High Definition Laryngology

Abstract

High definition laryngology is the combination of equipment and expertise leading to a precise diagnostic view of functioning vocal cords. High technology for imaging the vocal cords includes stroboscopic lighting, chip on tip endoscopes, high-definition cameras, digital recording, high definition monitors, high speed cameras and selective color filters.

High definition techniques allow the examiner to optimize images, regardless if they are obtained with high or low technology or even lower quality equipment. An optimum combination of equipment and technique leads to a cost-effective, high yield and accurate diagnosis for laryngeal problems. It also leads to an improved understanding of how the larynx actually functions normally, producing clear sound both for speaking and for singing. This is high-definition laryngology.

This lecture may help you decide what equipment to utilize or purchase. It will provide you with ideas for new techniques to image the vocal cords and how to think about laryngeal function more precisely.

Goals of accompanying lecture

1. Understand how the most important component of laryngology is the video recording of the image. The capacity to review an image several times reveals many additional details. Using a high resolution computer screen along with software which allows the easy ability to move frame by frame, backwards and forwards or at variable speed aids the examiner in visualizing microscopic vibratory impairments otherwise occurring faster than the examiner's perception is able to digest the information.
2. Understand how the correlation of sound with video augments the diagnostic value of the image. Variation in vowels, changes in pitch and changes in vocal intensity all alter the visual endoscopic image.
3. Understand how the most commonly used endoscope, the very cost-effective flexible fiber-optic endoscope, artificially alters our perception of the larynx. If the examiner keeps this visual alteration in mind, a better diagnosis can be made, even with these blurred and honeycombed images. It is also the wisdom of knowing what you don't know.
4. Understand how variations in lighting alter our perceptions of what we see and specifically how even standard definition rigid and flexible endoscopes can offer complementary views of the larynx, the combination resulting in essentially a high-definition perception of the larynx.
5. Understand how topical anesthesia - at very little cost and only a small addition of time - can turn a standard definition (SD) image into essentially a high definition (HD) image by navigating the endoscope closer. Closeness yields a recording with more pixels on the pathology and consequently is equivalent to a higher resolution image. Consequently audience members who can only afford the minimal amount of equipment can learn to obtain essentially high definition images of pathology with low-budget equipment.
6. Understand the capabilities of the highest resolution images that can be obtained with high definition cameras from Toshiba, Olympus and Pentax for both rigid and digital chip-on-tip endoscopes. Whether or not you can afford an HD endoscope, you will leave with an understanding of what you might be missing.
7. Understand how the added visual qualities of selective color imaging such as NBI (narrow band imaging) by Olympus or iScan by Pentax, highlight vasculature. Neovascularization readily identifies the borders of many lesions, some malignant and some benign.

Case study

History

A 72-year-old female underwent mitral valve surgery, waking up hoarse afterwards. She came into my office with a hoarse voice and difficulty breathing six months after her problem began.

Here is her story:

She says, “I had my heart valve replaced and became very ill. My daughter says that I had a tube in my throat to breath for me for 10 days. The first I can recall, I had a very weak voice. My doctor said just to wait, the voice almost always gets better with time.

About six weeks after surgery, I developed difficulty breathing and went to the emergency room. My voice was getting stronger at that time. They ran quite a few tests and told me that I did not have anything serious, at least I did not have a blood clot in my lungs. They sent me to a lung doctor.”

They treated her with inhaled racemic epinephrine and bronchodilators. She had a chest x-ray, CT scan of the lungs, and a VQ (ventilation-perfustion) scan. Physicians concluded in the record that she did not have a pulmonary embolism and discharged her with a diagnosis of probable emphysema. She was referred to a pulmonologist for further care.

She continued, “The lung doctor examined my lungs with a camera. He told me that I had a vocal cord problem and referred me to an ENT doctor. Then the ENT doctor also put a scope in and told me that my vocal cords were paralyzed. She sent me to a specialist in vocal cords. He then told me that both vocal cords were paralyzed and that I needed a test called an EMG and he put me on a pill to stop stomach acid.”

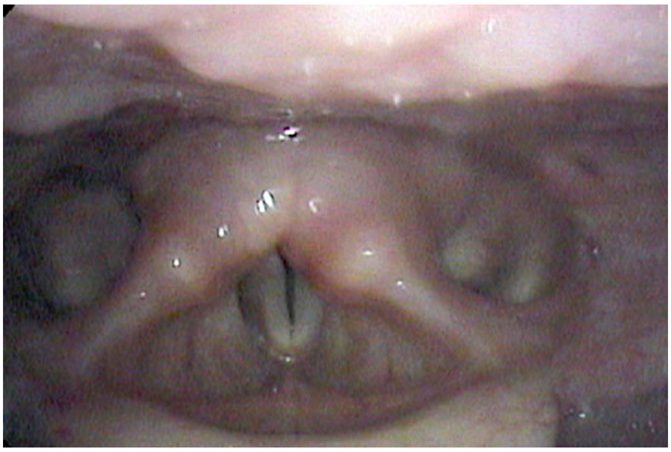
He had placed her on pantoprazole twice a day and referred her to a neurolaryngologist.

She adds further, “The next specialist told me that the EMG was abnormal and he recommended injecting Botox into my vocal cord. I let him inject it last week and now I make more noise breathing and really the breathing is worse. Even just getting up from a chair to walk makes me short of breath and causes a lot of noise.”

