

Guidelines on Procedural and Sedation Safety in Flexible Bronchoscopy and Pleuroscopy

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Preface

The purpose of this document is to provide a general reference on procedural and sedation safety for respiratory specialists and other healthcare professionals engaging in flexible bronchoscopy and pleuroscopy (Sections A and B respectively). Apart from providing practice guidance for specialist training in Respiratory Medicine, it also aims to enhance the quality and safety in these procedures.

This document will cover the general aspects such as the indications, contraindications, possible complications, pre-procedural preparations and measures to be taken during and after such procedures. Procedural sedation has been given considerable emphasis since it is frequently administered by respiratory physicians during these procedures.

Apart from referencing to recommendations from both international and local professional societies, some parts of this document would also take into consideration local perspectives and practice. This document is compiled and written based on the current knowledge and evidence available at the time of writing.

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(A) FLEXIBLE BRONCHOSCOPY (FB)

I. General preparation before FB (1,3,8)

1. Review the indications and contraindications of bronchoscopy for every patient.
2. Check the past medical, allergic and drug histories. Perform relevant physical examination (e.g. superior vena cava obstruction syndrome [SVCO], respiratory distress, prominent wheezes etc.). Pre-bronchoscopy assessment should also identify potential cardiovascular and respiratory risks, as well as the risk of airway compromise during procedural sedation.
3. Updated and relevant investigation results should be available (e.g. complete blood picture, liver & renal functions, chest radiographs and if necessary, electrocardiogram) before bronchoscopy. Coagulation profile should be considered in patients with clinical risk factors for abnormal coagulation (e.g. chronic liver disease, anticoagulant therapy etc.)
4. Updated imaging (e.g. Chest X-rays and if available, CT or PET-CT scan) should be available for assessment before and throughout bronchoscopy. Availability of CT scan would be beneficial in most cases as it can guide the target site or route for bronchoscopic planning.
5. Other optional investigations:
 - Arterial blood gas: patients with history of, or high risk of, developing respiratory failure.
 - Spirometry/lung function tests: in patients with clinical suspicion of undiagnosed airway diseases like asthma.
 - Sputum for AFB smear: clinical or radiological suspicion of open pulmonary tuberculosis (TB). Review the indications for bronchoscopy if the patient is having open TB.
6. Informed written consent should be obtained and duly completed, with fact sheets about the procedure, be given to the patient. The consent should cover both the procedure and the probable need for conscious sedation.
7. Bronchoscopists should review all investigation results before bronchoscopy and have an overall idea on (a) the planned procedures during the bronchoscopic session and (b) targeted site(s)/segment(s) for sampling or interventions.
8. There should be at least 4 hours of fasting before bronchoscopy: (a) Fast after midnight for bronchoscopy to be done the next morning and (b) Fast after light breakfast for bronchoscopy in the afternoon the same day.
9. An intravenous access site/portal should be established before bronchoscopy.
10. Atropine is generally not recommended.
11. Routine administration of prophylactic antibiotics is generally not warranted, except for cardiac conditions with the highest risk of adverse outcome from endocarditis, i.e. prosthetic heart valves or cardiac valve repair with prosthetic material, previous endocarditis, unrepaired cyanotic congenital heart diseases (CHD), completely repaired CHD defect with prosthetic material or device during the first six months after procedure, repaired CHD with residual defects at or near prosthetic material, and cardiac transplantation with cardiac valvulopathy. The antibiotic regimen should be active against the viridans group *Streptococci*, or should contain an anti-staphylococcal beta-lactam when an infection with *Staphylococcus aureus* is suspected or known.
12. For additional preparations in specific situations, please refer to Session VII.

II. Common indications: (1-2, 4-7)

A. Diagnosis

1. Bronchial neoplastic diseases
 - Diagnosis, staging and re-staging of lung cancer
 - Diagnosis of lung metastasis
 - Abnormal sputum cytology without image localization
 - Resection stump assessment for tumor relapse
2. Pulmonary infections
 - Recurrent or unresolved pneumonia
 - Pulmonary infiltrate/consolidation in immunocompromized hosts
 - Pulmonary cavitatory lesions
3. Persistent lung/lobar collapse
4. Hemoptysis
5. Foreign body aspiration
6. Reassessment after lung transplantation
7. Infiltrative/Interstitial lung diseases

Diagnosis can be achieved with procedures including bronchial aspirate, bronchoalveolar lavage (BAL), bronchial biopsy, endobronchial protected catheter brushing, transbronchial needle aspiration (TBNA) and transbronchial biopsy, etc.

