Subglottic stenosis—instrumentation and documentation

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Introduction

Historically, tracheostomy has been performed from about the first century, and instruments were devised to carry out such a procedure. Relief of airway obstruction was later facilitated by instruments to perforate the cricothyroid membrane and at the turn of the century, O'Dwyer introduced an instrument to allow blind intubation of the larynx with a metal cannula. Direct visualization of the larynx for the purposes of diagnosis and treatment was effectively delayed until general anaesthesia became available, and early laryngoscopes and bronchoscopes were hampered by poor illumination and difficulty in maintaining oxygenation. The invention of fibreoptic lighting overcame the former problem to a large degree, but easy maintenance of oxygenation and anesthesia during bronchoscopy has been revolutionized by the invention of rigid ventilating bronchoscopes.

Diagnostic endoscopy

The evaluation of the small infant with suspected subglottic stenosis follows a logical pathway of suspicion, history, clinical assessment, radiology and direct endoscopy of larynx, trachea and bronchi. The diagnosis can only be confirmed by direct vision and if an adequate examination is to be made, it requires general anaesthesia. Laryngoscopy without anaesthesia results in laryngeal spasm, precluding a view of the subglottis and trachea and endangering oxygenation.

Flexible fibreoptic laryngoscopes are advocated by many workers in this field. Small instruments of 3 mm diameter are available but have the disadvantage of not allowing either suction or oxygenation. Slightly larger flexible scopes with a suction port are available but are usually too large to be used in the neonate. A 3 mm flexible laryngoscope can be used under general anaesthetic to obtain a good view of the laryngeal structures and with care can be passed into the trachea. The procedure has the advantage of being quick but unfortunately allows no control of the airway. A further disadvantage of such a scope is cost—even the most simple costs in the order of £3000 with a suitable light source.

Direct Laryngoscopy to examine the structure of the larynx is best carried out in babies using specifically designed paediatric laryngoscopes. For direct naked eye vision my preference is the Storz Holinger type laryngoscope which has proximal lighting delivered by a fibreoptic cable to a prism. Using such a laryngoscope, a good view of the subglottis through the cords is usually obtained. If magnification is required, a laryngoscope that can be suspended in place is necessary and for neonates the Storz laryngoscope with its own supporting arm is invaluable. Such an arrangement allows the use of an operating microscope so that binocular magnified vision is available, and it also allows careful assessment of the subglottic lumen since the cords are held abducted.

Because the laryngoscope is supported in position, both hands are left free for any instrumentation that may be necessary. Naked eye removal of tissue such as granulations should not be attempted in neonates. Magnification allows much more precision in a tiny larynx.

Bronchoscopy

Reference has already been made to flexible fibreoptic scopes, and bronchoscopy in neonates is possible using such instruments. The small diameter necessary makes any instrumentation impossible however, and I am also concerned about the lack of control over the airway.

The ventilating bronchoscope using either proximal prism lighting or distal lighting through a Hopkins rod telescope has revolutionized bronchoscopy, particularly in babies. It has replaced almost entirely the older Negus bronchoscope tube in paediatric practice.

The features of such a ventilating bronchoscope are:

a) a hollow bronchoscope tube which may be parallel-sided or tapered. The tapered scope is more likely to cause cricoid damage.
b) a 15-mm connection to a T-piece anaesthetic circuit.
c) a side channel for instruments or suction catheter.
d) occlusion of the proximal end of the tube by either a glass window or more usually a Hopkins rod telescope. Such a telescope depends on a series of solid glass rod lenses to transmit a magnified image without the mottled effect of fibreoptics, the image being in focus from contact to infinity because of the extremely short focal length of the system.
e) a range of sizes from 2.5 mm internal diameter to adult size, and a range of length from 20 cm to adult size.

The most useful sizes for neonatal use are 2.5 mm, 3.0 mm and 3.5 mm internal diameter, and with a length

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of 20 cm. The telescope to fit such bronchoscopes is a nominal 2.7 mm, so it can be appreciated that the 2.5 mm scope allows little room for the passage of anaesthetic gases. Similarly it is too small to allow side channel instrumentation. This drawback can be overcome by withdrawing the telescope as necessary to allow oxygenation or suction, and replacing it for detailed inspection. It is only in the infant of less than 1-1.5 kg that the 2.5 mm scope is necessary unless there is a severe degree of subglottic stenosis, and in practice it is usually possible to obtain an adequate oxygen flow through the bronchoscope with the telescope in position, but the anaesthetist must be made aware of the problem beforehand.

