Official Journal of the Asian Pacific Society of Respirology
Respirology

CLINICAL PRACTICE GUIDELINES

Advanced interventional pulmonology procedures: Training guidelines from the Thoracic Society of Australia and New Zealand

DAVID FIELDING,[1] MARTIN PHILLIPS,[4] PETER ROBINSON,[5] LOUIS IRVING,[6] LUKE GARSKE[2] AND PETER HOPKINS[3]

[1]*Royal Brisbane and Women's Hospital,* [2]*Princess Alexandra Hospital,* [3]*The Prince Charles Hospital, Brisbane,* [4]*Sir Charles Gairdner Hospital, Perth,* [5]*Royal Adelaide Hospital, Adelaide, and* [6]*Royal Melbourne Hospital, Melbourne, Australia*

ABSTRACT

Training in interventional pulmonology procedures is increasing in popularity. However, the nature of training is difficult to define, particularly with respect to an adequate number of cases. These guidelines approach training not just from a modest number of supervised cases, but also from a range of educational and outcome targets which give a rounded approach to the issue. These include prerequisite skills from basic procedures, the place of simulated training, formal simulation testing, modest procedural outcome and side effect targets, audit presentations, ongoing reading, and hands-on training expectations. All of this would still be under the supervision of an experienced trainer.

Key words: bronchoscopy/standards, computer simulation, education, respiratory tract diseases/ultrasonography.

INTRODUCTION

These guidelines for thoracic medicine advanced procedural training encourage fulfilment of a range of parameters, not just accumulating an empirical number of cases. These include the following:

1 Completion of requisite reading and formal teaching on evidence relating to disease-specific applications of the methods (e.g. lymph node staging in lung cancer, pleural effusion management in lung cancer) and procedure-specific theory (e.g. laser bronchoscopy, argon plasma coagulation (APC) or diathermy).
2 Completion of simulated training, preferably before commencing procedures in patients.
3 Empirical numbers as a starting point.
4 The importance of a teacher–student relationship. The trainee has to achieve competence in the procedure as certified by an accredited trainer. As a guide, it usually takes about 20 cases to have achieved the appropriate skill level; however, that can vary as judged by the expert trainer.
5 Attainment of modest procedural outcome measures during training and in ongoing clinical practice.
6 Attendance at dedicated procedural conferences and fulfilment of modest presentation and/or publication goals.
7 Ultimately, when it becomes available, a 'pass' on a universally accepted objective assessment tool. In the absence of this last parameter, we can at least insist that trainees undertake simulated training, and that such training itself has an objective assessment. In time, such an assessment could become either a goal prior to commencing patient practice or, when such tools are more fully developed, a means of evaluating the individual's overall technical skill in the procedure.
8 Record keeping on procedural outcomes.

The procedures covered in these guidelines are the following:

- Endobronchial ultrasound transbronchial needle aspiration (EBUS TBNA)
- EBUS guide sheath
- Medical thoracoscopy
- Rigid bronchoscopy
- Thermal techniques
- Laser bronchoscopy
- Endobronchial electrosurgery
- Endobronchial stents
- Autofluorescence bronchoscopy (AFB) and narrow band imaging (NBI)

Ultimately, a demonstration of adherence to these points should allow a trainee to present their training experience for a particular procedure to a hospital

Correspondence: David Fielding, Department of Thoracic Medicine, Royal Brisbane and Women's Hospital, Herston, QLD 4029, Australia. Email: david_fielding@health.qld.gov.au

Received 18 April 2012; invited to revise 7 May 2012; revised 15 May 2012; accepted 24 May 2012 (Associate Editor: David Feller-Kopman).

doi: 10.1111/j.1440-1843.2012.02253.x

credentialing committee to allow commencement of practice.

PREAMBLE TO TRAINING GUIDELINES IN ADVANCED BRONCHOSCOPIC PROCEDURES

We encourage thoracic trainees and physicians to learn these advanced procedures. Some will be able to learn a range of techniques, but most will select one or two that extend their skills from basic bronchoscopy. Which procedure(s) you set out to learn often depends on what you are comfortable with. A number of the procedures simply build on skills you already know (transbronchial lung biopsy and TBNA for EBUS, chest tube placement for thoracoscopy), whereas others require a quite different and new set of skills, and take you more out of your comfort zone (rigid bronchoscopy). In general, we recommend focusing on one or perhaps two of the advanced procedures, rather than expecting to learn all of the procedures during advanced training. Australasian guidelines for basic bronchoscopy were published in 2001 and are to be reviewed in the next 12 months.[1] The guidelines below have been endorsed by the Thoracic Society of Australia and New Zealand (TSANZ).

Recent US interventional pulmonology guidelines suggest procedure training to occur either during conventional training or, where additional skills are required, within an additional year dedicated to procedures.[2] 'Training in these advanced procedures should only be pursued if there is a realistic expectation that the trainee will achieve sufficient proficiency in the given procedures to perform them without supervision at the completion of training and maintain the skill set thereafter. Brief exposures to these advanced procedures during most standard pulmonary and critical care fellowship programs or training courses are not adequate to achieve competency'. Similarly, The American Society for Gastrointestinal Endoscopy states that 'more complex diagnostic and therapeutic procedures are used less frequently than standardized procedures . . . [and] their successful performance requires fewer endoscopists with more skill and experience gathered during a longer training period . . . often for one year after a standard fellowship'.[3] They also state that 'not all trainees should pursue such advanced training nor should all programs offer advanced training . . . such training should be concentrated in those programs that have a combination of both patient volume and faculty expertise'.

Therefore, it is important for trainees to identify a need for a particular procedure at their current or intended hospital. A steady flow of referrals for a particular procedure is needed to maintain skills. If one is working in a major city hospital, there might be a relatively constant number of rigid bronchoscopy cases, whereas in a provincial centre, only one or two such cases might be seen in a year, and referrals to a major centre would be the sensible option. Conversely, some procedures that seem invasive at first (medical thoracoscopy) can be done effectively and safely in a provincial centre, as there is always a steady stream of pleural problems and skills can be easily kept up. In major cities, for example, there ought to be at least two proceduralists offering rigid/laser/stent services because it is unsatisfactory for no service to be available if the only skilled proceduralist is on leave.

The recent 'BTS guideline for advanced diagnostic and therapeutic flexible bronchoscopy in adults' provide up-to-date evidence on the clinical applications and outcomes of many of the procedures discussed in this guideline.[4]

THE NATURE OF TRAINING: PROCEDURE NUMBERS VERSUS SIMULATED TRAINING

In an editorial, Ost *et al*. summarize the problem of the best framework of procedure training:[5] 'The assumption is that the more a physician performs a procedure, the better he or she will be. However, precise data describing the learning curve for procedures are difficult to obtain. In addition, there is significant variability in terms of the rate of skill acquisition, so what constitutes sufficient volume to learn a skill may vary widely between individuals. Even if data on learning curves were available, where to set the volume thresholds for certification would always be a difficult question given this variability. Should it be toward the top of the distribution, such that 95% of all graduates will have adequate experience? Should it be the median? No matter where we set volume thresholds, the answer will be wrong. Set it too high, and many will be excluded, with the result being slow dissemination of otherwise useful technologies and missed opportunities. Set it too low, and complications and inappropriate utilization patterns will develop. A simpler solution is to measure and monitor outcomes and performance quality directly, and to provide feedback to physicians rather than relying solely on expert opinion, volume requirements, or other surrogate markers. Such a system could be combined with volume requirements and other didactic instruments. One of the greatest challenges in the field, however, is that the necessary procedural quality benchmarks for such a system do not exist'.