B. Therapeutic

1. Bronchial toileting
2. Bronchoscopic interventions (with their own specific indications) that can be performed via FB include:
 - Endoscopic cryotherapy
 - Brachytherapy
 - Argon plasma coagulation and electrocautery
 - Endobronchial valve placement
 - Endotracheal/endobronchial stent placement
 - Bronchial thermoplasty

III. Contraindications (1-2, 4-7)

Common contraindications include:

1. Lack of valid consent
2. Uncorrected coagulopathy
3. Uncontrolled respiratory failure with inability to maintain adequate oxygenation during the procedure
4. Asthma or COPD in exacerbations
5. Unstable cervical spine
6. Raised intracranial pressure and recent stroke within 4-6 weeks
7. Uncontrolled arrhythmias or unstable cardiac conditions (e.g. active myocardial ischaemia and < 4-6 weeks after acute myocardial infarction/acute coronary syndrome)

Extra precautions have to be exercised with the following conditions:

1. Increased bleeding risks: uremia, pulmonary hypertension, hepatic failure, underlying disorders with bleeding tendency, active hemoptysis and patients on anti-coagulant therapy.
2. SVCO, particularly if clinically significant and untreated, could possibly lead to higher bleeding risk and laryngeal edema.
3. Intractable cough
4. Known allergy or anaphylactic reactions to sedatives or relevant medications
5. Myasthenia gravis
6. Open TB or novel highly pathogenic infections (e.g. Avian influenza, MERS-CoV etc.)

IV. Safety issues with sampling procedures (1,24)

1. Endobronchial biopsy (EBBx):

- For endoscopically visible lesions
- Consider whether a biopsy is necessary or indicated in any patient
- The recommended number of biopsies is usually 4 to 6 if the patient can tolerate and no excessive bleeding occurs
- Prior imaging (e.g. CT thorax) would be helpful if available.
- Some would consider applying prophylactic topical adrenaline (1:10000, 2 ml) spray over visibly vascular endobronchial lesions before performing the first biopsy.
- Exercise caution when encountering the following findings/conditions because of the risk of severe bleeding after biopsy: suspected Dieulafoy's lesion and Kaposi sarcoma, and in patients with bronchiectasis.

2. Transbronchial lung biopsy (TBLB):

- While TBLB can be performed "blindly", fluoroscopic guidance would be preferable if available. Fluoroscopic guidance for TBLB could improve the diagnostic yield, reduce the risk of pneumothorax and allow early detection of pneumothorax after the procedure.
- Prior radiological imaging (i.e. CT thorax) is also helpful to guide TBLB and improve the diagnostic yield in non-diffuse interstitial lung disease
- Endobronchial ultrasound guided (EBUS) with radial probe (with or without guided sheath) and navigational tools (e.g. electromagnetic navigation, virtual bronchoscopy etc.) can help to localize the peripheral lesions and improve diagnostic yield
- Do not perform TBLB from both lungs in the same bronchoscopy session to avoid the risk of bilateral pneumothoraces or bleeding.
- Steps to avoid taking biopsies from pleura during TBLB:
 - Retract forceps 1 cm when it is advanced to the maximal limit
 - Forceps to be opened during inspiration
 - Instruct the patient to breath out when forceps are advanced and closed
 - Do not take biopsy if patient experiences pain when the forceps are closed and before the forceps are withdrawn.
 - Relatively light sedation is preferable for the need for patient cooperation
 - Cough control and suppression is helpful to reduce barotrauma
- Risk of pneumothorax is higher with TBLB (1-6%) when compared to EBBx (0.1%) and patient should be advised of the possibility of delayed occurrence of this complication.

