Postoperative pulmonary complications account for a substantial part of the risk related to surgery and anaesthesia and are a source of postoperative morbidity and mortality and longer hospital stays. Postoperative pulmonary complications are often life-threatening, as shown by associated mortality rates that can be as high as 20%.

The current evidence basis informing us of the nature of postoperative pulmonary complications is biased because of flaws such as the inclusion of a small number of studies of good quality, the lack of a uniform definition, and the reliance on studies restricted to specific patients and kinds of surgery.

The evidence supports that risk factors for postoperative pulmonary complications are related to the health status of the patient and with the anaesthetic and surgical procedure.

Age, co-morbidity in general and pre-existing respiratory and cardiac diseases in particular, the use of general anaesthesia and overall surgical insult are the most significant factors related to the development of postoperative pulmonary complications.

Election of anaesthetic technique, postoperative analgesia and physical therapy seem to be the preventive measures that are best supported by evidence. Aggressive treatment of postoperative pulmonary complications is mandatory if mortality is to be reduced.

Recently, a score for predicting postoperative pulmonary complications was developed from a prospective, multicenter study of a random-sample cohort of patients undergoing nonobstetric in-hospital surgical procedures with general, neuraxial, or regional anaesthesia. In the ARISCAT study, 59 Spanish hospitals participated. This study identified seven independent risk factors: low preoperative arterial oxygen saturation, acute respiratory infection during the previous month, age, preoperative anaemia, upper abdominal or intrathoracic surgery, surgical duration of at least 2 h, and emergency surgery. The area under the receiver operating characteristic curve was 90% (95% CI, 85-94%). The ARISCAT index can be used to assess individual risk of PPC and focus further research on measures to improve patient care.
Despite steady advances in care, patients with respiratory disease are still at increased risk for postoperative respiratory complications (PRCs) such as atelectasis and pneumonia. Indeed, PRCs may rival cardiovascular complications in frequency and severity. Fortunately, with proper perioperative care, even patients with crippling respiratory disease can usually be brought safely through surgery. Many factors responsible for PRCs are related to the disruption of the normal activity of the respiratory muscles, both by anesthetic drugs and by mechanisms related to surgical trauma in the postoperative period. Lack of normal respiratory muscle coordination leads to dependent lung atelectasis and impaired ventilation-perfusion matching. As a general principle, pulmonary function should be optimized preoperatively, with the definition of “optimization” depends on the type of respiratory disease and the individual patient. For example, patients with asthma should achieve optimal symptom control preoperatively. Smoking has special importance as a risk factor for PRCs because it can be modified preoperatively. Unfortunately, the lung probably requires several months to fully recover from the damage caused by cigarette smoke, and several weeks of abstinence may be necessary before benefit is observed. However, there is no evidence that brief abstinence increases risk, so that any time is a good time for patients to quit smoking, and anesthesiologists should help them do so. Principles of intraoperative management include bronchospasm prophylaxis in patients with reactive airways, avoidance of endotracheal intubation and mechanical ventilation when feasible, use of regional analgesia when feasible (although this may not prevent complications), use of lower tidal volumes with recruitment maneuvers followed by positive end-expiratory pressures, vigorous postoperative respiratory therapy, and continuous positive airway pressure for postoperative hypoxemia.
Optimization of Mechanical Ventilation, Grégory A. Hans, M.D., Ph.D. Department of anesthesia and intensive care medicine, CHU Liège, University of Liège, Belgium.

Anaesthesia-induced muscle relaxation reduces lung volumes, especially the functional residual capacity. This favours repeated closure of small airways and constitution of atelectases. Repeated closure of small airways and atelectases not only alter gas exchanges but also contribute to ventilator-related lung injury. Over the last decade, accumulating evidence has suggested that the way anaesthetized patients are ventilated should be changed. Lung collapse can be prevented from the beginning of anaesthesia induction by using a head-up position, applying a continuous positive airway pressure and lowering the inspired oxygen fraction. During mechanical ventilation, applying a positive end-expiratory pressure is the cornerstone of the prevention of alveolar collapse. Despite these measures, alveolar derecruitment does occur in some circumstances and need to be reversed by performing a recruitment manoeuvre. In addition, attention should be paid to limit the tidal volume, which is another major contributor to ventilator-related lung injury. The extubation phase is also critical since hypoventilation occurring during the transition between spontaneous and controlled ventilation often combined with the use of pure oxygen leads to recurrence of atelectases. In addition to the measures effective during anaesthesia induction, the use of an assisted mode of ventilation to smoothen transition between mechanical ventilation and spontaneous breathing can be proposed. Whether this new way of ventilating anaesthetized patients will help reducing postoperative pulmonary complications remains to be proven. The PROVILHO trial is a large prospective and randomized multicentre trial aimed at answering this question. Its results are expected by the beginning of year 2013.