Accordingly, these TSANZ guidelines use both previous published numbers as well as procedural outcomes that the authors considered modest on the basis of their experience. Knowing more about outcomes of these procedures, we should now start to look for those outcomes from the start of training. If outcomes are being met, training and ongoing practice must be going well. Numbers help, but expected outcomes are better as quality control for trainees. The proposed outcomes are modest in their expectation, not set at an expert level. The guidelines suggest internal audit parameters based on lung function improvement, comparative comfort questionnaires and so on.

SIMULATED TRAINING

Unroe *et al*. recently demonstrated clear improvement in bronchoscopic skill with early use of virtual reality simulators in a 2-year prospective multicentre evaluation of educational interventions to assist first-year pulmonary fellows in acquisition of bronchoscopy skills.[6] The group utilizing virtual reality simulator acquired bronchoscopy skills significantly faster than the control group. This was most pronounced in the first 30 bronchoscopies. They considered that 'the success of this type of comprehensive curriculum for bronchoscopy training lays the groundwork for training in advanced bronchoscopic techniques, such as EBUS TBNA'. Recently, both low- and high-fidelity EBUS TBNA simulators have been evaluated for their training benefits, and offer realistic tactile feeling of how the scope and needle operate. This cascaded approach to education shapes 'deliberate practice pedagogy. Joined with a mastery-learning program structure, the combination creates the potential for a more standard way to assess knowledge and competence'. As Unroe states, '[a]n ideal curriculum would include pre-procedure training on low or high fidelity simulators, as available, combined with a computer based CT and ultrasound image interpretation. By then, the learners would be prepared to perform EBUS-TBNA on live patients under close supervision from experienced faculty'.

In an American College of Chest Physicians review of the benefits of simulated practice, McGaghie *et al*. comment:[7] 'Deliberate practice is an educational variable associated with delivery of strong and consistent educational treatments as part of the mastery learning model. Although demanding of learners, deliberate practice is grounded in information processing and behavioral theories of skill acquisition and maintenance. It has at least nine requirements that can inform CME, as follows:

1 Highly motivated learners with good concentration;
2 Engagement with a well-defined learning objective or task;
3 Appropriate level of difficulty;
4 Focused, repetitive practice;
5 Rigorous, precise measurements;
6 Informative feedback from educational sources (e.g. simulators or teachers);
7 Monitoring, correction of errors, and more deliberate practice;
8 Evaluation to reach a mastery standard; and
9 Advancement to another task or unit'.

As stipulated below, attendance at training courses is, therefore, recommended as part of training in the particular procedure. Such courses should be predominantly simulated practice and preferably have an assessment at the end of the course, with a view to specific skill feedback to course participants. Such post-course assessments have been developed by Colt *et al*. for standard bronchoscopy (BronchusSTAT), EBUS TBNA (EBUS STAT) and medical thoracoscopy.[8,9] Colt's work at UC Irvine (see Bronchoscopy.org (http://www.bronchoscopy.org/education/BiEducEB_.asp)) is ongoing in evaluating subsequent clinical performance after post-course testing. Kemp *et al*. have published another putative method for objective assessment of EBUS TBNA skill known as cusum analysis.[10] They showed clear difference in speeds at which people learn new tasks, even studying operators highly experienced in similar procedural techniques. They state that '[w]ith the ever-expanding number and complexity of bronchoscopic procedures (and of medical procedures in general), there is a need to formulate adequate assessment tools for trainee development, and we propose cusum analysis as one such tool'.

Papers by Stather *et al*. and Salud *et al*. have also explored this issue.[11,12] In Stather *et al*.'s study, two cohorts of trainees were each evaluated while performing EBUS TBNA on two patients. Group 1 received training by performing 15 cases on an EBUS TBNA simulator ($n = 4$) and had never performed a clinical EBUS TBNA procedure. Group 2 received training by doing 15–25 EBUS TBNA procedures on patients ($n = 4$). There was no significant difference in the primary outcome measure of procedure time or number of successful aspirates between the groups. Indeed, the percentage of positive aspirates was very high and acceptable on clinical grounds, viz 93% and 86% for groups 1 and 2, and supports the number of 20 observed cases as an empirical number for training. It remains to be seen whether doing simulated training, as well as the observed 20 clinical cases, gives better outcomes than either intervention alone, but at the very least, doing the simulated training first starts trainees off at a good standard.

THE TEACHER

These guidelines are not meant to replace the relationship between a teacher (senior clinician) and student (senior registrar), which often is the best means to ensure adequacy of training and has been the time-honoured method in virtually every learned society. Some teachers may feel that one student grasps the procedures quickly, whereas another student, having completed the 'necessary number' of cases, clearly needs more instruction and supervision. The teacher–student relationship needs to be open so that if there is suboptimal progress, the reasons can be discussed during the training period.

Directly observed assessment of practical skills evaluation by a supervisor may be a useful tool to increase the speed of skills acquisition for procedures. This may be particularly useful for procedures done in relatively low numbers, such as rigid bronchoscopy, stents and thoracoscopy.

For a teacher to be a 'trainer', as far as these guidelines are concerned, the key is for that person to be experienced and accredited for the particular procedure in question. That is, they would have the case numbers as described in this guideline both in their prior experience and ongoing case numbers. They would also be accredited by their hospital to do the procedure in question. Whereas a trainer may have long experience in a variety of techniques, if he/she is not experienced, for example, in endobronchial stent placement, they would not train in that skill.

Table 1 Summary of published guidelines for numbers of procedures required in training

	ACCP[13]	ERS/ATS[14]	BTS[15]
Rigid bronchoscopy	20	—	—
Autofluorescence bronchoscopy	20	10	—
EBUS TBNA	50 (radial probe)	40 (linear 'convex' and radial probe combined)	—
Laser†	15	20	—
Diathermy/APC	15	10	—
Cryotherapy	10	—	—
Brachytherapy	5	—	—
Stents†	20	10	—
Balloon tracheobronchoplasty	5	—	—
Medical thoracoscopy	20	—	Levels of competence defined—see text

†Endoluminal therapies may be combined to achieve the recommended number.

ACCP, American College of Chest Physicians; APC, argon plasma coagulation; BTS, British Thoracic Society; EBUS TBNA, endobronchial ultrasound transbronchial needle aspiration; ERS/ATS, European Respiratory Society/American Thoracic Society.

Furthermore, by necessity, the full range of infrastructure components needs to be available and to function smoothly. This includes not only the necessary equipment; the bronchoscopy nurses, respiratory therapists and other allied health staff will need to be trained in order for the physician and institution to obtain adequate results and minimize complications.

ACCREDITATION

The process of accreditation for a procedure is complex. In many respects, accreditation actually means satisfying the hospital committee that the necessary credentials to do the procedure under their roof are met. Basically, it means that fellows have to be safe, and are willing to document and present their outcomes. Hospital accreditation committees quite rightly expect data on side effects, morbidity and mortality. Therefore, a focus of these TSANZ guidelines is to start a process of keeping a logbook that can be used when presenting to your hospital committee. They suggest outcomes of prospectively collected symptom/comfort scores for the different procedures, accomplishment of reasonable standards of diagnostic accuracy compared with international figures.

TRAINING CASE NUMBERS

Even though starting training is probably best done with simulated practice, case experience will, of course, still be essential. At first glance, 20 cases of any procedure seem a lot. The first suggestion is to apply to train at hospitals where the procedure of interest is regularly done. Second, visits to hospitals either in Australia or overseas for periods of up to a month or more either during or following advanced training could further case experience or exposure. Many senior clinicians will let fellows to at least partially assist them in cases, but even if this is not possible, simply observing the process and documenting cases for an intensive focused period will often satisfy a hospital accreditation committee. Creating a logbook is essential, by documenting all the cases observed or assisted at with still pictures and video, as well as basic history, along with biopsy results. Third, hands-on training at accredited courses is essential and is a part of recommended training in these guidelines. For the purposes of the ongoing tally of their own cases consultants teaching trainees these techniques could count the same procedure as the fellow.