3. Bronchoalveolar lavage (BAL)

- Limit BAL to a maximum of 3 different lobar segments in each session
- Do not instil more than 200ml per lavage
- Use normal saline at room temperature
- Avoid BAL in unstable asthmatics and consider pre-medications with inhaled bronchodilators and intravenous glucocorticoids when BAL is to be performed in asthma patients
- Middle lobes (particularly lateral segment of RML and superior segment of lingular lobe) are less dependent lobes with better fluid return than lower lobes

V. Complications (1,9,24)

Common complications include transient fever, severe cough, dyspnea, bleeding, desaturation, arrhythmias, pneumothorax, apnea and respiratory failure. Overall incidence of complications/adverse events varies in different studies, which were mostly retrospective with variable definitions and classifications of adverse events. Overall mortality associated with flexible bronchoscopy is less than 0.1%.

For management of complications, please refer to session XI-XIII.

VI. Managing bleeding risk, anti-platelet and anti-coagulation therapy (10-16,25-29)

(A) Target platelet count / clotting profile:

- (a) Platelet count: > 20 x 10⁹/L for simple bronchoscopic examination without anticipation of biopsy
> 50 x 10⁹/L for anticipated biopsy; a higher level (e.g. > 75 x 10⁹/L) might be considered in TBLB with its higher inherent bleeding risk
- (b) INR < 1.5

(B) Adjustment of anti-platelet or anticoagulant therapy prior to bronchoscopy:

1. Background and Principle:

- Management involves the balancing of the risk of procedural bleeding with continued treatment against the thromboembolic risk with suspension of treatment. Other factors to be considered include the urgency of the procedure, type of bronchoscopic interventions and the anticipated patient's cooperation.
- Liaise with cardiologists and neurologists for special precautions on patients with coronary stents/mechanical heart valves and recurrent strokes respectively.

2. Procedural risk stratification:

- Low-risk procedures: Simple bronchoscopy (white-light or autofluorescence imaging) without additional diagnostic or therapeutic intervention, except bronchial aspirate in patients under optimal conscious sedation.
- High-risk procedures: Bronchoscopic procedures that involves diagnostic or therapeutic intervention(s) other than bronchial aspirate.

3. Thromboembolic risk stratification for anti-platelet therapies:

- High-risk conditions: (1) all patients with coronary stents, particularly patients with drug-eluted stent (DES) inserted ≤ 12 months, bare-metal stent (BMS) inserted ≤ 6

weeks, any coronary stents with associated risk factors*; (2) Cerebrovascular disease ≤ 6 weeks. Cardiologist or neurologist should be consulted.

- Low-risk conditions: (1) Peripheral vascular disease (2) Ischaemic heart disease (without coronary stent) and cerebrovascular disease stabilized with treatment for ≥ 6 weeks from the acute onset. (3) Atrial fibrillation

*Risk factors: diabetes, renal failure, cancer, congestive heart failure, complex coronary stenosis and history of coronary stent thrombosis.

4. Patient on Aspirin:

- In general, it is considered safe to continue on low dose aspirin (80-160 mg) in most cases, without absolute need to stop before bronchoscopy. It is, however, still not an uncommon practice to withhold aspirin for five days before bronchoscopy, particularly in patients with (a) higher risk of bleeding e.g. chronic renal failure, SVCO, pulmonary hypertension etc. or (b) those who cannot tolerate significant bleeding e.g. advanced age, underlying anemia
- Factors to be taken into consideration include those laid down in “Background and Principle” above.

5. Thienopyridines: Clopidogrel (Plavix[®]) and Prasugrel (Effient[®])

- Continuation of Thienopyridines has been allowed with low-risk GI endoscopic procedures and in low-risk bronchoscopy without biopsies. However, individual patient assessment and similar considerations as for aspirin should be made. In general, the use of oral route, avoidance of inadvertent and unnecessary suctioning close to the bronchial walls and appropriately titrated conscious sedation might reduce bleeding risk.
- High-risk procedures + Low-risk conditions:
 - Thienopyridines should be withheld for 5-7 days.
 - Continue aspirin if already prescribed.
 - Consider aspirin while thienopyridines withheld
- High-Risk procedures + High-risk conditions:
 - Consider deferring the procedure particularly in patients with drug-eluted stent (DES) inserted ≤ 12 months, bare-metal stent (BMS) inserted ≤ 6 weeks, any coronary stents with associated risk factors*; (2) stroke ≤ 6 weeks.
 - Discuss with cardiologists or neurologists
 - Can consider withholding thienopyridines for 5-7 days in patients with drug-eluted stent (DES) inserted > 12 months or bare-metal stent (BMS) inserted > 6 weeks, particularly if there are no associated risk factors as mentioned above. Discussion with cardiologists is necessary.
 - Continue aspirin while thienopyridines withheld