Examination

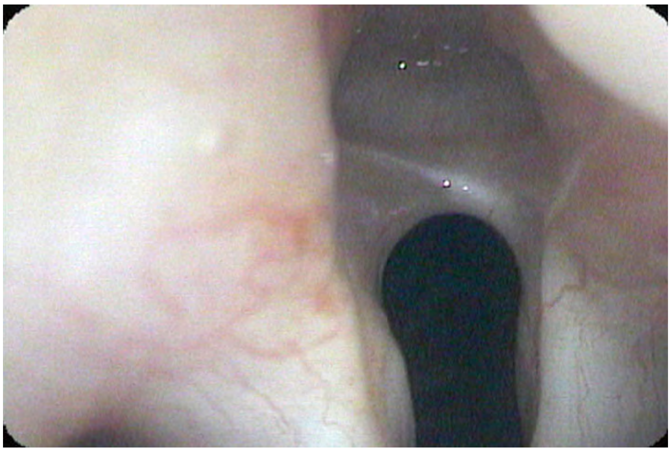
All of these medical visits and tests occurred over the period six months after her surgery, or about 4 months after she first became short of breath.

On exam, she makes obvious noise when she breathes inward and inspiration appears effortful. When I place an endoscope in her pharynx, her vocal cords are resting near the mid-line. When she breathes in, she makes a high pitched noise and the right vocal cord draws inward, vibrating and generating the sound. When she breathes out, the vocal cords shorten in length and the mid-membranous portion of the right vocal cord moves laterally. The upper portion of the arytenoids do not appear to move laterally very far during inspiration and also hide the posterior, cartilaginous portion of the vocal cords.



Since I cannot see all of the vocal cords nor can I see beneath her vocal cords, I ask her for permission to topically anesthetize her larynx with lidocaine.

After anesthesia, I can place the endoscope adjacent to the vocal cords for close imaging, beneath the forward-leaning arytenoids for a view of the vocal processes and even pass the endoscope between the vocal cords, viewing the subglottis and trachea to the carina or beyond. Significantly, a band of scar tissue beneath the vocal processes bridges the vocal processes, fixing the arytenoids about 2 mm apart at the tip of the vocal processes.



The right vocal cord, which had been injected with OnabotulinumtoxinA about one week earlier, is atrophic. With any increase in her rate of inspiration, the right membranous vocal cord passively draws medially and flutters, narrowing the airway and generating a high pitched stridor. During phonation the upper portion of the arytenoids move closer together and touch, while the left vocal process appears to move about 1 mm closer to the right vocal process. The rest of her trachea, carina, left and right mainstem bronchi are normal.

Interpretation

After an intubation, there are two principle risks to be considered in the differential diagnosis. Is this a neurologic injury or is this a traumatic mucosal injury? An endotracheal tube cuff which is inflated too tightly and ends up located in the immediate subglottic area can put pressure on the anterior branches of the recurrent laryngeal nerves as they pass beneath the thyroid cartilage and partially or completely paralyze one or both of them, typically limiting adduction of the vocal cords. It will also typically lead to atrophy of the injured thyroarytenoid muscle(s).

In the case of surgery along the pathway of the recurrent laryngeal nerve, a nerve injury may leave both the abductor and adductor muscles impaired. Initially after this type of injury, there may be limitation of both adduction and abduction. When the nerve fibers regrow (over several months) back to the muscles, they often cross pathways and end up misdirected in terms of stimulating abduction and abduction. Consequently, frequent delayed findings include vocal cords positioned near the midline or vocal cords that move in an inappropriate direction, such as medially during inspiration.

In terms of injury to the lining of the larynx, even after as little as a two hour intubation, pressure ulcers frequently develop on or near the vocal processes. With longer intubations, larger ulcerations, followed by granuloma formation and fibrin deposition may create a bridge between the ulcers, which ultimately epithelializes and contracts, pulling the vocal processes towards each other.

Both synkinetic reinnervation and scar contracture, end up bringing the vocal cords closer together in the mid-line. In my experience, scar contracture ends up restoring the voice and limiting breathing sooner (often about 2 months) than neurologic synkinetic reinnervation (often about four months). Consequently, both diagnoses need to be considered whenever there is a limitation of vocal cord motion after an intubation and surgery near the nerve.

In our example case, when the larynx is visualized with an endoscope, with the tip of the endoscope at a level above the tip of the epiglottis, only the lack of abduction is perceived and this frequently leads to the premature, simplistic diagnosis of paralysis. After we topically anesthetized her vocal cords and passed the endoscope beneath the arytenoids, we viewed the limited movement of the vocal processes with inspiration, expiration and attempted phonation. We viewed the mass of both vocal cords, effectively assessing the thyroarytenoid muscles. We viewed the posterior subglottis where scar tissue typically forms. We passed the endoscope into the trachea where there can be a secondary injury from the endotracheal tube cuff pressing the walls of the trachea and creating a second stenosis. We performed a complete and detailed examination.

We also performed a high definition examination. Moving the standard definition endoscope immediately adjacent to the posterior glottis, we effectively filled about 200 pixels of the endoscope's 640 by 480 pixels with the scar tissue creating her glottic stenosis.

If we compare this close view (where a 200 x 200 pixel area of the image is filled with the pathology) to a typical endoscopic overview image of the entire larynx from above the epiglottis, where the pathology is effectively hidden by the upper portion of the arytenoids, we can appreciate that moving the endoscope close to the pathology creates a high definition view of the pathology. In fact, we initially had effectively a 0 x 0 pixel view or one could say, a zero-definition view of the pathology, when the vocal cords were viewed from the level of the epiglottis.