We have included prerequisite techniques for each procedure. Trainees have to be able to 'walk before they can run'. Trainees should focus on getting all the basics right before starting the more advanced method. The right time to start learning the new procedures will vary greatly—and should be mutually agreed with the supervisor.

Table 1 summarizes published recommendations from the American College of Chest Physicians,[13] European Respiratory Society/American Thoracic Society[14] and British Thoracic Society[15] for training numbers for particular procedures. Note that, as per the original publications, '[n]umber achievement alone does not establish competency', and that '[m]astery of these skill sets is an ongoing process in practice, extending beyond the IP fellowship'.

EXPECTED ONGOING INTERVENTIONAL PULMONOLOGY ACTIVITIES FOR TRAINEES AND PHYSICIANS

In a 2-year cycle, trainees and physicians are expected to do the following:

- Attend one hands-on training course (preferably with simulated training, either low or high fidelity, with assessment), preferably before commencement of training in the procedure

• Attend one dedicated interventional pulmonology meeting
• Attend one interventional pulmonology special interest group oral and/or poster session
• Present or co-present an abstract, or publish an article on some aspects of interventional pulmonology at state/national or international level
• Read the *Journal of Bronchology & Interventional Pulmonology*. Pertinent manuscripts in *Chest*, *Respirology*, *Respiration*, *American Journal of Respiratory and Critical Care Medicine*, and *Journal of Thoracic Oncology* should be read as well.

ONGOING READING

Recommended web resources include the following:
• Guidelines at ATS—http://www.thoracic.org/sections/publications/statements/index.html
• Guidelines at ERS—http://www.ers-education.org/pages/default.aspx?id=725
• Essential bronchoscopist—http://www.bronchoscopy.org/education/BiEducEB_.asp
• Lung and mediastinal anatomy—http://www.imaios.com/en/e-Anatomy/Thorax-CT
• Interventional pulmonology website at TSANZ members only page: 'Insertion of chest tubes and management of chest drains in adults'.
• American Association for Bronchology and Interventional Pulmonology—http://www.aabronchology.org

Recommended textbooks include the following:
• Bolliger C, Mathur P (eds). *Interventional Bronchoscopy*. Karger, Basel, 2000.
• Kitamura S. *Colour Atlas of Clinical Application of Fiberoptic Bronchoscopy*. Wolfe Publishing Ltd, Tokyo, 1990.
• Boutin C, Viallat JR, Aelony Y. *Practical Thoracoscopy*. Springer Verlag, Heidelberg, 1992.
• Simoff MJ, Sterman DH, Ernst A. (eds) *Thoracic Endocoscopy. Advances in Interventional Pulmonology*. Blackwell, Malden, 2006.
• Beamis JR, Mathur PN, Mehta A (eds). *Interventional Pulmonary Medicine*. Marcel Dekker, New York, NY, 2004.

EBUS TBNA[16–21]

Introduction

Introduced in 2003, this method of sampling mediastinal and hilar lymph nodes has rapidly gained popularity and wide use because of a strong safety profile and high diagnostic yield. It is useful not only for staging of known carcinoma but also for allowing the original tissue diagnosis in patients with lung masses. A dedicated bronchoscope is used, which incorporates an ultrasound tip for real-time imaging of nodes adjacent to the bronchial/tracheal wall. It also utilizes a dedicated TBNA needle with dedicated biopsy channel. This needle is passed into the node in question and can be visualized in real time as samples are taken. Seven well-described anatomical sites can be sampled as defined for standard TBNA. This method, therefore, builds on the previous technique of 'blind' TBNA, which has been shown as safe for over 20 years. A number of aspects of conventional ('blind') TBNA have meant that, despite its safety, the technique has always been underutilized. Design aspects of the scope improve the ability of the TBNA needle to enter the lymph node through the bronchial wall. Studies comparing to 'blind' TBNA show that real-time ultrasound imaging improves results, particularly where the node is small and in less commonly biopsied sites. Even in more commonly biopsied sites, such as the subcarinal region, it improves the confidence of the operator to know the needle position at all times. Mediastinal staging is critical to many lung cancer patients; combining EBUS TBNA for anterior, subcarinal and hilar nodes with endoscopic ultrasound fine needle aspiration of the low posterior and subcarinal nodes means that very few patients now need a mediastinoscopy, and as such EBUS TBNA is now part of the basic staging mechanism for lung cancer.

Typical sensitivity for malignancy in a large number of studies is 90–95%. Accuracy of convex probe TBNA in lung cancer staging is exceptionally high, and in controlled studies exceeds that for positron emission tomography scan and computed tomography. The method has been shown in numerous studies to be an effective and simple way of obtaining tissue in the histological diagnosis of sarcoidosis, with yields of over 85% in patients with suspicious radiology. It thereby reduces the need for transbronchial lung biopsy and indeed has been shown when used in combination with transbronchial lung biopsy (TBLBx) to significantly improve the yield.

Indications

• Diagnosis of mediastinal/hilar nodes in patients with lung masses, either as the first means of making a tissue diagnosis or as staging of a known cancer
• Diagnosis of other isolated mediastinal masses
• Confirmation of sarcoidosis in patients with bilateral mediastinal/hilar nodes, either as a sole method or in combination with transbronchial lung biopsy

Requisite prior experience

• 100 flexible bronchoscopies with demonstrated competence
• 5 standard TBNAs

Number of cases in training

20

Requisite knowledge prior to training

• Understand node positions as described by K.P. Wang for standard TBNA, as well as nodal maps as per the International Association for the Study of Lung Cancer guidelines (see references)[22,23]
• Key anatomical relations at each of the seven commonly biopsied sites

Internal audit goals

• Print out and label major anatomical relations adjacent to lymph node biopsy sites in all cases—logbook

- Balloon and needle set-up in all cases
- Ability to pass scope through vocal cords in >90%
- Ability to image lymph node in question in >90% of cases
- Ability to pass TBNA needle through wall of trachea/bronchus into node in >80%
- Sensitivity for carcinoma in >75%
- Typical procedure time: 30–40 min

Safety goals
In ongoing cases, major bleeding <1%, pneumothorax <1%, infection <1%. Trainees should not have more than one of any of these complications.

Ongoing numbers
20 per year

EBUS GUIDE SHEATH/MINIPROBE[24–26]

Introduction
EBUS miniprobe is a tool that allows directed sampling of localized lesions beyond the view of the bronchoscope. It is used in conjunction with detailed interpretation of (reconstructed) computed tomography scans and usually fluoroscopy during the procedure. Therefore, it is an improved way of doing transbronchial lung biopsy of a peripheral lesion. Many bronchoscopy units do procedures for such lesions, and common yields are around 20% where only a bronchial washing is done. This can go up to around 40% where X-ray fluoroscopy is used. Comparative studies have shown the improved diagnostic yield of adding EBUS miniprobe compared with just doing fluoroscopy alone. The miniprobe can be used to sample lesions in distal bronchi, bronchioles and alveoli. Lesions that are angiocentric, such as metastases, tend to have a lower yield. The sensitivity for primary malignancy is >70%. Some parts of the lung are less easy to access with any form of transbronchial lung biopsy, and this is true for EBUS miniprobe in the left upper lobe. A wide range of localized infective and inflammatory lesions can also be sampled using miniprobe EBUS.