6. Thromboembolic risk stratification for anti-coagulant therapy

- Low-risk conditions: (1) aortic bi-leaflet metallic prosthetic heart valve without atrial fibrillation (AF) or other risk factors of stroke (e.g. AF, prior stroke or transient ischaemic attack (TIA), hypertension, diabetes mellitus, congestive heart failure, age > 75); (2) xenograft heart valve; (3) non-valvular AF with a **CHADS2 score of 0 to 2 (with no prior stroke or TIA); (4) > 3 months from the previous episode of venous thromboembolism
- High-risk conditions: (1) Prosthetic metallic mitral valve and any prosthetic heart valve with AF; (2) AF with chronic rheumatic heart disease particularly mitral

stenosis; (3) an episode of venous thromboembolism within the past 3 months; (4) thrombophilic syndromes (e.g. deficiency of protein C, protein S or anti-thrombin III, etc.)

****CHADS2 score:** Congestive heart failure, Hypertension, Age ≥ 75 , Diabetes (1 point each) and prior Stroke or TIA (2 points)

7. Patient on Warfarin:

Oral anti-coagulants should be stopped before all bronchoscopic procedures.

- Stop warfarin for five days before bronchoscopy
- Check INR prior to procedure to ensure INR < 1.5
- In situations where simple omission of anticoagulants will impose high risks to underlying disease (i.e. high-risk conditions in section 6), start subcutaneous low molecular weight heparin (LMWH) or intravenous unfractionated heparin (UFH) as “bridging anticoagulation” 2 days after stopping anticoagulation
- The last pre-procedural dose of LMWH should be administered 12-24 h before bronchoscopy, depending on the renal function status and the perceived risk of bleeding during the procedure (UFH 4-6 hours). In general, one should consider withholding the last LMWH dose when a twice daily regimen is used. Half the total dose can be given the morning before bronchoscopy when a once-daily regimen is used.
- Resume warfarin for low risk patients on the evening of the procedure with the usual daily dose when hemostasis is achieved.
- In high-risk patients (as in section 6), continue LMWH or UFH and resume warfarin when hemostasis is achieved within 24 hours after the FB, until INR becomes optimal when heparin can be stopped and warfarin continued alone.

8. Patients on Novel Oral Anti-coagulants (NOAC)

- At present there are no standard recommendations and good quality data for peri-procedural management with novel oral anticoagulants such as direct Thrombin inhibitor (Dabigatran) or direct Factor Xa inhibitor (Rivaroxaban, Apixaban) before bronchoscopy.
- In the absence of reversal agents, a relatively conservative approach could be adopted.
- Because of the relatively rapid onset of action and short half-life of most currently available preparations of NOACs, bridging anticoagulation after pre-procedural suspension of NOACs is usually not considered necessary.
- Timing of the last dose of NOACs: (with respect to procedural risk and renal function)

		Dabigatran	Rivaroxaban	Apixaban
CrCl \geq 50ml/min	Low risk procedure	1-2 days	1-2 days	1-2 days
	High risk procedure	2-3 days	3-4 days	2-3 days
CrCl < 50ml/min	Low risk procedure	2-4 days	2-3 days	3-4 days
	High risk procedure	4-6 days	3-4 days	4-5 days

VII. Special clinical conditions (1)

1. **Renal failure:** Consider administration of DDAVP before bronchoscopy when biopsy is contemplated in patients with significant renal impairment. Hemodialysis might be considered before bronchoscopy if necessary for severely uremic patients, or in patients already on regular dialysis. Liaison with nephrologists is encouraged.