The harm of using up 6 months of someone's life before obtaining an accurate diagnosis; the financial expense of all the non-essential tests performed on her; the reliance on a difficult to interpret test - a laryngeal EMG - for clinical decision making; the harm done when the unilateral injection of botulinum toxin led to the right thyroarytenoid muscle no longer remaining tense during inspiration and Bernoulli effect inducing further functional obstruction of the airway which increases with air hunger; the unnecessary proton-pump inhibitor; all of this makes me appreciate the additional 15 minutes required to topically anesthetize her larynx and pass the endoscope between the vocal cords, to the carina, at the initial visit is an incredibly valuable, low technology, high definition laryngology maneuver. This is putting more pixels on the pathology.

Summary

Low technology, high definition laryngology is using inexpensive techniques to put pathology onto more pixels of the endoscope, no matter what endoscope the examiner already has. Low definition laryngology is where examiners may have high technology equipment, even a high technology education but;

1. they don't realize where to aim the endoscope, or
2. don't take the time to record quality images of the pathology or
3. do not understand the need for using low technology wisely to bring the pathology into focus
4. and/or do not review for mistakes to learn from them.

Voice Laboratory

A voice laboratory might contain some or all of the following:

1. Endoscopes (rigid &/or flexible)(fiberoptic or chip-on-tip)
2. Camera & Processor (integrated or external)
3. Bright light source
4. Stroboscope
5. Hardware and software for recording and reviewing video with audio.
6. High definition monitors
7. High Speed camera

Rigid endoscopes

Rigid endoscopes (Hopkins rod) tend to come in two configurations based on the angle of view, 70° and 90° endoscopes. Sometimes a quick focus ring is added, although the claim is made that this absorbs some light. In general, the glass transmitting the image in a rigid endoscope, carries more light than flexible endoscopes.

The benefits of the rigid endoscope are that it provides a high clarity image. It can be attached to a standard definition camera and may be upgraded with a high-definition camera later. It is particularly valuable for the perpendicular view of vibrating margin (mucosal edge) lesions of the vocal cords. When attached to a stroboscope, mucosal lesions on the margin of the membranous vocal cord stand out in high contrast against the background of the dark trachea.

The potential pitfalls of the rigid endoscope are that it usually provides only a single perspective view, various anatomic structures can obstruct the image (uvula, base of tongue, epiglottis, posterior pharyngeal masses, supraglottic squeeze), gagging may preclude an examination altogether and it has a relatively shallow depth of field. Functional evaluation is limited, because the tongue is often stabilized by the examiner's hand.

Flexible endoscopes

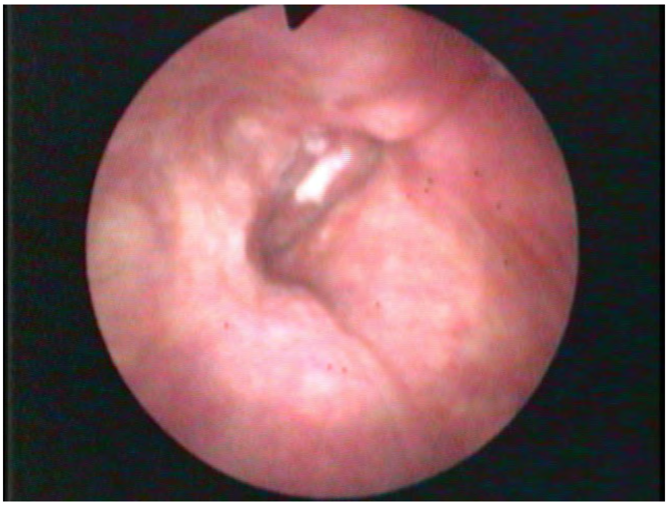
There are a number of variations in the equipment available for flexible laryngoscopy. The main differentiation is between fiber-optic technology and chip-on-tip technology.

Fiberoptic endoscopy

Typically the flexible fiber-optic endoscope is attached to a separate camera. The flexible aspect of this technology allows the endoscope to be passed through the nose, typically reducing the gag reflex during the examination. It allows the endoscope to easily be passed closer to the vocal cords and even beyond the structures of the larynx. Most laryngeal function is retained during a flexible examination. The angle of view of the structures of the larynx can be modified to provide various perspectives on the same pathology.

Flexible endoscopes have a wider angle lens than rigid endoscopes and a wider angle perspective than the human eye. Consequently close objects appear relatively larger than objects farther away. There is a high depth of field so more of the image is in focus at a given time. Endoscopes with an even curve in the tip and with the articulation for bending, close to the tip of the endoscope are easy to maneuver. One significant appeal for this equipment is that fiber-optic technology is relatively inexpensive compared to chip-on-tip technology.

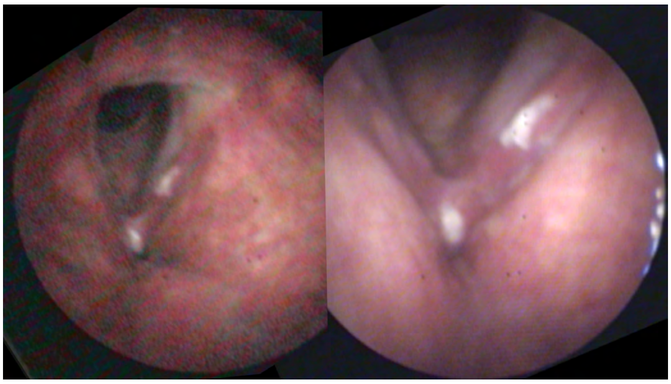
On the downside, although an attached camera can be updated from standard definition to high definition, the images provided by this technology are inherently quality-limited by the flexible glass fibers carrying both light to the interior of the larynx as well as transmitting the image of the larynx back to the camera to which it is attached. These relatively large glass fibers are visible in any image produced. When the image is recorded, the pixelation of the glass fibers interact with the pixels on the recording device and create a moiré effect. Attempts to diminish the honeycomb image and moiré effect produced by this technology involve a loss of resolution by blurring the image either physically or electronically.