The techniques for miniprobe EBUS are the same as those currently used for sampling peripheral lesions with fluoroscopy. There are two additional aspects to training for this technique: first, the use of the plastic guide sheath through which the miniprobe is passed. This is described in detail by Kurimoto and others. It is a simple matter of learning to fit the plastic sheath to the miniprobe before the procedure; once the probe has entered the lesion, the probe is removed, while the sheath is left in place. Biopsy forceps are passed through this sheath to take the samples. In fact, this makes the whole process of doing the transbronchial biopsy easier because there is no need to re-localize the lesion each time. Second, when the probe enters a lesion, an ultrasound image is displayed in real time. During the procedure, the image is primarily used to confirm that lesion localization has occurred, and interpretation of the image is simply that of showing that there is a circumferential ultrasound shadow corresponding to a lesion as opposed to uninvolved lung surrounding the miniprobe. This is obviously the key to the success of a procedure. The added benefit of this image is that studies have shown that using simple ultrasound criteria, a classification of the image into 1 of 3 classes has a strong predictive value for the nature of the underlying pathology in the lesion, specifically whether it is malignant or benign. Therefore, learning to interpret these stored images after the procedure can assist in supporting pathology once it is returned, particularly where there is benign tissue on the biopsy and there are clear features of benign tissue on the EBUS image.

An important aspect of the miniprobe technique with the use of the guide sheath is the very low complication rate compared with standard transbronchial lung biopsy. Bleeding and pneumothorax with the technique are <1%, whereas these are seen in around 5% of standard TBLBx, including reports of major bleeding.

Indications
Biopsy of peripheral lung lesions (either masses or localized segmental infiltrates) beyond the view of the bronchoscope.

Requisite prior experience
- Standard transbronchial lung biopsy ×10, with competency in this technique, including familiarity with X-ray fluoroscopy
- 100 flexible bronchoscopies with competency in all forms of biopsy

Number of cases in training
20

Requisite knowledge prior to training
- Able to interpret computed tomography images
- Able to draw take-offs of the common positions of take-off of the 10 segmental bronchi on the right and nine on the left
- Able to draw the corresponding locations of each of the pulmonary segments and relevant mediastinal corresponding localizing levels

Internal audit goals
- Preparation of miniprobe and biopsy forceps and brush in all cases
- Print out bronchoscopic picture of the relevant lobe, labelling all segmental branches up to fifth order where possible and labelling the branch where the probe was passed to give entry to the lesion—logbook

• Enter the lesion to obtain an ultrasound image (either central or peripheral type) in 75% of cases of lesions >2 cm
• Take pictures of the EBUS image and attribute an EBUS score (I/II/III) before obtaining the histological report. Should have correlation between the image and the final histology in >75%—logbook
• Sensitivity for malignancy 60–70%
• Typical procedure time: 30–40 min

Safety goals
In ongoing cases, major bleeding <1%, pneumothorax <1%, infection <1%. Trainees should not have more than one of any of these complications.

Ongoing numbers
20 per year

MEDICAL THORACOSCOPY/ PLEUROSCOPY[15,27–29]

Introduction
Thoracoscopy or pleuroscopy is a minimally invasive procedure in which the pleural space of one hemithorax is inspected, and additional diagnostic or therapeutic procedures may be performed. It is frequently performed for patients with pleural effusion to diagnose the cause and/or for therapeutic control of effusion, and may also be used for other indications such as pneumothorax. This procedure allows biopsies to be taken from the parietal pleura of diaphragm and chest wall. Therapeutic control of recurrent fluid may be achieved by drainage, talc insufflation and chest tube placement. Additional more advanced indications and procedures may be performed with specific additional training. The focus of medical thoracoscopy is on pleural disorders, and any procedure that might require lung manipulation should be performed by a thoracic surgeon as a 'surgical VATS'. Foudarakis has recently commented: 'Thoracoscopy is currently the gold standard for the diagnosis and treatment of pleural diseases. Its diagnostic yield is 95% in patients with malignant pleural disease, with approximately 90% successful pleurodesis for malignant pleural effusion and 95% for pneumothorax. At the same time, thoracoscopy constitutes an important tool in the research of pleural pathophysiology and molecular biology. The improvement of technology has provided important tools to thoracoscopy, such as autofluorescence, NBI, and infrared light, used in clinical and basic research in many disorders involving the pleura. For these reasons, training in thoracoscopy should be considered equally important as training in bronchoscopy for residents in respiratory medicine'.

Indications
• Investigation of undiagnosed pleural effusion
• Therapeutic drainage and pleurodesis in malignant pleural effusion
• Pleurodesis for secondary pneumothorax in those unfit for surgery
• Empyema: lysis of loculi and lavage of pleural space
• Recurrent primary spontaneous pneumothorax (less commonly—in centres with longer experience)

Required previous experience before commencing thoracoscopy training
• Trainees must be competent in chest drain insertion before performing a thoracoscopy
• Completion of the online chest tube insertion module as sponsored by TSANZ is recommended: 'Insertion of chest tubes and management of chest drains in adults'
• Knowledge of general sterile procedural technique is critical

Recommended training
Potential minimum number of supervised procedures is 20.

Twelve months spent in a relatively high-volume centre in Australia, with the opportunity to perform 20 or more supervised thoracoscopies, in combination with attendance at a thoracoscopy course, would be considered a minimum period of training required to independently perform this procedure. Attendance at a high-volume centre in Europe, Asia or North America, with observation or assisting for at least 10 thoracoscopies, would be considered sufficient to substantially reduce the need for attendance at a course and would also reduce the number of supervised procedures needed in Australia. Experience with both rigid and semi-rigid ('flex-rigid') thoracoscopy is recommended (depending on local expertise), including single and double port entry. Although the technique of rigid and flex-rigid thoracoscopy are similar, anecdotally there is still a learning curve when thoracoscopists experienced in one of these techniques start to use the alternative technique.

The 2010 British Thoracic Society guideline on local anaesthetic thoracoscopy has itemized basic skills that would be regarded as goals of initial thoracoscopy training which are 'likely to be the level of competence at which the majority of district general physicians practice':

> 'A medical thoracoscopist practising at this level of competence should be able to:
> 1. manage patients who have large pleural effusions; however, in some instances, and as experience increases, a level I thoracoscopist may undertake the procedure in patients with smaller effusions;
> 2. biopsy the parietal but not the visceral pleura;
> 3. undertake therapeutic talc insufflation'.

Ongoing procedure numbers: 10 per year, although this might be fewer in those centres where there was a high throughput of other pleural procedures, such as indwelling pleural catheters.

Requisite knowledge prior to training

1 Pleural anatomy
- Visceral, parietal and pleural space anatomy.
- Parietal pleural layers.
- Suspensory ligaments.
- Pleural sinuses.
- Related structures, that is, mediastinum and diaphragm.
- Blood supply, lymphatic drainage and nerve supply.

2 Pleural physiology
- Functions of the pleura.
- Pleural fluid turnover.
- Composition of pleural fluid in health and disease.

3 Pleural pathology
- Infection.
- Fibrotic and inflammatory disease.
- Malignant disease, primary and secondary.
- Pathogenesis of pleural effusions.
- Pleural porosity.
- Pneumothorax.

Audit tools

A detailed logbook should be kept by the trainee, to include data such as the following:
- Photographs of procedures
- >80% sensitivity for malignancy
- Success rate of therapeutic measures, such as pleurodesis: >70% success rate of pleurodesis at 1-month post-thoracoscopy

Expect complication rate of <1% (wound site infections, significant bleeding, significant subcutaneous emphysema).

Four of the procedures performed by the trainee should have a formal directly observed assessment of practical skills evaluation by supervisor.

Recommended reading: references 15,27–29.