2. **Asthma and COPD:** Bronchoscopy should not be performed during acute exacerbations of COPD or asthmatic attacks. The control of the underlying disease should be optimized before the procedure. Bronchoalveolar lavage (BAL) can potentially be associated with an acute fall in FEV1. Because of a higher risk of desaturation and bronchoconstriction, employing conscious sedation should be cautious in COPD patients. Inhaled short-acting bronchodilators can be considered prior to bronchoscopy in asthmatic patients and individual COPD patients. While pre-medication with a single dose of intravenous hydrocortisone is not commonly practised, it can be considered in patients with difficult-to-control asthma, those put on long-term oral steroids or those in critical clinical conditions where adrenal insufficiency is a potential possibility.
3. **Diabetes mellitus:** (a) Type I diabetes: intravenous insulin-dextrose infusions commensurate with the subject's usual daily insulin requirement would be required after fasting and titrated by regular hemoglucostix monitoring till oral intake is allowed again after bronchoscopy. (b) Type II diabetes: oral hypoglycemic agents and/or insulin should be withheld on the same day upon fasting, with regular hemoglucostix monitoring till oral intake is resumed after bronchoscopy. Intravenous dextrose-insulin infusions might be required in some patients with labile or poor glycemic control.
4. **Ischemic heart disease:** Oral anti-platelet and anticoagulant therapies should be managed as discussed above. Bronchoscopy should be avoided within the initial four to six weeks after myocardial infarction/acute coronary syndrome and in patients with clinically active myocardial ischemia (e.g. unstable angina) or unstable arrhythmias (e.g. rapid AF or ventricular arrhythmias). Liaise with cardiologists if necessary.

VIII. Checklist and monitoring immediately before and during FB (1)

1. "Time-out" procedure: Confirm patient's identity (including the clinical records and radiographs), the intended procedure and the duly signed informed consent form. The procedure should involve the patient, bronchoscopist and the nurse/assistant.
2. Re-confirm the pre-procedural actions taken (e.g. Nil by mouth, patent intravenous line etc.). Check for any loose denture(s).
3. Regular heart rate, blood pressure and continuous oxygen saturation (via pulse oximetry) monitoring immediately before, during and immediately after bronchoscopy until patient returns to a stable state.
4. Application of lignocaine gel or spray to nose (if via nasal route) and oropharynx before the procedure. The dosing should be recorded and included to the total dosage of local anesthetic being administered.
5. Supplemental oxygen should be given to patients with persistently significant desaturations (SpO₂ dip > 4% or SpO₂ < 90%). Since the use of supplemental oxygen at flow rate \geq 2L/min via nasal or pharyngeal catheter can reduce hypoxemia during bronchoscopy, routine supplemental oxygen should be provided in high risk situations (e.g. BAL in patients with diffuse interstitial lung disease) and in patients with abnormal lung function.
6. Level of sedation should be monitored, with instrument such as Modified Ramsay Score if applicable.
7. If necessary, other monitors such as ECG or capnography may be considered
8. Documentation of the following items:
 - a. Vital signs (blood pressure, heart rate and oxygen saturation): at baseline and at regular intervals
 - b. Name of administered drugs, with the time, dosages, route of administration and together with the signatures of the administering and checking personnel(s).

- c. The venue, names of bronchoscopist(s), duration and specific bronchoscope(s) used
- d. Bronchoscopic findings, and if facilities available, bronchoscopic images (electronic or hard copy) and video clips of the procedure.
- e. The procedure performed and complications, if any, in the procedural record.

IX. Procedural sedation and local anesthesia during FB (1,3, 17-23,30-33)

1. Introduction:

The sedation process is a continuum with transition through various degrees or depths of sedation from full consciousness to complete anesthesia at the extreme. It is achieved with medication(s) to depress the central nervous system and reflexes, aiming to reduce patient discomfort without creating unnecessary loss of consciousness and protective reflexes.

Administration of sedation has been recommended for FB, unless contraindications exist, in order to improve patient satisfaction and procedural tolerance. However, it has been noted that some patients can tolerate un-sedated procedures well without adverse safety issues. Patient preference can be sought on this before the procedure.

2. Conscious vs. Deep Sedation

Conscious sedation is a minimally depressed level of consciousness induced by the administration of pharmacologic agents in which the patient retains continuous and independent ability to maintain protective reflexes and a patent airway without additional interventions. Verbal communications with subjects should be possible at all times, with the patient being seen to be responsive to physical or verbal stimulations. Conscious sedation is the usual mode of sedation required in most FB procedures in endoscopy suites.

Deep sedation is a controlled state of depressed consciousness or unconsciousness from which the patient's conscious state is not easily arousable without withdrawal of sedation. It may be accompanied by a partial or complete loss of protective reflexes, including the ability to maintain a patent airway and to respond purposefully to repeated or painful stimulations. Deep sedation may be associated with the risk of inadequate spontaneous ventilation and/or impaired cardiovascular function.