Adequate visualization of the glottis and good technique are mandatory to perform safe and atraumatic tracheal intubation in children as well as in adults. In neonates, infants and small children this is even more critical due the anatomic differences with the adult airway and to the increased risk of hypoxemia during and following the procedure. A lot of new devices have recently been presented on the market: most of them need to position the patient’s head differently and to use a slightly different intubation technique. However, their learning curve is steep and they could be a good alternative to fiberoptic laryngoscopy in case of difficult intubation. The goal of this review is to critically review them in light of the literature and the author’s experience. Retrograde intubation and fiberoptic laryngoscopy will not be considered.

1. Classic laryngoscopes and blades

Different pediatric laryngoscope blades are available: their selection is usually a matter of the user’s training and familiarity. Most textbooks recommend using a straight blade in neonates and infants and a curved blade in children and adolescents. In theory, to obtain a good view of the glottic aperture, a straight blade is used to lift the epiglottis anteriorly while a curved blade is placed in the vallecula, anterior to the epiglottis. In practice however, a straight blade should be used in the same way as a curved blade not only because the epiglottis is reflexogenic but mainly because if the arytenoids are lifted with it (which easily occurs if the blade is inserted a little too far), the only aperture visible to the unfamiliar intubator is the esophagus!

Many brands of laryngoscope blades with the same official denomination are available on the market: however apparently small differences in size or curve between them can make a huge difference when performing direct laryngoscopy. For any model of blade, size 0 is used in neonates, size 1 in infants and size 2 from 2 to 7 years of age.

1.1. Straight blades

The Miller blade is straight with a slight curve near its tip while the Wisconsin, Wis-foregger and Wis-Hipple blades have no curve at all. In cross-section, as seen from the handle connection, these blades are C-shaped: this gives just enough room to perform oral intubation but does not always prevent the child’s tongue from slipping into the visual axis. The Robersshaw blade is curved near the tip but its cross-section presents a C shape which is extended to the left (as seen by the intubator) in order to give more room to use a Magill forceps.

Other straight blades have a reverse-Z shaped cross section. This keeps the patient’s tongue away and facilitates the use a Magill forceps for nasotracheal intubation. They are the Soper (straight) and the Seward, Cardiff (1) or Heine (curve near the tip) blades.

1.2. Curved blades

The only curved blade is the Macintosh blade. In cross-section, as seen from its handle connection, it has a reverse Z shape. One drawback of the small Macintosh blades equipped with a light bulb is the excessive height of their connection to the handle. It is smaller in the fiberoptic curved blades.

1.3. Special blades

The McCoy levering laryngoscope allows mechanical manipulation of the blade tip in order to improve the glottic view without applying excessive force on the pharyngeal structures. A pediatric levering laryngoscope with a Seward blade (size 1 or 2) has recently been introduced in practice but it does not provide any advantage over a classic Miller blade (2).

1.4. Light-bulb versus fiberoptic blades

The blade is equipped with a light bulb, a fiberoptic bundle or light emitting diodes that transmits light from a source in the handle. The position of this light source should be near the tip of the blade. If it is too proximal, the pharyngeal soft tissues or the distal part of the tongue can come in front of it and obstruct the light. The brightness and steadiness of the light as well as the proper contact between handle and blade should be checked before use by placing the blade in working position. It has been suggested that the light output should be at least 700 lux at a distance of 20 mm for minimum 10 minutes but this level of illumination seemed too bright in one study (3).