RIGID BRONCHOSCOPY[30]

Introduction

First performed by Gustav Killian in 1897, rigid bronchoscopy was initially used primarily for foreign body removal but was soon extended to diagnostic indications. The instrument consists of a straight hollow metal tube, which for adult use is approximately 40-cm long and between 7 mm and 13.5 mm in diameter. The distal end is bevelled, allowing easier passage through the vocal cords and through stenotic areas, as well as providing a chisel action to allow resection of tumour from the airway wall. The distal portion of the bronchoscope has side holes to allow ventilation. A tracheoscope is similar but shorter and has no side holes.

The intrinsic advantages of the rigid bronchoscope over the flexible bronchoscope lie in its inherent rigidity, in its ability to serve as an instrument for ventilation, and in the size of its operative lumen which allows the passage of instruments such as large forceps, large channel aspirators, telescopes, stents, and laser fibres or coagulation devices. The combination of visualization, therapeutic manipulation of the airway and simultaneous ventilation is of particular value in situations where there is airway obstruction, as well as in paediatric patients.

Main indications

- Control and management of massive haemoptysis
- Removal of foreign bodies from the tracheobronchial tree
- Treatment of airway stenosis by dilatation
- Removal of neoplastic obstruction
- Placement of tracheal or bronchial stents
- Laser bronchoscopy

Required training experience

- Competency in flexible bronchoscopy
- Thorough knowledge of laryngeal and tracheobronchial anatomy
- Knowledge of potential complications of bronchoscopy
- Practice in insertion of a rigid bronchoscope in a mannequin model, using direct vision, videotelescope and laryngoscope approaches
- Observation of the procedure in patients on several occasions
- Supervised successful insertion in at least 10 cases
- Ability to manipulate instruments, such as telescopes, forceps, etc.
- Basic understanding of anaesthetic techniques for rigid bronchoscopy, including high-frequency jet ventilation and spontaneous breathing, and total intravenous anaesthesia

Audit goals

- Ability to pass instrument into the trachea on first attempt in > 90% of cases without significant hypoxic periods
- Injury to teeth, gums or larynx on <2% cases

LASER BRONCHOSCOPY[31,32]

Introduction

Laser technology was first applied in the treatment of airway conditions in the 1970s when advances in fibre optic technology allowed laser beams to be passed through flexible fibres, and thus combined with endoscopic procedures. Its use in the tracheobronchial tree was first reported by Toty in 1979.

The term laser is an acronym for light amplification of stimulated emission of radiation, and is characterized by electromagnetic energy that is collated and delivered as parallel, synchronous rays of light of the same wavelength. The most commonly used lasers used for bronchoscopic purposes have been the carbon dioxide (CO_2) laser with a wavelength of 10 600 nm, the Neodynium:Yttrium-Aluminium-Garnet (Nd:YAG) laser with a wavelength of 1064 nm, and the potassium-titanyl-phosphate (KTP) laser

with a wavelength of 532 nm. The CO_2 laser has a high absorption with a tissue penetration of 0.5–1.0 mm, good cutting but poor coagulation properties, and cannot be directed down flexible fibres but must be directed using articulated mirrors. It is, thus, used in the ear–nose–throat context, not within the tracheobronchial tree. The Nd:YAG laser is the one most commonly used in pulmonary medicine and is the focus of this discussion. It can be delivered via a flexible fibre that can be passed down a rigid or flexible bronchoscope. It has a power output of between 5 W and 100 W so that photocoagulation is the predominant effect at low settings and vaporization at high settings, with a tissue penetration of 5–10 mm.

Although laser therapy can be delivered exclusively with flexible bronchoscopy, most operators favour use in conjunction with rigid bronchoscopy under general anaesthesia as this allows better control of haemorrhage and hypoxaemia, and also facilitates removal of tumour and debris using the chisel action of the rigid bronchoscope, as well as large forceps and suction tubes.

Main indications

- Malignant intraluminal obstruction of the proximal tracheobronchial tree with the purpose of re-establishing ventilation, eliminating secretions accumulated behind obstructions, and relieving symptoms such as haemoptysis, dyspnoea and cough
- Benign obstruction due to fibromas, hamartomas, papillomas, inflammatory granulomas, tracheobronchial stenoses, etc

Requisite pre-procedure training experience

- Competency in rigid bronchoscopy
- Thorough knowledge of tracheobronchial anatomy and adjacent structures
- Completion of a laser safety course
- Completion of an applied laser course using inanimate or animal models
- Supervised application of laser therapy in at least five cases
- Completion of a further five mentored cases

Audit goals

- Relief of symptoms in > 85% cases
- Complication rate (haemorrhage, hypoxaemia, perforation, cardiac events) <5%

TRACHEOBRONCHIAL STENTS[33–35]

Background/introduction

Endobronchial stents are one of a range of techniques used primarily to palliate dyspnoea in patients who have major airway obstruction. A fundamental part of training is learning to know those cases that are symptomatic enough to actually need any intervention at all, the urgency with which it may or may not be required, and simple alternative non-interventional techniques to improve a patient's quality of life, particularly where life expectancy is short. Having considered these things, stents remain an important part of a bronchoscopist's armamentarium.

In practical terms, the most important point is being able to confidently distinguish between large airway obstruction due to extrinsic compression (where stents may be required) and intraluminal or mural obstruction (where other methods are required). The ability to make this distinction comes during flexible bronchoscopy training—continually ask yourself and your mentor this question: 'Is that tumour causing extrinsic or intrinsic obstruction?' Very often, tumours cause both. The skill is knowing, first of all, whether anything mechanical needs to be done at all, and second, which combination of treatments is required, and whether this combination includes a stent.

Second, knowledge of the wide variety of available stents is required, and that, whereas in malignant conditions either silicone or metallic stents can be used, in benign conditions non-metallic stents are generally preferred. Utility of covered and uncovered metallic stents needs to be understood.

Indications

The ATS guidelines list these indications for large airway stenting:

- Extrinsic stenosis of central airways with or without intraluminal components due to malignant or benign disorders
- Complex, inoperable tracheobronchial strictures
- Tracheobronchial malacia
- Palliation of recurrent intraluminal tumour growth
- Central airway fistulae (oesophagus, mediastinum, pleura)

Requisite prior skills

Expertise with flexible and rigid bronchoscopy. Rigid experience is not essential in insertion of all stent types (such as those inserted over a guidewire) however occasionally even with these stents rigid bronchoscopy may be needed. Other stents, such as the Dumon stent, require rigid bronchoscopy for insertion. Sometimes, these stents are inserted after a rigid bronchoscopy procedure to debulk an obstructing endobronchial lesion.

Practice

See practice for rigid bronchoscopy. Also, all techniques should be practised on inanimate models. At least one training course should be attended where hands-on practice is done. During training, 10 supervised procedures should be done or assisted, and in practice, at least five procedures should be done per year. Where this is only just met, a regular session of training with inanimate models could be incorporated into the bronchoscopy schedule, for example, a 1-h session 2–3 times a year.

Internal audit goals

- A significant improvement in the score of breathlessness as measured by an appropriate instrument should be demonstrated in at least 80% of cases (see reference 3)
- Keep a picture of pre- and post-procedure endobronchial appearance and chest X-ray in all cases
- Typical procedure time (not including laser or other ablative intervention) for stent of <20–30 min
- For fistulae, there should be reduction in fistula sequelae in 80% of cases

Safety goals

Complications should happen in <20% of cases. They include stent displacement, cough, mucus impaction, granulation tissue at stent ends, infection and perforation of airway walls.