Fiberoptic endoscope view

A major downside to fiber-optics is that glass fibers absorb light (and when they break over time, the absorption becomes complete and leads to a black spot in the image). There is ultimately a limit to how much light can be passed through the glass fibers and auto gain features of the cameras can lead to artifact. Digital noise produced by increasing video gain alters both the color and clarity of the images. Reflected light decreases greatly with distance.

Digital noise is particularly evident when the endoscope is relatively far away from the pathology. For example, with the endoscope at the level of the tip of the epiglottis, there is significant loss of light at the level of the vocal cords several centimeters away. Since most users have the auto-gain function turned on, electronic amplification of the image occurs without the examiner even sensing the degradation of the image. As electronic gain increases, more pixels in the image are assigned colors that don't actually exist. The image becomes more pixelated. Additionally, as capillaries become blurred, the image becomes more apparently red.



Far away view (left). Moving endoscope closer (right), light increases and automatic gain is reduced with a reduction of digital noise.

Chip-on-tip endoscopy

Chip-on-tip technology derives its name from miniaturizing the electronic sensor or chip and then moving it from the camera (which was typically attached to the endoscope eyepiece) onto the tip of the endoscope, transmitting images electronically through the flexible scope to an external processor. Since the image no longer passes through light fibers, moiré effect is eliminated and the images are much clearer.

As chips become smaller, higher resolution chips lead to higher definition images and/or smaller endoscopes. When topical anesthesia of the larynx is not utilized, smaller endoscopes can generally be moved closer to the laryngeal structures before gagging or laryngeal irritation occurs. Additional processing of the image such as selective light absorption can alter the images before they are recorded.

fiberoptic endoscope left - chip-on-tip endoscope right. clearer image on right with less digital noise (less speckled red appearance)

Camera & Processor

What is meant by "definition?"

Although any combination of x by y dimensions could be utilized, the video industry has settled on a relatively few standardized sizes and ratios. The most popular, based originally on TV formatting, has become labeled standard definition. When televisions were still analog, the standard called NTSC consisted of 525 lines, the aspect ratio was 4:3 and the images were recorded at 30 frames per second. Each frame consisted of two frames, which were interlaced. As digital technology took over this standard, the 4:3 aspect ratio, turned into 640 x 480 pixels utilized to record the same image (some of the additional vertical lines were used for other things during the analog era). 60 frames per second are often recorded with only 1 field per frame, which eliminates interlacing artifact. Many other compromises have been made over time for technical reasons as well as commercial reasons and Wikipedia has a nice overview if you desire further information. Technology has not remained still and silicon means more and more pixels can be processed and stored. Various compromises have led to high definition video recording standard resolution and settling on a 16:9 aspect ratio. Some of the shorthand utilized to express video recording is listed below.

Video format classification

Video format = resolution + frequency + frame rate

SD - 525i - 640 horizontal by 480 vertical pixels + 59.94 Hz + 59.94 Interlaced Fields

HD - 720p - 1280 x 720 pixels + 59.94 Hz + 59.94 Interlaced Fields

HD - 1080i - 1920 x 1080 pixels + 59.94 Hz + 59.94 Interlaced Fields

Graphic format classification

Highly variable, almost any x:y variation of pixels

Determining the video output of the processor affects the resolution that should be captured. Capturing at a higher resolution than the video output results in wasted hard disk storage. Capturing at a lower resolution than the video output results in loss of video resolution.

Although high definition carries a variable meaning, the variations are fairly well accepted and when the terminology HD is accompanied by a number, such as HD 1080i, you have a fairly good idea what you are getting. The term "high resolution" has no standard meaning in terms of video and I have frequently heard medical marketing representatives use the term loosely to mean this current endoscope is better than our previous endoscope and sometimes the buyer's brain misinterprets the words "high resolution" as "high definition". The marketing representatives don't seem to object to this confusion.

Light

The camera and processor are usually sold as a package. Often the light source is integrated into the processor. However, for laryngology, separating the light cable from the camera allows for connection to a stroboscope. Xenon, halogen and LED lights are being used for laryngeal endoscopy. Each colors the image in a slightly different way. Even the camera used for recording and the screen used for viewing the video recording alters the perceived color of the laryngeal tissues.

I have detailed my thoughts on two major producers of laryngeal endoscopes, Olympus and Pentax. Even when the resolution of the cameras is identical, videos of an individual larynx appear different depending on the camera used to obtain the images.

Transmission

Carrying audio and video signals along a cable requires a format. Some of the terms that you might run into include:

- DVI - Digital Video interface (carries analog or digital signals, SD or HD, but no audio)
- HDMI - High Definition Multimedia Interface (SD, HD, video, audio)
- SDI - Serial Digital Interface (single cable)
- HD-SDI - High Definition Serial Digital Interface
- Firewire 400, 800 -
- Thunderbolt (Apple)

Conversion

Basically, what comes out of the camera may not be what a computer wants to suck in. So unless one manufacturer designs your entire system, you may need to do a conversion between the output on your camera and the input on your computer. Also, since high definition video consists of so much data, most conversion processes require hardware in order to do a conversion quickly enough not to lose frames on the video. So quite typically, the cable comes out of the camera processor carrying video to a hardware converter which may combine the audio with video, convert the video to a different format and then plug into a computer.

Capture

I have been capturing video on Apple laptop computers for some time. There are various software programs that can grab live video. The one I currently use is designed to go with the hardware conversion box which encodes the video for Apple's QuickTime video format. QuickTime seems to have remained a stable standard "wrapper" over the past 15 years. The codecs within QuickTime have changed over time but I can still view all of the video I have recorded with this program.