The light bulb is screwed into a socket with a metallic contact. This area is subject to soiling and oxidation which can affect the quality of the light. The adequate screwing of the bulb to its socket should be verified before each use because it can fall out during laryngoscopy (4). Moreover, the light bulb reach temperatures that could result warm the blade and result in burns to the oropharynx. It should therefore be switched on for less than 1 minute before use (5).

1.5. Single-use blades

Both straight and curved blades are also available in plastic, single-use, fiberoptic versions that are especially useful in infected cases. Their quality (flexibility, brightness and direction of light) varies according to the conditions.
anterior wall of the subglottic area (12). to use a styletted tracheal tube and to turn it 180° once laryngoscopy has been successfully used in cases of difficult intubation in infants: it is however recommended to use a styletted tracheal tube and to turn it 180° once the glottic aperture is passed in order to avoid hitting the anterior wall of the subglottic area (12).

1.6. Technique for direct and retromolar laryngoscopy

For direct laryngoscopy, the blade is introduced at the right side of the mouth and passed on the side of the tongue to displace it to the left and reach the vallecula. A modified technique, called the retromolar or paraglossal approach, is useful in case of micrognathia. The straight blade is inserted through the corner of the mouth, posterior to the molar teeth, and directed in the groove between the tongue and the homolateral tonsil until the epiglottis is seen. The tracheal tube is then inserted through the homolateral corner of the mouth and directed into the glottis with the help of external laryngeal manipulation and a stylet or an intubation guide (7, 8, 9).

During every laryngoscopy, care should be taken to avoid crushing the child's lip between the blade and teeth, and to avoid applying force on the neonate’s upper gum because this could result in damage to future teeth.

2. Videolaryngoscopes

They can be divided in two categories: 1) standard laryngoscopic blades equipped with a video channel or 2) new models of blades designed to show a clear view of the glottis without alignment of the oral, pharyngeal and tracheal axes, i.e. without moving the head and neck.

2.1. Classic blades with a video channel

Both Miller and Macintosh blades equipped with an external fiberoptic bundle (2.8 mm such as X-Lite Video® or Fiberoptic Laryngoscope®) (10) or in which a fiberoptic lens is integrated and coupled with a camera through the handle (X-Lite® video by Rüsch, Storz DCI videolaryngoscope, Berci-Kaplan videolaryngoscope) are available. They are useful for teaching direct laryngoscopy (the instructor can directly guide the novice) and when external laryngeal manipulation is necessary for intubation.

These devices provide a better view of the glottis and tracheal intubation time remains the same as with classic laryngoscopes. However, intubation is not always easier because some training (eye-hand coordination) is needed to learn how to use a flat two-dimensional image instead of the three-dimensional direct vision. Moreover, the laryngeal picture is obtained while applying less force on the jaw and pharyngeal structures: the pharyngeal, laryngeal and tracheal axes are thus not as well aligned as during direct laryngoscopy (11). Videolaryngoscopy has been successfully used in cases of difficult intubation in infants: it is however recommended to use a styletted tracheal tube and to turn it 180° once the glottic aperture is passed in order to avoid hitting the anterior wall of the subglottic area (12).

2.2. Glidescope®

The Glidescope Cobalt® (Verathon Inc) is made of a high-resolution video imaging tube enclosed in a reusable handle (called “baton”) and a single use plastic blade (Stats®). It provides a view of the laryngeal structure on a separate screen and looks like a Macintosh blade but bent at 60° with the handle. Two sizes of batons and four sizes of blades are available. Although the glottic view is usually easy and excellent, it is often not easy to introduce the tracheal tube into the glottic opening. For oral intubation, the use of the accompanying stylet or of a standard stylet to bend the tube makes its manipulations toward the glottis easier. It seems that bending at 90° is more successful at first attempt than 60° (13).

The Glidescope® should be introduced under direct vision in the middle of the tongue with the head in the neutral position. One should look at the monitor to obtain the best view of the epiglottis and glottic opening. The blade should be used like a Macintosh blade, without lifting the epiglottis. To avoid any damage to intraoral structures, the styletted tracheal tube is carefully introduced from the right corner of the mouth under direct vision up to when its tip is near to the distal part of the blade (14). At that time, the intubator looks again to the monitor to complete the intubation process under video control. Some manipulation like turning the tube 180° or removing the stylet are often necessary to avoid the tube hitting the anterior wall of the glottis or subglottis.