3. Drugs commonly utilized for sedation during FB

(A) Benzodiazepine

- Midazolam produces sedation, anxiolysis and anterograde amnesia. The onset of action is within two minutes and the maximal sedative effect could be achieved at 5-10 minutes. Given in slow intravenous administration, it should be administered 5-10 minutes before procedure. Small supplementary doses (e.g. 1 mg) can be given at 2-10 minutes intervals if necessary in a progressively titrating manner. Duration of action is short though variable (30-120 min). The usual dosage range that can achieve optimal sedation is 1 to 5 mg, depending on patient characteristics and length of the procedure.
- It is metabolized via liver, with 50% renal excretion.
- Serious adverse effects: excessive sedation, respiratory depression, bronchospasm, laryngospasm, hypotension, paradoxical agitation etc.
- Individuals more prone to adverse effects: elderly, impaired respiratory or cardiovascular status, concomitant opioid administration, impaired renal and liver functions. Dose reduction is necessary for elderly and with concomitant opioid

administration.

- Flumazenil (Anexate[®]): a competitive receptor antagonist that can reverse the CNS and cardiorespiratory depressive effects of benzodiazepines. Initial dose: 0.2 mg intravenous push over 15 seconds, repeated every 1 minute for up to four times if response inadequate. Onset of action is usually in 1-2 minutes and the duration of action is 30-60 minutes. As its duration of action might be shorter than benzodiazepine, there could be possible recurrence of CNS and cardiorespiratory depressant effects and hence the patient should be closely monitored for at least an hour following its administration. Flumazenil should be administered first in an indicated patient who received both midazolam and opioid, unless a large dose of opioid had been administered. Possible side effects of flumazenil include nausea, vomiting, agitation, dizziness, tachycardia, hypertension, etc.

(B) Opioids

- Opioids provide sedative, analgesic and antitussive effects. Short-acting agent such as Fentanyl[®] is advantageous in reducing unnecessary post-procedural sedation.
- Adverse effects: respiratory depression, hypotension, nausea, vomiting, bradycardia, etc.
- Fentanyl[®] is efficacious and highly lipid-soluble, with a rapid onset of action (1-2 minutes, reaching a maximum effect at 5 minutes) and short duration of action (30-60 minutes). The usual initial dose is 25 mcg, with supplemental 25mcg doses if necessary in slow intravenous injections. The usual maximum dose is 50-100mcg (1-2mcg/kg).
- Meperidine (Pethidine[®]) is another commonly used opioid. It is less potent than Fentanyl[®], with a slower onset (3-5 minutes) and longer duration of action (2 to 4 hours) after intravenous administration. It should also be administered in small incremental doses in a titrating manner, with a usual maximum dose being 1-2mg/kg. Its use is associated with risk of seizures, paradoxical agitation and drug interactions with MAOIs, SSRIs and tramadol. Some endoscopists employ intramuscular injection as a pre-medication.
- Both Fentanyl[®] and Pethidine[®] are metabolized via liver, with renal excretion < 5%.
- Addition of an opioid to a benzodiazepine might reduce cough and dosage of lignocaine required for local anesthesia, as well as in improving patient tolerance. Since there may be a risk of over-sedation with combined use of sedative agents, opioids should be given first with time allowed to become maximally effective before administration of benzodiazepine.
- Naloxone (Narcan[®]) is a competitive opioid antagonist that reverses respiratory depression and sedation. It is given at 0.1 to 0.2 mg per dose every 2-3 minutes, with onset of action at 1-2 minutes and duration of action of 45 minutes to 4 hours. Possible side effects include nausea, vomiting, dizziness, headache, hypertension, tachycardia etc. There is a possibility of withdrawal in those with prior chronic opioid use. As its duration of action can be shorter than some opioids, the possibility of recurrence of cardiorespiratory depression should also be observed after its administration.

(C) Propofol[®]

- Phenolic derivative with sedative, amnestic and analgesic properties
- It demonstrates high lipophilicity with rapid CNS penetration and hence its rapid onset of actions (30-60 seconds). Rapid re-distribution and metabolic clearance from plasma, with duration of action of 3-5 minutes and rapid recovery in 10-15 minutes.