After capture, I organize and review the video in Apple's Final Cut Pro video program. Another common program is Adobe's Premiere video editing program. I appreciate these programs for their ability to slow video, move frame by frame, view in forward or reverse and render a given frame completely, on a high resolution monitor and make annotations on interesting frames.

Less conveniently the video files can be viewed directly on the desktop. This is quick, but lacks much of the abilities mentioned above.

Storage

No one wants to store every pixel that comes out of your endoscope. Consequently there are various compression and storage formats for video called codecs. Some of the more common ones are listed.

Video codecs & wrappers

- Compression algorithms
  - MPEG-4
  - MPEG-2
  - H.264
  - WMV (Windows Media Video)
  - Apple ProRes 422
  - DV
  - .mov (quicktime)

I end up with a mix of formats on my hard drive. My old files are formatted in DV. I record my high-definition camera's Using Apple ProRes 422. I store my standard definition videos in H.264. The hospital operating room cameras and endoscopes variously capture video in MPEG-4 and WMV formats.

Speaking of hard drives, my laptop rapidly fills up with high-definition video files. I currently copy them to a Pegasus RAID hard drive which makes two copies of each video so that when one hard drive dies, the video still exists elsewhere on the RAID drives. Every few weeks, I also store another copy of all the video files on a separate hard drive which I store at a different physical location. Redundancy is a key word for data files.

Slow Motion

There are two main ways to capture images of moving vocal cords: each method has trade-offs. Since video is typically captured at about 60 images per second and almost all vocal cord vibratory movement occurs at more than about 80 cycles per second and interlaced video is the most common format, almost all images of vibrating vocal cords will appear blurred on standard video recordings played on video monitors. After one has seen enough slow-motion video recordings, one can often infer from these blurred images what is might be happening to the vocal cords in real time.

A significant improvement on standard video occurs with a stroboscope. An audio sensor detects the pitch of the voice and triggers a strobe light to flash at one or two beats more per second than the vibration of the vocal cords. The video then records slow, apparent motion of the vocal cords. The trade-off with stroboscopy is that when there is diplophonia, the strobe light cannot track two separate pitches and will flash irregularly. This artifact may create a false impression of the actual physical movement of the vocal cords.

High-speed video records several thousand frames per second, thus recording actual vocal cord motion. Some of the trade-offs with this technique are that it requires a large amount of storage, it can be difficult to capture actual pathologic movement of the vocal cords since you have to record in short bursts and it can take a long time to review this video to find the pathologic motion. As a newer technology, it is also relatively more expensive than stroboscopy.

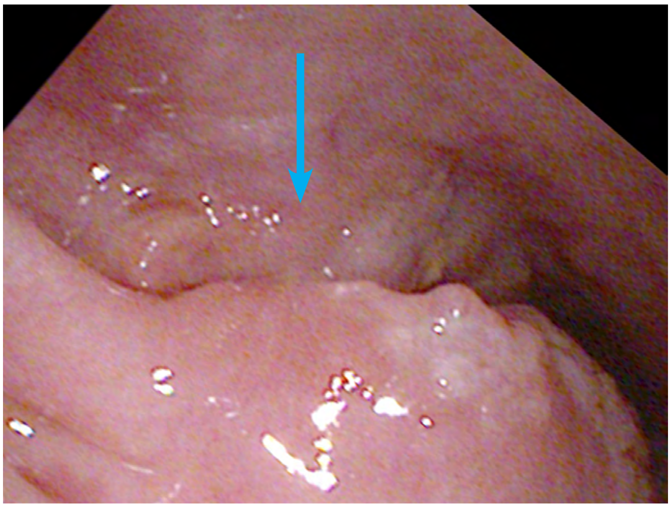
Selective Color imaging

Since video images consist of red, green and blue channels, it is possible to selectively filter out some of the light on the individual color channels. Both Olympus and Pentax have made use of this and electronically filter certain bands of light in the blue and green wavelengths, which are absorbed by hemoglobin. Blood, normally viewed as red in video images, then appears dark or black in the video recordings, adding additional contrast with the surrounding tissue.

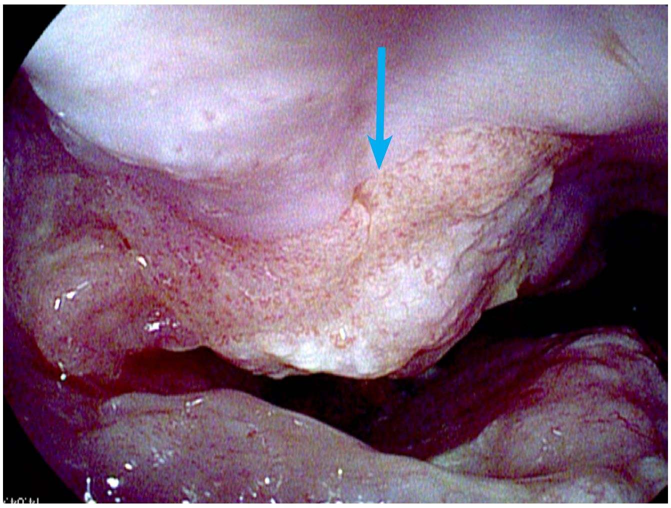
This makes the capillary vasculature of the larynx pop out in the images. While the capillaries are visible using the normal lighting algorithms, emphasizing capillaries tends to lead the eye to various laryngeal conditions. In particular, hemorrhage and dilated capillaries occur with trauma and infections, but most notably capillaries are dilated and generate specific patterns as tumors grow and require or induce an increased vascular supply for their metabolic needs. Additionally, very thin films on the vocal cords can be more readily visually identified because the films obscure the expected normal capillary architecture beneath them. See photos to right.