This device can be used in case of difficult intubation provided the patient’s mouth opening is greater than 15 mm. When used to perform nasotracheal intubation in children with no criteria for difficult intubation, it does not offer any benefit over direct laryngoscopy (15).

2.3. McGrath®

This device incorporates a light source and a miniature camera in a blade (the length of which can be modified to match the patient’s characteristics) and a handle onto which a small LCD screen is mounted to show the image obtained. A sterile transparent blade covers the reusable camera-blade assembly. It can be used in the same way as a classic laryngoscope but the blade is best introduced in the middle of the mouth using a curving motion until the glottis is seen. Although the glottic view is excellent, the tracheal tube needs to be mounted on a stylet bent upwards at 60° to facilitate intubation. The McGrath® videolaryngoscope can be used in big children and adolescents if the smallest length of blade is chosen.

3. Optic laryngoscopes

They can be considered as a modern and smaller versions of the Bullard laryngoscope, an intubation device that did not become popular outside North America (16, 17).
3.1. Airtraq®

The Airtraq® (Prodol Meditec, Spain) is a single use indirect laryngoscope: the exaggerated curvature of its blade and the configuration of its optical components provide a view of the glottis with no need to align the oral, pharyngeal and tracheal axes. The main channel of the device contains the optical components (with a built-in light source and antifog system) and a right-sided parallel channel equipped with a groove to place the adequate tracheal tube and guide its insertion. Five sizes are available.

The Airtraq® should be introduced under direct vision in the middle of the tongue with the head in the neutral position. When the monitor (built-in small optical system or wireless monitor) gives the best view of the epiglottis, the tip should be placed in the vallecula. The handle should then be lifted up vertically to lift the epiglottis and expose the glottic opening. The latter should be aligned with the center of the visual field because the right-sided groove is designed to direct the tip of the tube towards the center of this visual field. The tip of the tube is guided into the glottic opening under direct visual control. After intubation, the tube is separated from the Airtraq® by pulling it laterally. The Airtraq® is rotated backwards and taken out of the mouth.

The Airtraq® improves visualization of the glottis and facilitates both normal and difficult intubation in adults while reducing the hemodynamic response to laryngoscopy. It has been used successfully in a few cases of pediatric difficult intubation (18, 19). One case of trauma to the right tonsil has been described in a 4-years-old child with tonsillar hypertrophy: the authors could not determine whether the blade itself or the external part of the intubation channel was responsible for this but stress the importance of introducing carefully an Airtraq® in a small mouth (20).

3.2. Truview® laryngoscope blade

The Truview infant EVO2® laryngoscope blade includes a fiberoptic light, an integrated optical lens system and a 46° angulated tip. This provides a good indirect view of the glottis through a magnifying optic sideport without needing to align oral, pharyngeal and tracheal axes. There is an integrated O2 jet (flow rate 2-5 L/min) to prevent fogging and allow O2 administration during laryngoscopy. The child’s head is best placed in the neutral position. A stylet (a special Optishape® stylet is provided with the blade) is introduced into the tracheal tube to give him the correct angulation (a hockeystick shape, usually). The Truview EVO2® is introduced in the middle of the mouth over the tongue. When the glottic opening is seen in the eyepiece, the tracheal is introduced in the mouth along the side of the blade under visual control until its distal part is seen in the eye piece. It is advanced slightly upwards to enter the cords. This system provides an excellent view of the glottis but requires some practice to get good eye-hand coordination (21).

4. Optical intubation styles

They can be considered as a video equipped versions of the lightwand or Trachlight®. North-American devices using laryngo-tracheal transillumination to achieve blind tracheal intubation (22, 23).