Therapeutic endoscopy

Following intubation or laryngeal reconstruction, there may be a need to remove granulation tissue. This can be accomplished using optical forceps, employing the same Hopkins telescope, allowing precise vision of the jaws. The disadvantage is that such forceps can only be passed through a bronchoscope tube of at least 3.5 mm diameter, which may be too big to pass through a stenosed subglottis. Alternatively, flexible instruments can be passed through a side channel on the bronchoscope but manipulation is much more difficult.

The shape of the Wolf bronchoscope, being tapered, lends itself to use with the carbon dioxide laser, and appropriate couplings are available.

Alternatively, if the lesion is visible by suspension microlaryngoscopy, it is easier to attach the laser with a manipulator to the operating microscope, and gain direct access thereby. This allows more precise control of the surgery under steroscopic magnified vision.

Closed circuit television (CCTV)

Advances in electronics have allowed miniaturisation of television cameras to a size that makes direct attachment to the endoscopic telescope feasible. Clearly when carrying out laryngoscopy or bronchoscopy, safety of the airway is paramount and considerable practice is necessary to be able to perform such procedures visualized on the television screen. It is preferable to carry out initial inspection without the camera, and to attach it subsequently for recording or demonstration. The small size of the telescopes used in paediatric bronchoscopy makes illumination a problem, and ideally a xenon arc light source is necessary.

The xenon light is a much higher colour temperature (i.e. bluer) than halogen light and correction to the colour balance will be necessary. Sadly, the cost of such a light source makes it beyond the reach of most ENT departments. There is no doubt though, that the availability of television during endoscopy is invaluable for teaching both medical and nursing staff and is also of help to the anaesthetist. Video recording is a simple matter, and can be done either on U-matic or VHS format. The former gives recordings of a higher quality but the equipment is more expensive and less widely available. Editing of the video tape poses more problems than with cinefilm and to achieve good results a professional studio is necessary. Unfortunately, most departments of medical illustration do not have facilities for editing video tape.

The use of suspension laryngoscopy allows a choice of television techniques. The camera can be attached to a 4 mm telescope which is introduced through the suspended laryngoscope. This gives the best results for recording detail of the larynx, since the telescope can be moved close to the area under inspection. It does not however allow any surgical procedures to be performed or recorded. Alternatively, the same camera can be attached to the microscope in place of the teaching arm. This requires a special adaptor to be fitted to the beam splitter, and the camera is attached with a C-mount ring. The camera is of course monocular and it is a help to alignment of the picture to have a cross wire graticule fitted to the microscope eyepiece on the side on which the television is attached.

The quality of image obtained by a small camera attached to the microscope is excellent in laryngeal examination where a relatively low magnification is used but high magnification may not be possible because of inadequate illumination. Fibreoptic xenon lighting to the microscope would overcome such problems.

Still photography

35 mm transparency photography remains the most important means of recording laryngeal findings, and the equipment to do this easily and conveniently has improved steadily. Several techniques are available according to circumstances, and as in CCTV depend either on the use of endoscopic telescopes or the operating microscope.

The simplest way of taking laryngeal photographs is to have a camera attached to the beam splitter on the operating microscope. A single lens reflex camera with aperture priority exposure control makes correct exposure straightforward; the microscope lighting should be set to its highest level and the diaphragm on the beam splitter should be stopped down a little to increase depth of focus. It is preferable to compose the image through the view finder on the camera, and for this a plain glass viewing screen giving an aerial image is easier to see than the common matte screen, which may be too dark. High magnification at x 16 or x 25 will allow the laryngeal image to fill the frame without disconcerting reflections from the edge of the laryngoscope.

A remote shutter release is essential to prevent vibration during exposure and the surgeon should not be in contact with the microscope, again to prevent vibration. The exposure duration will depend on the film speed, and the ideal film type is discussed below.

Photography using the camera attached to the bronchoscopic telescope gives better framing of laryngeal pictures and is essential to take photographs of the trachea and bronchi.

