9$  versus  $4.1 \pm 1.4$  years) ( $P < 0.001$ ).*

A statement of the comparison is less cluttered and more succinct—refer the reader to the figure for more details:

*Myeloperoxidase (MPO) activity was approximately 17-fold greater in the treated group than in controls ( $773 \pm 192$  versus  $44 \pm 39$   $\mu\text{U MPO/mg protein}$ ) (Fig. 0).*

Here is another example that contains almost more numbers than words:

*Three variables were independently associated with delayed graft function: recipient height (odds ratio (OR)*

1.20; 95% confidence interval (CI) 1.04–1.39;  $P = 0.131$ ), number of HLA matches (OR 2.26, 95% CI 1.07–4.75;  $P = 0.032$ ), and cold ischemia time (OR 1.25; 95% CI 1.06–1.48;  $P = 0.008$ ) (Table 0).

To restore this to a readable sentence, refer the reader to the table for the details:

*Multivariate analysis showed that only recipients' height, number of HLA matches, and cold ischemia time were independently associated with delayed graft function (Table 0).*

## WRITE STRUCTURED PARAGRAPHS

Paragraphs make your writing more accessible and easier to read because they break your writing up into manageable units that readers can process more readily than long pages of text. Paragraphs should do much more than simply provide much needed “white space” on the printed page. They can help you tell a clear story by presenting and discussing *an idea in each paragraph* and connecting the paragraphs to each other with *transitions*. Well-written paragraphs usually make a point in the first sentence and then develop it, permitting readers to follow the author's thinking because the author has focused on a single major point in each paragraph. The ideas in the paragraph need to be organized and the relationship between ideas—the *continuity* of thought—must be clear.

### Use Topic Sentences

A good way to write a paragraph is to give an overview first and then the details—to create an expectation and then fulfill it [13]. The classic way to give the overview first in a paragraph is to write a topic sentence that states the main point of the paragraph clearly and directly. It *anchors* your paragraph. What does the following topic sentence make you expect to read about next?

*The best way to manage ductal carcinoma in situ is not well established.*

You would probably expect more details about the reasons for this. A topic sentence in the Methods section might begin something like this: *We reviewed our database . . .* The details about specifically what was recorded would follow. The next topic sentence in the Results section suggests to the reader that the supporting details will follow.

*When the results of preoperative fine-needle aspiration (FNA) biopsy were compared with the scoring model results for the extracellular matrix protein-1 (ECM1) gene and the transmembrane protease serine-4 (TMPRSS4) gene, it was evident that the results of gene expression analysis were more accurate than those of FNA cytology.*

## Organize Supporting Details

Details that support the topic sentence are logically organized in the remaining sentences of the paragraph. There are several logical ways to organize a paragraph—most of them closely resemble typical ways of thinking, such as: cause and effect, effect and cause, comparison and contrast, definition, illustration, classification, narration or process, and analogy [17]. In scientific writing, the most common ways to organize a paragraph tend to be: from most to least important, for and against, chronological order, problem-solution, and solution-problem [13]. The following paragraph is an example of a *problem-solution* paragraph, as is typical for the Introduction section of a paper:

*In an effort to curb the emergence of resistant organisms, the Centers for Disease Control and Prevention have issued evidence-based guidelines for reducing the current over-prescribing of antibiotics. Although healthcare providers may understand the harms of over-prescribing antibiotics, they continue to use antibiotics rather than risk the possibility that an infection may worsen. Because no definitive studies have systematically examined the types of soft tissue infections that do not require antibiotic therapy, we designed this randomized controlled trial to define which soft tissue infections require antibiotic therapy and which do not.*

### Establish Continuity

A scientific report or proposal tells a story, which is conveyed in sentences and paragraphs that contribute to its development. Even if a paragraph is well organized—that is, it has a topic sentence and logically organized supporting sentences—the story can be hard to follow if the paragraph lacks continuity. Continuity is the smooth flow of ideas from sentence to sentence and from paragraph to paragraph. The essence of continuity is a clear relationship between every sentence and the sentence before it [13].

There are several techniques for creating continuity. You already know two of them—to use topic sentences and to use the same word for the same thing throughout the paper. Another technique is to use transitions. Transitions let the reader know how each sentence relates to the story and how parts of sentences are related. They indicate the direction of your thinking and your reasoning. Without transitions, there can be no logical relationship within and between sentences. The story a paragraph conveys is not simply what the sentences say. It is also what the sentences do in relation to one another and how they contribute to the overall thought—giving a reason, adding a detail, showing a contrast, showing a similarity, or stating a conclusion. Transitions are important because they help the reader follow, and so understand, the story the author is relating.

Transitions can be words that indicate causation, like *because* or *as*. They can indicate a sequence, as with *next*, *then*, *after*, and *first*, *second*, *third*. Transitions can also indicate similarity, as with *similarly* or *likewise*, or contrast, as with *however*, *although*, *whereas*, or *nevertheless*. Transitions can also be phrases like *in addition to* or *in contrast*. Transitions can help you indicate the exact logical relationship you are trying to make clear when you write. Be sure you use the right one for the meaning you intend to convey because the wrong transition can cause confusion.

Often there is no appropriate transition word or phrase to indicate the logical relationship between two sentences, and you must create the transitional phrase. In the following example, the phrase *to induce* . . . works as a transition to indicate purpose:

*To induce a heat shock response, cells were heated to 43°C in a tissue culture incubator.*

Note that continuity is strongest, and the story clearest, when transitions are placed at the beginning of a sentence [13].

Another important technique for achieving continuity is to write with a consistent point of view, which means that—within a paragraph—if the topic of two or more sentences is the same, the subjects and objects in all sentences in the paragraph should be placed in the same order. In the following example, the point of view switches from *cause* in the first sentence, to *effect* in the second, making it hard to see the point of the comparison:

*Thrombin **activates** proteinase-activated receptor (PAR)<sub>1</sub>, PAR<sub>3</sub>, and PAR<sub>4</sub>. PAR<sub>2</sub> **is activated by** pancreatic trypsin, coagulation factors VIIa and Xa, mast cell tryptase, and neutrophil proteases.*

When the point of view is consistent, readers have no trouble seeing the point:

*Thrombin **activates** proteinase-activated receptor (PAR)<sub>1</sub>, PAR<sub>3</sub>, and PAR<sub>4</sub>, whereas pancreatic trypsin, coagulation factors VIIa and Xa, mast cell tryptase, and neutrophil proteases all **activate** PAR<sub>2</sub>.*

Keeping the point of view consistent is very important when you are describing similarities or contrasts. For that reason, a consistent point of view is particularly helpful in the Results and Discussion sections of the paper.

## CONCLUSIONS

Writing is a vital part of the scientific process—a form of thinking that helps you appreciate what you have discovered. To communicate effectively with your readers, state the message as simply and directly as possible by choosing words carefully, designing well-constructed sentences, and building structured paragraphs. Display your thinking by using topic sentences

to show the outlines of your story and transitions to make clear the connections between sentences, paragraphs, and the ideas they contain. To write well, you must rewrite and revise until your message is clear and unambiguous. As the great Samuel Johnson said, *What is written without effort is in general read without pleasure* [18].

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