4.1. The Shilkani® Optical stylet

The Shilkani® Optical stylet (Clarus Medical, Menneaoplis, USA) is a malleable stainless steel fiberoptic stylet equipped with an eyepiece which can be connected either to a video camera or the light source of a special or standard fiberoptic laryngoscope handle. Is is easy to use and does not require a long learning process. It combines the advantages of a lightwand and a fiberoptic bronchoscope. The only drawbacks are the limited depth of the visual field (± 1 cm) and loss of visibility once secretions cover the lens. The pediatric version is 27 cm long and can be introduced in a 2.5 mm ID tracheal tube. The adult version can be used with a 5.5 ID tracheal tube or larger. Both the outer surface of the stylet and the inner surface of the tube need to be lubricated. The stylet is introduced in the tube so that the distal lens does not exit past the end of the tube. This position is secured using the “tube stop” device through which a flow of O2 can also be administered. The tube equipped with the stylet is introduced in the pharynx and advanced towards the glottis under both external transillumination and direct endoscopic visual control. An assistant performing a light jaw-thrust or pulling the child’s tongue out of its mouth is helpful to enlarge the space between the epiglottis and the posterior pharyngeal wall. The tube is advanced on the stylet and introduced in the trachea when the trachea is just entered (24).

4.2. Bonfils® and Brambrink® fiberscopes (Storz®)

They are reusable rigid fiberscopes with a 40° curved tip and an eye piece on the handle. Light is provided via a cold light source or a handle with a battery. It is equipped with a special connector that fits a 15 mm standard tracheal tube connector that is designed to secure the tube position on the scope and to allow insufflation of O2 to prevent fogging of the distal lens. The Brambrink® is a 2.0 mm OD 22 cm long optical rod suitable for tubes with an ID 2.5-3.5 mm. The Bonfils® fibrescope is available in two pediatric sizes: the 3.5 mm OD model for tracheal tubes 4.0 to 5.5 mm ID and the 5 mm OD model (equipped with a suction channel) for larger tubes. Both the outer surface of the device and the inner surface of the tracheal tube must be lubricated. The fibrescope is inserted in the tube up to 0.5 to 1 cm proximal of its end. The tube is fixed to the fibrescope using the special connector.

The child’s head should be in the neutral position and the scope is inserted from the right side of the mouth. A jaw thrust maneuver is helpful to enlarge the space between the epiglottis and the posterior pharyngeal wall. The scope is advanced under visual control until its tip is
at the level of the glottis. The tube is then disconnected and advanced over the fiberscope into the trachea.

One team recommends using the Bonfils® fiberscope like a Trachlight®, ie with a midline approach and grasping the jaw with the non-dominant hand, allowing the tip to advance slowly down to the level of the epiglottis along the pharyngeal wall. The fiberscope is rotated anteriorly toward the epiglottis and advanced under it to uncover the glottis (25).

An evaluation of the Bonfils® device in children with a normal airway had a significant failure rate and its use cannot be recommended (26). Failures were mainly caused by poor visualization of the glottic structures because of the presence of secretions and the small pharyngeal space.

5. Aids for Intubation

This equipment, designed to make oral or nasal intubation easier, is not new but the new intubation devices described above often require their use to achieve tracheal intubation.

5.1. Bougies or Intubation Guides

They act as an atraumatic guide over which the tracheal tube is advanced when its tip cannot be directed easily into the glottis during direct or indirect laryngoscopy.

The following devices can be used for this purpose:
- an exchange catheter such as the Cook airway exchanger®, the Sheridan T.T.X.® and Tracheal tube guide®,
- a suction catheter
- or even a nasogastric tube.

The use of a hollow device allows the delivery of O₂ during the procedure and/or the measurement of CO₂ to confirm its intratracheal position before inserting the tube over it. Tracheal trauma is possible when using a bougie, especially in neonates and infants. It should thus be used very gently and force should never be applied if any resistance is met.