- Its efficacy in achieving sedation and adverse effects profile has been shown to be at least non-inferior to midazolam in randomized controlled trials with both patient and investigator satisfaction outcome measures, and it can be associated with faster induction of sedation and recovery.
- Adverse effects: cardiopulmonary depression (dose dependent with hypotension, respiratory depression, hypoxemia and decreased cardiac output), injection site pain, microbial contamination of the emulsion formulation. The risk of cardiopulmonary depression is usually dose-dependent and would be increased if its use is combined with opioids. There is no significant difference in adverse event rates when compared with benzodiazepines.
- In the absence of specific anti-dote, treatment of adverse effects is mainly supportive.
- It is not considered to be an appropriate choice for conscious sedation, since deep sedation and even general anesthesia can be induced rapidly with its narrow therapeutic window, requiring airway intervention and assisted ventilation. It should be administered by doctors who are familiar with the drug and skillful in airway management, such as anesthesiologists, during Monitored Anesthetic Care (MAC).

The above list is not exhaustive, and some other alternatives might be employed by individual specialists. However, the pharmacokinetic and pharmacodynamic characteristics of such agents, as well as the management of related adverse effects (including overdose) should be noted and thoroughly studied before embarking on utilizing such agents.

4. Local anesthesia (LA)

Lignocaine is the commonest LA agent used in bronchoscopy.

- LA reduces cough and decreases sedation requirement.
- The onset of action is 2-5 minutes. The duration of action for lignocaine is variable, usually 60-90 minutes.
- Various preparations are available, including nasal spray (e.g. Xylocaine® pump, 10mg/dose), nasal gel (e.g. Xylocaine® jelly 2%), tracheobronchial spray (1% lignocaine, i.e. 10 mg/ml) with “spray-as-you-go” manner via the bronchoscopic working channel and less commonly, for cricothyroid injection. Nebulized form of local anesthetic is no longer recommended.
- The total administered dose should also take into account those administered to the oro-nasal route and the upper airways.
- In contrast to the recommended maximum dosage for infiltrative injections (3mg/kg body weight), the maximum dosage allowed for bronchoscopy is not well-defined, although toxic symptoms had been reported above a median dose of 9.6mg/kg. On the other hand, effective cough control had been reported with dosage of less than 160mg. Apart from its unpredictable and differential absorptions at different parts of the respiratory tract, there is also significant individual variation in serum concentrations after receiving the same dose. Also, a significant yet variable proportion of the administered LA is removed by suctioning during FB. Peak serum concentrations can be reached within 20-30 minutes and toxicity can occur with serum levels > 5 mcg/ml.
- As a result, the lowest dose should be used to prevent excessive coughing during FB.
- Lower dosages should be considered for patients with advanced age, active liver and cardiac diseases, significant renal impairment, atherosclerosis, debilitated states, impaired conscious level etc.
- LA toxicity:
 - Central Nervous System: can be absent or non-specific (e.g. dizziness, blurred vision, nystagmus, tinnitus, paresthesia, etc.) particularly if early. Toxicities

can be (a) depressive nature: drowsiness, coma, respiratory suppression, etc. or (b) excitative nature: confusion, restlessness, seizure, myoclonus, etc.

- Cardiovascular System: hypotension, bradycardia (leading to asystole), ventricular ectopics and arrhythmias (VT, VF)
- Concomitant use of sedating agents might reduce the clinical detection of LA toxicity

5. **Requirements for procedural sedation**

(A) Staffing

1. All procedural sedation must be carried out and supervised by a registered medical practitioner.
2. In all circumstances, there should be a minimum of two professional staff members (endoscopist and nursing staff) during sedation for interventional procedures. It is preferable to have another appropriately trained medical / nursing staff whose sole duty is to monitor the conscious level and cardio-respiratory status of the patient. If such an additional staff member is not available, the endoscopist may be responsible for carrying out the sedation process, provided that verbal communications with the patient is continuously possible during the procedure. If such communication fails during the procedure, the endoscopist must pay full attention to monitoring and managing the patient till recovery, or until another appropriately trained individual is available.
3. An appropriately trained medical practitioner or anesthesiologist should be present to monitor the patient throughout the procedure if (a) deep sedation is planned; (b) the patient has serious medical conditions, or is at increased risk of cardiovascular, respiratory or airway compromise. The competency requirements, apart from the relevant knowledge concerning sedation, include also the ability to recognize and manage the adverse effects of sedation and resuscitation.
4. There should be regular audits to safeguard the quality and standards of procedural sedation.