ENDOBRONCHIAL ELECTROSURGERY: APC AND DIATHERMY[36–39]

Introduction

Endobronchial electrosurgery refers to the application of heat produced by electrical current via the bronchoscope to treat abnormal tissue using a probe or a snare. The two types of electrocautery are the contact form (diathermy) and the non-contact form utilizing argon gas—APC. APC is a monopolar, high-frequency form of energy used therapeutically for the management of bleeding and devitalization of tissue abnormalities.

It is a 'contact free' form of energy in which thermal haemostasis or ablation of pathological tissue is achieved through the use of ionized argon gas. The current can be applied axially, laterally or radially depending on the indication. APC has been used for more than 15 years in open surgery, laparoscopy and gastrointestinal endoscopy especially for haemostasis of large surface bleeding. The equipment required for successful APC includes the APC unit, an electrosurgical generator and specific APC instruments, including applicators, which vary in diameter from 1.5 mm to 2.3 mm. Pre-procedure assessment of any patient referred for APC is as per fiberoptic bronchoscopy including checks for implanted cardiac defibrillators, pacemakers or other electrical stimulators, which are also contraindications to endobronchial electrocautery.

Argon gas has a number of useful properties for endobronchial work: it is inert, highly conductive as it can be ionized, and has a self-limiting mode of operation (the plasma beam tends to turn away from tissues already coagulated or of high impedance). APC has a number of advantages over conventional laser therapy: it being a non-contact procedure, it provides effective coagulation and devitalization; has limited penetration depth, and therefore reduced risk of airway perforation and vascular compromise; and has minimal carbonization and smoke plume, lowering the risk of endobronchial ignition and fewer unpleasant odours. Finally, it is compatible with modern-day metal stents, noting that the polyurethane or silicone coating in the covered stents can still be an ignition source.

An alternative application to APC is endobronchial diathermy or electrocautery. Diathermy is defined as the interventional use of high-frequency electrical current under bronchoscopic guidance, with delivery of thermal energy via direct contact with the relevant tissue.

General principles of electrosurgery

1 Procedures may be performed in the bronchoscopy suite under flexible or rigid bronchoscopy.
2 Synthetic materials within the airway are potential fuels or combustible materials, and therefore promote the risk of endobronchial ignition or fire. It is preferable for procedures to be performed via laryngeal mask or the rigid bronchoscope, especially for procedures involving the large or proximal airways (NB: metal stents such as Ultraflex stent made from nickel titanium are not combustible).
3 The smoke plume generated from the APC or diathermy probe may interact with oxygen to form an inflammatory gas mixture. The risk of combustion or fire is minimized by constantly evacuating the smoke plume using intermittent suction on the bronchoscope.
4 Activation of the APC or diathermy probe should be for the shortest period of time required to achieve the desired clinical effect and reduce the formation of the smoke plume.
5 Oxygen concentrations during application should be less than 40% (FiO_2 <0.4), or the lowest possible percentage to obtain oxygen saturations equivalent to or above 90% via pulse oximetry.
6 No potential flammable inhalational agents are to be used after discussion with the attending anaesthetist. APC or diathermy should be applied in the tracheobronchial system during the apnoea phase of respiration.
7 No alcohol scrubs or other inflammatory preparatory liquids are to be used for procedures, with no gel placed on the tip of the bronchoscope.
8 During activation of the argon plasma beam the distal end of the applicator (minimum of one black band) must always be visible through the bronchoscope to minimize damage to the fiberoptic system.
9 APC procedures utilize non-contact technology with activation of the beam recommended approximately 5 mm from the tissue surface. This gives a projected penetration depth typically of 3 mm, which reduces the risk of airway perforation.

For argon, the modern systems consist of three modes of delivery:

- Precise mode (a narrow argon beam to facilitate more precise application)—may be useful in laryngeal work
- Pulsed APC (enables controlled activation of the argon beam with a particularly large ignition interval)
- Forced APC (continual application of the argon beam)

For all APC modes, activation time should be limited to a maximum of 5 s but usually 1–2 s. Typical

recommended settings for argon plasma procedures are an argon flow rate of 0.4–1.5 L/min (for the 1.5-mm diameter probe) or 0.6–1.5 L/min (for the 2.3-mm diameter probe). It is often recommended to use the lowest flow that gives the desired effect, given the postulated link between high flows and the side effect of gas embolism (see reference below). Wattage is to commence at 30–40 watts. Place diathermy pad on the patient on the side to be treated (e.g. right thigh for right main bronchus treatment) and as close as possible to the treatment area. Note that diathermy pads should not be placed over metal prostheses, as this may cause thermal injury.

Indications

1 Control of superficial and small vascular haemorrhages from bronchial papillomas or malignant growths.
2 Tumour reduction especially in patients who present with large airway or proximal obstruction (normally in conjunction with other techniques, including balloon dilatation and rigid bronchoscopy). This can include cases prior to external beam radiotherapy, to reopen atelectatic lung with the goal of reducing radiation exposure to normal lung.
3 Tumour bleeding.
4 Re-cannalization of an obstructed airway or bronchus from multiple potential aetiologies.
5 Reduction and removal of granulation tissue, especially in conjunction with a stent.
6 Fistula conditioning.

Prior experience and number of cases

- 100 flexible bronchoscopies with demonstrated competence and with appropriate supervision
- 20 APC procedures, 20 electrocautery cases

Prerequisite knowledge prior to training

To ensure that patients with obstructing airway tumours meet the following criteria for APC or diathermy procedures:

- Symptoms primarily related to airway obstruction and not to systemic disease
- Tumour located within the lumen of the airway, that is, intraluminal malignancy
- The margins between the tumour and normal airway are clearly identifiable
- Avoid tissue contact with the non-contact technique and probe adhesion to friable tissues which reduces the risk of bleeding
- Tumour length generally less than or equal to 3.5 cm
- There is functional lung distal to the obstruction, or relief of post-obstructed pneumonia is feasible
- Obstructions to airways from lesions causing extrinsic compression are best palliated by external beam radiotherapy or balloon dilatation followed by stent insertion rather than APC
- To have a thorough knowledge of how to approach a patient who experiences endobronchial combustion during an electrosurgical procedure
- Awareness of the specific safety requirements for APC delivery to reduce the risk, in particular, of endobronchial ignition
- Thorough knowledge of tracheobronchial anatomy and adjacent vascular structures
- Ability to adjust APC settings in order to optimize the delivery of thermal energy to facilitate tissue devitalization
- Familiarity with the equipment required for APC delivery, including the generator, and the range of cautery tools including snare, knife and probe
- Connection of cables and diathermy plate
- Ensure argon probe is tightly connected and primed
- Ensure correct settings, positioning of the foot pedal and gas cylinders are full with the argon gas

Internal audit goals

For cases where electrocautery is used to re-canalize, large airways procedure outcome goals are as for laser bronchoscopy.

A detailed logbook should be kept by the trainee to ensure that there is a record of safety and potential complications. Complications should happen in less than 5% of cases, and may include haemorrhage (<2%), pneumothorax (<1%), infection (<1%), air embolism (<0.1%), bronchomalacia after thermal injury to the bronchial cartilage (<1%), scope damage, ulceration with potential for delayed haemorrhage, endobronchial ignition (this risk is well <1% following appropriate guidelines) and injury to adjacent normal structures.

Typical procedure time: 30–45 min depending on the complexity of the case.

AFB AND NBI[40–50]

Introduction

AFB is used to detect precancerous lesions in the central airways of the respiratory tract. The first systems came into use in 1993.[40] A blue light of wavelength 400–450 nm is used as the incident light; this causes normal tissues to fluoresce green. Abnormal preneoplastic tissues have a reduced fluorescence. Fluorescence signals can be detected using cameras which reduce the reflected blue light and amplify the fluorescence. These signals can be displayed in real time, allowing the bronchoscopist to biopsy those areas with reduced fluorescence. Alternating with white light allows the bronchoscopist to check for common abnormalities, such as mucus, inflammation or airway bleeding which might cause false positive fluorescence changes. Therefore, it does require the proceduralist to be very familiar with standard white light appearances. Typically, fluorescence bronchoscopy adds 5–10 min to a standard white light procedure.