Again, a single lens reflex camera is essential, and automatic flash control with through-the-lens metering (TTL) and automatic flash quenching when exposure is sufficient is helpful. A light source with coaxial flash is required, and to obtain consistency the same fibreoptic cable should be used each time. A zoom lens attaches directly to the telescope.

Using suspension laryngoscopy, a large telescope

(4 mm) can be used which gives a large image on the transparency and in which adequate lighting is not a problem. The telescope with camera attached can be introduced directly into the suspended laryngoscope and photographs taken.

Alternatively, the camera can be attached to the 2.7 mm telescope when fitted to the bronchoscope, and in this case the camera is used as the eyepiece of the bronchoscope. It calls for some experience in the use of the bronchoscope and it is often easier to introduce the bronchoscope before attaching the camera. Exposure with automatic flash is sometimes excessive, since the image is tiny in the centre of the field and the automatic exposure attempts to compensate for the area unexposed. This may result in over exposure of the central portion of the image; the problem can be overcome by bracketing exposures i.e. deliberately over and underexposing subsequent frames. It is better to waste a few frames of film than fail to obtain unrepeatable photographs. Adjustment of exposure is easily accomplished on most cameras by an exposure value (EV) dial of ± 2 stops but if this is not available, the film speed dial can be changed up and down one stop. (One stop = double or half the ISO film speed rating).

Choice of film

It is assumed that only transparency film is to be used, though there is no reason why negative or polaroid film cannot also be used.

Two main considerations apply, namely film speed and colour balance. Film speed represents the relative light sensitivity and is measured on the arithmetical ISO scale, a doubling of the ISO number representing a doubling of sensitivity. The faster the film, the larger the grain size of the light-sensitive silver halide crystals in the film emulsion needs to be. Quality of photographs needs a balance between adequate sensitivity and small grain size. For photography using endoscopes, a film speed of ISO 400 is an ideal compromise, particularly since grain technology has improved dramatically over the last few years and has reduced grain size.

Colour balance has also to be considered in the choice of film. Daylight and electronic flash have a colour temperature of about 6000 K which is a fairly blue light, whereas halogen and tungsten lamps as found in surgical microscopes have a temperature of about 3000 K, a much redder light. Film is therefore balanced either for daylight or tungsten light. If daylight film is used directly on the microscope, an orange cast will be apparent on the transparencies which will distort colour values and reduce contrast. A better colour rendition will be obtained by using tungsten film, though this is usually only available as ISO 160 film speed. For photographs taken using flash through the bronchoscopic telescope, daylight film is appropriate.

There is no substitute in this type of photography for practice and experiment, and recording of light settings, film speed and other variables helps to obtain reproducible results.

Bull—Discussion

Graham

How do you stop your Storz telescope misting up?

Bull

Hot water. What also works well, particularly with the 3.5 millimetre bronchoscope, is the use of a size six feeding tube down the side arm with continuous suction, producing turbulence around the end to keep it clear. Misting is a problem with the suspended laryngoscope.

Bailey

I have reverted to using Storz's ultra-stop solution, which is basically a photographic anti-fog solution, and lasts longer than hot water, taking you right through an endoscopy.

Kearns

We have also had a problem with bronchoscopy of not getting enough light down there, and especially when you are on automatic exposure, it is almost impossible to focus.

Bull

Yes. The problem with automatic exposure is that you expect to get an 18 per cent grey over the whole of the transparency area, but with the small telescope only a little bit is exposed. This can be overcome by changing the film speed setting on the camera, so that the camera then believes it has exposed enough whereas, in fact, it has probably underexposed. To take photographs you have to waste film, bracket the exposures and take several different frames of each.

Bull

Polaroid gives rapid processing but you still need to expose the full length of film. The transparency film can be processed instantly but a length of film of, say, 24 exposures still needs to be processed.

Cinnamond

Vaughan in Boston described the true suspension laryngoscope where the extension of the upper arm extends beyond the tip of the laryngoscope.

Bull

Does anyone use a fibreoptic scope?

Graham

I use a fibreoptic larynoscope which is very good for a quick view of the trachea and subglottis.

Evans

It would be nice to fibreoptically laryngoscope babies with laryngomalacia.