Recording & Reviewing Video

Ultimately, many things happen in the larynx very quickly and sometimes pathology may be highly visible or recognizable on as little as only a single frame of a video recording. This means that during live recording, the problem might be present, but not be visually recognized. Even during the quick overview of the recording that I perform while the patient is in the examination room and during my explanation of the problem to the patient, I slip through the video to the most pertinent pictures in order to describe the problem I recognized. On a regular basis though, I review the video again as I am developing a report on a patient; I try to find optimal individual frames of the video that demonstrate the pathology. During this detailed review, as I sometimes play the video frame by frame, I often notice additional detail.



With normal lighting, it is difficult to separate the tumor from normal tissue (arrow points to tumor margin).



Selective color imaging of the same area (and the trumpet maneuver to insufflate the piriform sinus) highlights the vascularity of this tumor and differentiates easily the tumor margin (arrow points to tumor margin).

Sometimes after surgery or some type of intervention or even just the passage of time, when something doesn't turn out as expected, I return to prior videos and review them in light of the new video information and I will find discover details that I missed on prior reviews. Consequently, I find that the recording of a video is valuable not only for finding the immediate problem, but is equally valuable for teaching myself about the significance of audio and visual findings that I might have initially missed.

Low Technology

Low technology is really the most valuable part of a High Definition endoscopic examination. The high definition image obtained does not depend on money. It depends on the examiner's knowledge, skill and patience. In our example patient at the beginning of this article, no matter what definition the endoscope recorded, the pathology occupied zero pixels of the endoscope when it was placed at the level of the epiglottis, a common location for many endoscopic laryngeal recordings. By applying topical anesthesia and maneuvering the endoscope beneath the upper portion of the arytenoids, the pathology could be seen just inferior to the vocal processes. By the time the tip of the scope was close to the vocal processes, I estimate that about 200 x 200 square pixels of Low Technology, High Definition imaging was exposed to the lesion, merely by supplementing a typical laryngeal examination with an additional 10 minutes and topical lidocaine.

Here are some selected ways that low technology can be utilized to obtain a high definition laryngeal exam.

Closeness

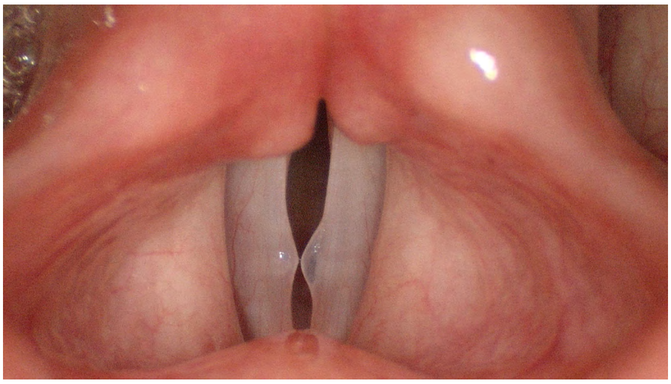
Occasionally the endoscope can be maneuvered close to the larynx just because a patient can tolerate it, or because a sensory nerve injury allows the endoscope to actually touch the larynx without triggering a gag or initiating a laryngospasm. Sometimes it is possible to maneuver the endoscope in between the vocal cords during inspiration and back it up during expiration as the vocal cords tend to abduct during inspiration.

More typically though, topical anesthesia is the laryngologist's best friend. With the addition of 4 to 5 mL of topical 4% lidocaine, typically dripped on the vocal cords in 1 mL aliquots over several minutes, the larynx can be completely anesthetized and an endoscope can usually be maneuvered anywhere in the larynx or trachea. The first aliquot of anesthetic makes the patient cough and distributes medication around the entire larynx, pharynx and subglottis. I ask the patient to phonate while I add additional topical lidocaine and this generates a laryngeal gargle. After the fourth milliliter is dripped and gargled and I wait for an additional 2 to 3 minutes, the topical anesthesia is complete.

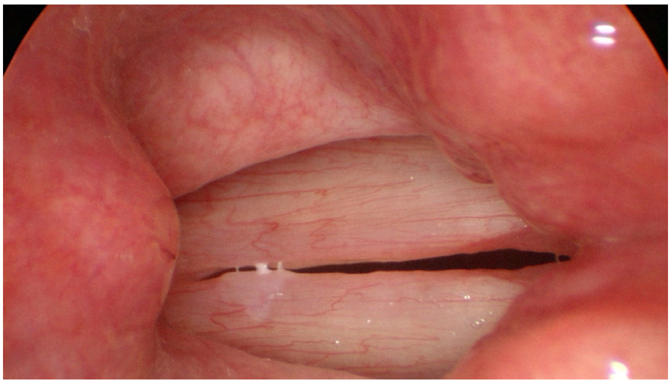
Camera orientation

Rigid

While the image captured by endoscopes is typically round, there is enough transmission of light with rigid endoscopes too mechanically zoom some cameras without abundant loss of light and resolution. When combined with the newer high definition ratio of 16:9, vibrating vocal cord anatomy nicely aligns with this horizontal visual field in terms of length: width ratio, utilizing more of the pixels available on the camera. Compared to my typical placement of the camera on a flexible fiber-optic endoscope or the orientation of the camera chip on integrated chip endoscopes, this rotation of the external camera attached to the rigid endoscope 90°, aligns the vibrating edges of the vocal cords horizontally on the stretched, high definition video monitor. It has the potential to place more pixels onto vocal cord pathology.