Only 29% of thin subtle carcinomas in situ are visible to experienced bronchoscopists.[41] In numerous studies with direct comparisons between white light and fluorescence, there is usually a two- to three-

fold improvement in detection rates. In a multicentre study[42] of patients at risk or with known lung cancer, the combination of fluorescence bronchoscopy and white light had a relative sensitivity (sensitivity of the test divided by the sensitivity of the comparative test) of 6.3 compared with white light alone. When invasive cancers were included, the relative sensitivity was still 2.7. Similar findings have been shown in other studies.[43–45] Collected data from over 1400 patients suggests that white light bronchoscopy alone detects 40% of high-grade dysplasia and carcinoma in situ, while fluorescence bronchoscopy improves this to 88%.

NBI is also an autofluorescence technique, but the excitation light has a wavelength that includes haemoglobin; hence, small mucosal vessels can be demonstrated.[46] The development and complexity of mucosal vessels are highly predictive for the presence of dysplasia. Dysplastic lesions of moderate or severe type have mucosal capillaries which are directed towards the surface, and hence appear as dots given the end—on orientation to the surface. With worsening dysplasia and malignancy, the vessels become dilated and more tortuous. The method is, therefore, looking at mucosal structure, whereas AFB utilizes a difference in the biochemistry of the lesion to allow detection.

Because of this difference, NBI offers a greater specificity than AFB for the detection of preneoplasia.[47] Reports state that this is achieved without the loss of sensitivity compared with AFB; however, developing familiarity with NBI images is not as easy as the simple colour distinctions that are used with AFB.

Important in the development of this technique is standardization of reporting of histology of preneoplastic lesions.[48] It is generally accepted that higher inter-observer agreement by pathologists occurs the more severe the dysplasia. It is important to develop a working relationship with interested pathologists, and for there to be a clear definition of pathological interpretation, particularly as some cases will require repeat biopsy and consistency of reporting is paramount.

Indications for both AFB and NBI

1 Particular use for this has come in bronchoscopy to investigate abnormal sputum cytology.[7] In a series of 50 cases, prior to the development of fluorescence bronchoscopy, the yield for the cause of the abnormal tissue was significantly lower than when fluorescence bronchoscopy was introduced. Furthermore, only one fluorescence bronchoscopy was required to find the culprit lesion, whereas patients usually required at least two, and sometimes three to four, standard white light bronchoscopies to find the lesion.
2 The detection of one high-grade preneoplastic lesion by standard bronchoscopy suggests the need for fluorescence bronchoscopy because of the field change hypothesis. Multicentric disease is present in up to 40% of cases, and the other sites not visible to standard bronchoscopy may be of higher grade than the initial biopsy.[2–7]
3 When small endobronchial carcinomas in situ are being considered for treatment (surgery vs radiotherapy vs endobronchial ablation), fluorescence bronchoscopy defines the true margins of the lesion more accurately than white light and allows better decision making.[8]

Prior experience

- The procedure requires only the same technical skills as a standard bronchoscopy; however, it needs experience to understand the many common variations of normal of white light bronchoscopy
- Skills in endobronchial biopsies, with at least 20 biopsies of endobronchial carcinoma

Number of cases in training

20, with each method

Requisite knowledge prior to training

- Detailed understanding of anatomical variations
- Ability to draw freehand three common variations of each of the six lobar divisions

Internal audit goals

1 Overall yield of moderate dysplasia or worse of >10%.
2 Degree of fluorescence abnormality can be graded 1, 2 or 3 as described by Lam, with 3 being most likely to indicate high-grade dysplasia. This grading can be recorded at the time of the procedure prior to results of histology being reported.
3 Positive predictive value of moderate dysplasia or worse for a grade 3 fluorescence lesion of >30%.
4 In patients coming for repeat surveillance who have prior documented fluorescence lesions, be able to identify to the supervisor >90% of lesions previously seen (document with video).
5 Typical procedure time: 15–20 min.

Safety goals

As for white light bronchoscopy.

Ongoing numbers

20

FUTURE DIRECTIONS

We have not covered some techniques that are well described in the literature but not widely done in Australasia as yet. These include cryotherapy, endobronchial valve placement, tunnelled pleural catheters and bronchial thermoplasty. Future versions of these guidelines will likely include these methods. In the long term, we look forward to more relatively inexpensive and widely accessible simulation tools becoming available. We also anticipate greater use of

validated instruments of assessment of competency for use both on simulators and live cases.

CONCLUSIONS

These guidelines aim to provide practical solutions to the difficulty of just using case numbers as a means of determining competency. A broad approach, including required reading and suggested course attendance and presentation of data, is described. Despite all of the recommendations, the place of the teacher remains central.