5.2. Stylets

Stylets are pliable but firm devices (usually plastic coated metal rods) used to modify the curvature of the tracheal tube and impose a predetermined shape to it. This is mandatory when using the retromolar approach and most video- and optic-laryngoscopes. Some teams use them for routine intubation. The stylet should resist to chipping and breaking, and its distal end should be smooth to avoid trauma to the pharyngeal and laryngeal tissues. Before inserting the stylet into the tube it should be well lubricated and the tube connector should be removed to make withdrawal of the stylet easier. The stylet is inserted into the tube until its distal end is just inside the distal end of the tube. Bending the stylet at the proximal end of the tube or placing an adjustable stop is necessary to prevent the stylet from advancing past the end of the tube during the intubation procedure. The stylet and tube are bent to the desired shape, which is usually a “hockey stick” configuration (distal end bended sharply). When the laryngeal inlet is exposed, the stylet-ted tube is directed into it: the stylet must be removed as soon as the extremity of the tube has passed the vocal cords. Possible complications are difficult removal of the stylet after intubation, shearing off of part of the stylet during its difficult removal and subsequent tube obstruction (27) and tracheal trauma. Many brands and sizes of stylets are available which can be used in tubes as small as 2 mm ID.

Conclusion

Although all the new airway devices described above were very quickly adopted by the anesthesiologic community worldwide, some important points need to be stressed:

1) they provide a better, often excellent, view of the glottis than direct laryngoscopy and thus an improved Cormak and Lehane score. However this score was specifically designed to describe the picture observed during direct laryngoscopy and so the ease of intubation in that context. Using the same score to predict ease of intubation with devices that do not align the pharyngeal, laryngeal and tracheal axes could be misleading;

2) most need to use of a stylet or bougie to achieve tracheal intubation despite the excellent view provided: this is because the image transmitted from the tip of their blade is obtained without applying much force on the jaw and pharyngeal tissues, i.e. without not aligning the pharyngeal, laryngeal and tracheal axes. Moreover, some training is needed to learn how to use a flat two-dimensional image instead of the three-dimensional direct vision to intubate;

3) they are not equivalent in terms of cost/benefit ratio: it is hard to predict which of them can be used in most cases of difficult intubation. The shape and size of one device can make it better suited for one patient than for another (27);

4) their learning curve is much quicker and their cost is much lower than for fiberoptic laryngoscopy, up to now the gold standard for difficult intubation: this could lead to loss of expertise in using it when nothing else works;

5) up to now, difficult intubation algorithms do not include any one of these devices: should they be used at first attempt in case of foreseen difficult intubation? should they be used instead of fiberoptic laryngoscopy when direct laryngoscopy fails?

These new airway devices are of course the welcome result of progress in miniaturization and fiberoptic light transmission but their exact place in anesthetic practice and safety needs to be determined by well-designed research.

References

comparison with the Miller size 1 and the Macintosh size 2 laryngoscope blades, Anaesthesia, 59, 1016-9, 2004.
Noninvasive ventilation 

Noninvasive ventilation (NIV) was primarily designed for the treatment of acute cardiogenic pulmonary oedema and exacerbations of chronic obstructive pulmonary disease. However, in the last years, it has been used in several other clinical conditions, such as perioperative acute respiratory failure (ARF). ARF in the perioperative setting develops especially after abdominal and thoracic surgery and is responsible for important morbidity and mortality. Avoiding endotracheal intubation while conserving adequate gas exchange is the main goal of NIV in the perioperative setting. NIV supports the respiratory muscle function, reduces work of breathing, diminishes atelectasis and increases alveolar ventilation. Moreover, NIV produces favourable hemodynamic effects in patients with cardiac failure by reducing left ventricular afterload and increasing cardiac output.

NIV can be applied as continuous positive airway pressure (CPAP) or as the combination of PEEP with inspiratory pressure support, which is commonly called BiPAP. CPAP alone exerts its effect mainly by increasing intrathoracic pressure and thereby increasing alveolar ventilation. On the other hand, BiPAP gives a better support of the respiratory muscle function and is more effective to enhance CO2-elimination. NIV can be applied with ventilators designed specifically for non-invasive ventilation. However, the newest generation conventional ICU-ventilators have all incorporated NIV-modes. Leak compensation and cycling to exhalation is of main importance to obtain a good patient-ventilator interaction during NIV. A key determinant for success with NIV is the used interface. Masks can be nasal-, face-, total facemasks or helmet. In the acute setting, a nasal mask is not indicated. The mask should be individually adapted to suit the patient.

There are no clear guidelines about the timing of NIV. In all cases, NIV should result in a significant amelioration of the clinical status of the patient in the first hours. Endotracheal intubation should not be postponed until an emergent situation occurs.