vertical orientation



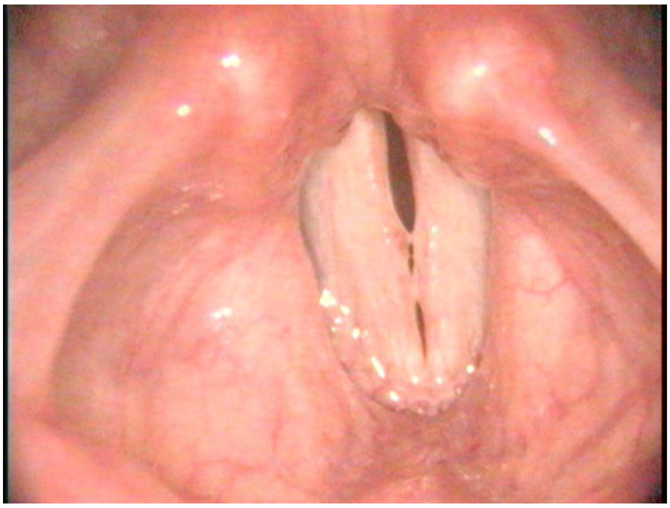
horizontal orientation of the vocal cords

Laryngeal Maneuvers

Choose a vowel

Since most consonants are produced at the level of the palate, tongue and lips, it is not necessary to visualize connected speech during a laryngeal examination. Vowels are produced in the pharynx. The vocal cords are primarily responsible for the production of sound. They primarily modulate frequency and volume. Consequently If we eliminate words during our examination we reduce inadvertent movement of the flexible endoscope by palatal and tongue movement. We want to keep the pharynx as open as possible and the epiglottis as far forward as possible. The vowel /i/ provides for this maximal pharyngeal opening.

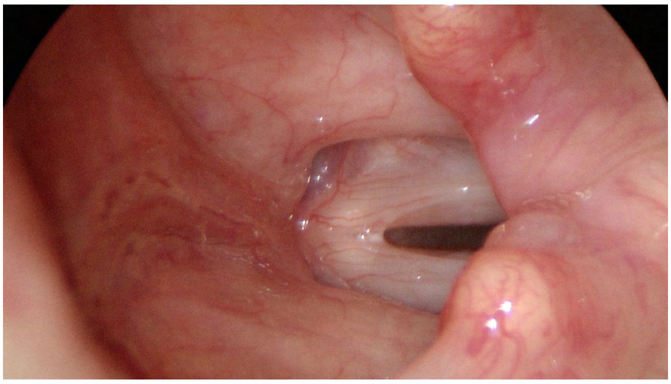
"Ahhhh" sound allow epiglottis to occlude some of the vocal cords



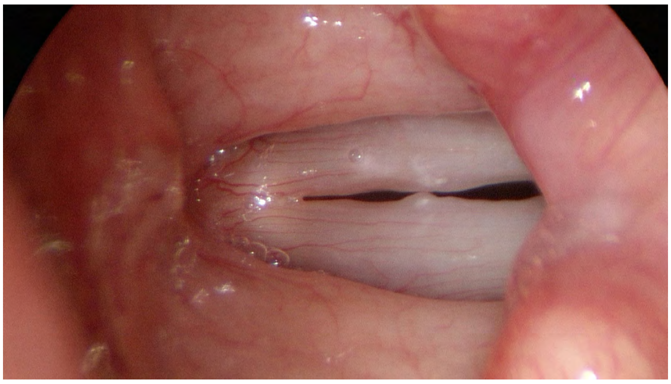
"eeeee" sound or /i/ opens up the pharynx for a better view of the vocal cords

Alter Pitch

We can record our examination at both low and high pitch. In fact, if we identify a particular pitch during the vocal capabilities pattern matching portion of our examination that triggers dysphonia, we should make an attempt to record that pitch during our endoscopic examination. Apart from finding a specific pitch that triggers dysphonia, high pitch activates the cricothyroid muscle to lengthen the vocal cord and the thyroarytenoid muscle to intrinsically tension the vocal cord. As the vocal cords lengthen, any lesion along the vibratory margin will tend to be pushed out into the field of view, particularly from the rigid endoscopes vertical viewpoint. At high pitch, the vocal cords are also reaching their maximum tension which will aggravate any pre-existing stiffness and make the vibratory impairment more visible.



Low pitch, vocal cords short and loose - marginal lesions disappear into the vocal cord mucosa



High pitch, vocal cords long and tense - marginal lesions are pushed into the central glottic opening

Recording at low pitch removes any inadvertent or obligate compensation by the cricothyroid muscle. Activation of the cricothyroid muscle may occur in nonorganic voice disorders. It almost always occurs in neurologic disorders involving paresis of either the thyroarytenoid muscle or the lateral cricoarytenoid muscle.

As the patient reduces pitch, this natural or intrinsic compensation by the cricothyroid muscle for a weakened thyroarytenoid muscle allows the weak vocal cord to oscillate more laterally, and sometimes, with enough difference in tension, the vocal cords will break synchrony and the weak cord will flutter.

With the removal of intrinsic compensation by the cricothyroid muscle, a weakened lateral cricoarytenoid muscle will allow the vocal process to cant laterally, creating an obtuse angle between the vocal process and the membranous vocal cord.

At high pitch the weak right vocal cord is held tense by a contracted cricothyroid muscle

At low pitch the weak right vocal cord is lax, oscillates far lateral to its axis, buckles and the thyroarytenoid muscle thinness is very apparent.