REFERENCES

1 Wood-Baker R, Burdon J, McGregor A *et al*. Fibre-optic bronchoscopy in adults: a position paper of the Thoracic Society of Australia and New Zealand. *Intern. Med. J.* 2001; **31**: 479–87.
2 Lamb C, Feller-Kopman D, Ernst A *et al*. An approach to interventional pulmonary fellowship training. *Chest* 2010; **137**: 195–9.
3 Eisen GM, Dominitz JA, Faigel DO *et al*. American Society for Gastrointestinal Endoscopy. Standards of Practice Committee. Guidelines for advanced endoscopic training. *Gastrointest. Endosc.* 2001; **53**: 846–8.
4 Du Rand IA, Barber PV, Goldring J *et al*. British Thoracic Society guideline for advanced diagnostic and therapeutic flexible bronchoscopy in adults. *Thorax* 2011; **66**(Suppl. 3): iii1–21.
5 Ost D, Eapen G, Jimenez C *et al*. Improving procedural training and certification in pulmonary medicine. *Chest* 2010; **137**: 6–8.
6 Unroe MA, Shofer SL, Wahidi M. Training for endobronchial ultrasound: methods for proper training in new bronchoscopic techniques. *Curr. Opin. Pulm. Med.* 2010; **16**: 295–300.
7 McGaghie W, Siddall V, Mazmanian P *et al*. Lessons for continuing medical education from simulation research in undergraduate medical and graduate medical education: effectiveness of continuing medical and graduate medical education: American College of Chest Physicians Evidence-Based Educational Guidelines. *Chest* 2009; **135**: 62S–8S.
8 Colt HG, Davoudi M, Murgu S *et al*. Measuring learning gain during a one-day introductory bronchoscopy course. *Surg. Endosc.* 2011; **25**: 207–16.
9 Colt HG, Davoudi M, Quadrelli S *et al*. Use of competency-based metrics to determine effectiveness of a postgraduate thoracoscopy course. *Respiration* 2010; **80**: 553–9.
10 Kemp S, Batrawy S, Harrison RN *et al*. Learning curves for endobronchial ultrasound using cusum analysis. *Respiration* 2011; **81**: 325–32.
11 Stather DR, Maceachern P, Rimmer K *et al*. Validation of an endobronchial ultrasound simulator: differentiating operator skill level. *Respiration* 2011; **81**: 325–32.
12 Salud LH, Peniche AR, Salud JC *et al*. Toward a simulation and assessment method for the practice of camera-guided rigid bronchoscopy. *Stud. Health Technol. Inform.* 2011; **163**: 535–41.
13 Ernst A, Silvestri GA, Johnstone D. American College of Chest Physicians Interventional pulmonary procedures: guidelines from the American College of Chest Physicians. *Chest* 2003; **123**: 1693–717.
14 Bolliger CT, Mathur PN, Beamis JF *et al*. ERS/ATS statement on interventional pulmonology. *Eur. Respir. J.* 2002; **19**: 356–73.
15 Rahman NM, Ali NJ, Brown G *et al*. Local anaesthetic thoracoscopy: British Thoracic Society pleural disease guideline 2010. *Thorax* 2010; **65**(Suppl. 2): 56–60.
16 Yasufuku K, Fujisawa T. Staging and diagnosis of non-small cell lung cancer: invasive modalities. *Respirology* 2007; **12**: 173–83.
17 Yasufuku K, Nakajima T, Motoori K *et al*. Comparison of endobronchial ultrasound, positron emission tomography, and CT for lymph node staging of lung cancer. *Chest* 2006; **130**: 710–18.
18 Adams K, Shah PL, Edmonds L *et al*. Test performance of endobronchial ultrasound and transbronchial needle aspiration biopsy for mediastinal staging in patients with lung cancer: systematic review and meta-analysis. *Thorax* 2009; **64**: 757–62.
19 Nakajima T, Yasufuku K. How I do it—optimal methodology for multidirectional analysis of endobronchial ultrasound—guided transbronchial needle aspiration samples. *J. Thorac. Oncol.* 2011; **6**: 203–6.
20 Yasufuku K. Current clinical applications of endobronchial ultrasound. *Expert Rev. Respir. Med.* 2010; **4**: 491–8.
21 Wong M, Yasufuku K, Nakajima T *et al*. Endobronchial ultrasound: new insight for the diagnosis of sarcoidosis. *Eur. Respir. J.* 2007; **29**: 1182–6.
22 Rusch VW, Asamura H, Watanabe H *et al*. The IASLC lung cancer staging project: a proposal for a new international lymph node map in the forthcoming seventh edition of the TNM classification for lung cancer. *J. Thorac. Oncol.* 2009; **4**: 568–77.
23 Tournoy KG, Annema JT, Krasnik M *et al*. Endoscopic and endobronchial ultrasonography according to the proposed lymph node map definition in the seventh edition of the tumor, node, metastasis classification for lung cancer. *J. Thorac. Oncol.* 2009; **4**: 1576–84.
24 Herth FJ, Ernst A, Becker HD. Endobronchial ultrasound-guided transbronchial lung biopsy in solitary pulmonary nodules and peripheral lesions. *Eur. Respir. J.* 2002; **20**: 972–4.
25 Kurimoto N, Miyazawa T, Okimasa S *et al*. Endobronchial ultrasonography using a guide sheath increases the ability to diagnose peripheral pulmonary lesions endoscopically. *Chest* 2004; **126**: 959–65.
26 Kikuchi E, Yamazaki K, Sukoh N *et al*. Endobronchial ultrasonography with guide-sheath for peripheral pulmonary lesions. *Eur. Respir. J.* 2004; **24**: 533–7.
27 Buchanan DR, Neville E. *Thoracoscopy for Physicians: A Practical Guide*. Hodder Arnold, London, 2004.
28 Boutin C, Viallant JR, Aeloney Y. *Practical Thoracoscopy*. Springer Verlag, New York, 1991.
29 Foudrakis M. New challenges in medical thoracoscopy. *Respiration* 2011; **82**: 197–200.
30 Turner JF, Ernst A, Becker HD. Rigid bronchoscopy: how I do it. *J. Bronchol.* 2000; **7**: 171–6.
31 Dumon JF, Reboud E, Garbe L *et al*. Treatment of tracheobronchial lesions by laser photoresection. *Chest* 1982; **81**: 278–84.
32 Colt HG. Laser bronchoscopy. *Clin. Chest Med.* 1995; **16**: 415–26.
33 Bolliger CT, Sutedja TG, Strausz J *et al*. Therapeutic bronchoscopy with immediate effect: laser, electrocautery, argon plasma coagulation and stents. *Eur. Respir. J.* 2006; **27**: 1258–71.
34 Saito Y. Endobronchial stents: past, present, and future. *Semin. Respir. Crit. Care Med.* 2004; **25**: 375–80.
35 Wood DE, Liu YH, Vallières E *et al*. Airway stenting for malignant and benign tracheobronchial stenosis. *Ann. Thorac. Surg.* 2003; **76**: 167–72.
36 Fischer K, Raiser J. Guidelines for the safe application of electrosurgical current in the tracheobronchial system. ERBE Elektromedizin GmbH. Tubingen 2000.
37 Sutedja TG, Bollinger CT. Endobronchial electrocautery and argon plasma coagulation. In: Bolliger CT, Mathur PN (eds) *Interventional Bronchoscopy. Prog Respir Res*, Vol. **30**. Karger, Basel, 2000; 120–32.
38 Horinouchi H, Miyazawa T, Takada K *et al*. Safety study of endobronchial electrosurgery for tracheobronchial lesions. *J. Bronchol.* 2008; **15**: 228–32.
39 Feller-Kopman D, Lukanich JM, Shapira G *et al*. Gas flow during bronchoscopic ablation therapy causes gas emboli to the heart: a comparative animal study. *Chest* 2008; **133**: 892–6.
40 Lam S, MacAulay C, Hung J *et al*. Detection of dysplasia and carcinoma in situ with a lung imaging fluorescence endoscope device. *J. Thorac. Cardiovasc. Surg.* 1993; **105**: 1035–165.

41 Woolner LB, Fontana RS, Cortese DA *et al*. Roentgenographically occult lung cancer: pathologic findings and frequency of multicentricity during a 10-year period. *Mayo Clin. Proc.* 1984; **59**: 453–66.
42 Lam S, Kennedy T, Unger M *et al*. Localization of bronchial intraepithelial neoplastic lesions by fluorescence bronchoscopy. *Chest* 1998; **113**: 696–702.
43 Kusonoki Y, Imamura F, Uda H *et al*. Early detection of lung cancer with laser-induced fluorescence endoscopy and spectrofluorometry. *Chest* 2000; **118**: 1776–82.
44 Hirsch FR, Prindiville SA, Miller Y *et al*. Fluorescence versus white-light bronchoscopy for detection of preneoplastic lesions: a randomized study. *J. Natl. Cancer Inst.* 2001; **93**: 1385–91.
45 Haussinger K, Becker H, Stanzel F *et al*. Autofluorescence bronchoscopy with white light bronchoscopy compared with white light bronchoscopy alone for the detection of precancerous lesions: a European randomised controlled multicentre trial. *Thorax* 2005; **60**: 496–503.
46 Shibuya K, Hoshino H, Chiyo M *et al*. High magnification bronchovideoscopy combined with narrow band imaging could detect capillary loops of angiogenic squamous dysplasia in heavy smokers at high risk for lung cancer. *Thorax* 2003; **58**: 989–95.
47 Herth FJ, Eberhardt R, Anantham D. Narrow-band imaging bronchoscopy increases the specificity of bronchoscopic early lung cancer detection. *J. Thorac. Oncol.* 2009; **4**: 1060–5.
48 Nicholson AG, Nicholson AG, Perry LJ *et al*. Reproducibility of the WHO/IASLC grading system for pre-invasive squamous lesions of the bronchus: a study of inter-observer and intra-observer variation. *Histopathology* 2001; **38**: 202–8.
49 Ohtani K, Lee AM, Lam S. Frontiers in bronchoscopic imaging. *Respirology* 2012; **17**: 261–9.
50 Zaric B, Perin B, Becker HD *et al*. Autofluorescence imaging videobronchoscopy in the detection of lung cancer from research tool to everyday procedure. *Expert Rev. Med. Devices* 2011; **8**: 167–72.