Another inadvertent compensation is that typically and surprisingly, patients do not want to sound abnormal during an examination, even though abnormal voice is the raison d'être for their office visit. This is particularly true for singers. They often convince themselves that abnormal vocal sounds are the results of poor technique. In order to avoid audible impairments in their upper vocal range they increase vocal cord tension and their subglottic pressure and consequently their volume. Small gaps, small elevations and minor stiffness are overcome by the increased subglottic pressure. By eliciting from the patient, low-volume sound production, smaller vocal impairments can be visually discovered during the examination.

Higher volumes, especially at low pitch, can augment neurologic and muscular weakness visual findings by causing the weakened vocal cord to vibrate abnormally. A non-tense thyroarytenoid muscle may break up into two or more oscillatory segments, generating the appearance of flutter on stroboscopy and also oscillate lateral to its axis creating an infinite open phase on stroboscopy.

- Alter Pitch
  - High pitch
    - Highlights vocal margin
    - Augments stiffness
  - Low pitch
    - Highlights weakness
    - Typically removes compensation
      - From superior laryngeal nerve (cricothyroid muscle)
- Alter Volume
  - Low volume
    - Highlights gaps, stiffness, elevations
  - High volume
    - Highlights weakness

Monitoring the vocal cords closely during quiet respiration can detail subtle neurologic findings. Fasciculations are often noticed during quiet breathing when the larynx is relatively still. These can be seen on the arytenoids relatively easily. They are also visualized within the laryngeal ventricle on the superior surface of the vocal cord in a denervated thyroarytenoid muscle.

The timing of abduction and adduction are also well assessed during quiet respiration. During expiration, partial adduction typically occurs, while during inspiration, partial abduction occurs. The degree of abduction and adduction should be symmetric. With acute denervation the range of degree of motion is less on the injured side. Later, as varying amounts of synkinetic reinnervation occur, the timing of motion can become asymmetric. Additionally, with synkinetic reinnervation, the resting position of the vocal process may become more medial.

Height differences between the vocal processes can really only be appreciated well when the flexible endoscope is placed between the arytenoids, nearly parallel to the axis of vocal cords. From this posterior view, oriented along the axis of the vocal folds, the mass of each thyroarytenoid muscle can be compared.

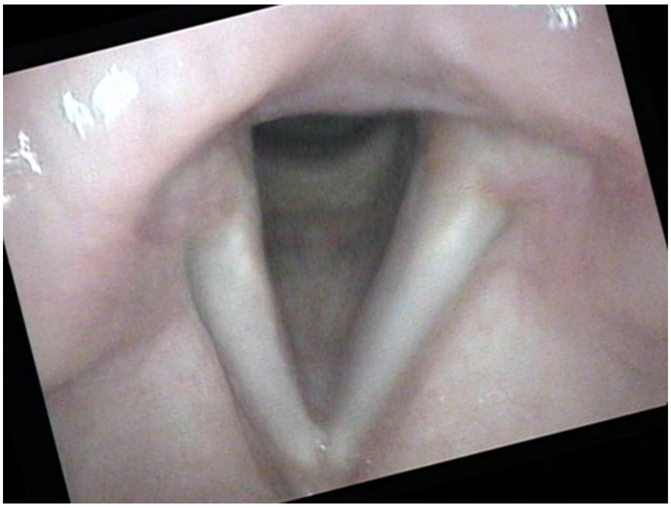
Sniffing augments abduction, lengthening the vocal cords while they are pulled further apart than during expiration or even quiet inspiration and an atrophic vocal cord will thin even further. This finding is most prominent when deep inspiration occurs immediately after phonation. See photos to right.

The same inference may be visualized in a negative way. During deep inspiration, the ventricle on the side of thyroarytenoid muscle atrophy, appears to enlarge relative to the other side. This may be easier to visualize in the sense that both thyroarytenoid muscle atrophy and false vocal cord atrophy contribute to the size of the laryngeal ventricle. See photos to right.

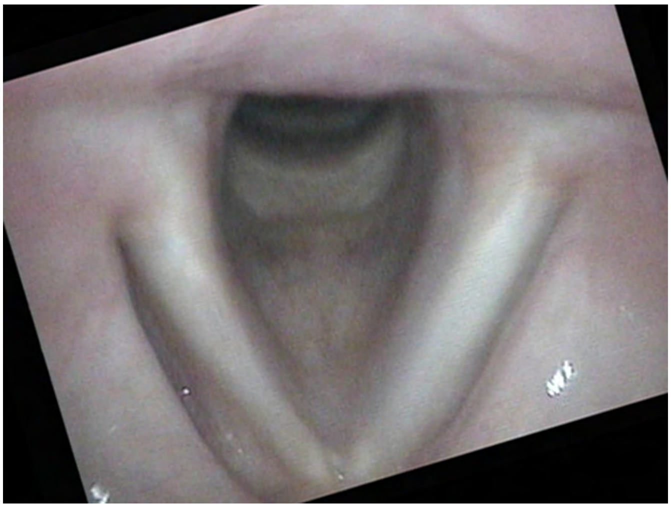
Summary

When you have the money, spend it for the new high technology. When you don't, use what you have better.

Thomas, JP: "Topical Anesthesia for Office Based Laryngeal Interventions" in Principles and Practice of Lasers in Otorhinolaryngology and Head and Neck. (Ed. Oswal, V; Remacle, M; Jovanvic, S; Zeitels, SM; Krespi, JP; Hopper, C) Kugler Publications 2014, ISBN 978-90-62992-32-4



During quiet respiration, the vocal cords and ventricles appear similar in size.



During deep inspiration (sniffing), the left vocal cord thins and the left ventricle appears to enlarge.