(B) Equipment

1. Adequate space to for the procedure and resuscitation if necessary
2. Adequate lighting and electrical outlets
3. Suction device, suction catheters and oral airway
4. Oxygen supply and delivery devices
5. Resuscitation/Emergency trolley with the standard equipment and drugs
6. Blood pressure monitor and pulse oximeter equipped with visible and audible alarms.
7. Drugs for reversal of sedation
8. Ready access to cardiac monitor and defibrillator.
9. Availability of tilting operating bed

X. Post-procedural care / Recovery period (19-20)

1. Recovery should take place in a properly equipped and staffed area, capable of managing patients who are unconscious or suffering from complications.
2. Patients should be kept nil by mouth for at least two hours after procedure. Patients with diabetes should have regular hemoglucostix monitoring before resumption of oral feeding.
3. Blood pressure and pulse should be regularly monitored and pulse oximetry continuously for at least 2 hours after the procedure.

4. Patients with substantial bleeding during the endoscopy should be turned to lie lateral on the bleeding side.
5. Discharge of the patient from recovery area must be authorized by a doctor or registered nurse. Discharge of an outpatient after the procedure should be made after assessment by a doctor in a similar manner. Time of transfer-out of recovery room or discharge from out-patient should be recorded.
6. A system for safe transfer to an appropriate medical care should be available.
7. Post-procedural chest X-ray after transbronchial lung biopsy should be considered, or if clinically indicated or ordered by the endoscopist.
8. Post-bronchoscopy sputum specimen for microbiological or cytological examinations if necessary.
9. If the patient is to be discharged the same day after the procedure with conscious sedation, the patient/accompany person(s) should be provided with verbal and written information and instructions that sedation effects may last through the rest of the day (e.g. advised not to sign important/legal documents, not to drive or to operate heavy machinery, how and when to seek medical attention etc.) as well as the possibility of delayed pneumothorax. Advice should be provided on having a responsible adult to escort the patient home if available.

XI. Management of hypoxemia /oxygen desaturations during FB (1-4,23-24,33)

1. Hypoxemia should be quickly confirmed by checking the accuracy of the oximeter and the peripheral circulation.
2. Common causes of hypoxemia during bronchoscopy include:
 - the bronchoscopic procedure (occlusion of airway, suctioning and bronchial aspirate)
 - other sampling procedures like bronchoalveolar lavage and transbronchial lung biopsy
 - complications such as pneumothorax and bleeding
 - sedation process (e.g. either inadequate sedation or over-sedation)
 - bronchospasm
3. Oxygen supplementation (e.g. 2L/min) is recommended to keep SpO₂ to at least 90%, and to be escalated if there is persistent significant desaturations (SpO₂ dip > 4% or SpO₂ <90%).
4. Hypoxemia may last for considerable time after bronchoscopy has been completed, and hence oxygen supplementation should be continued in the recovery room following the procedure.
5. Other vital signs such as blood pressure and pulse rate should also be monitored. Tachycardia could be the first sign of impending hypoxemia. Bradycardia is always a signal for the bronchoscopist to remove the bronchoscope from the airway immediately and to assess for any need of ventilatory support. Check and monitor the conscious level and if necessary, cardiac rhythm monitoring (e.g. with hemodynamic instability), should be considered with persistent or profound desaturations.
6. The risk of hypoxemia can increase with greater complexity of the bronchoscopic procedure and longer procedural time.
7. General measures during hypoxic episodes: (a) Judicious use of suction during bronchoscopy and reduce/suspend suction during hypoxic episodes; (b) Increase oxygen supplementation; (c) Suction removal of excessive fluid, secretions and blood if present; (d) Partial removal of the bronchoscope up to the trachea or even complete removal of bronchoscope with suspension of the procedure should oxygen desaturations becomes

- profound or persistent.
8. Review the use of sedating agent and level of consciousness. Inadequate sedation may cause agitation and breath-holding that may lead to hypoxemia. Suspected over-sedation should be reversed with appropriate antidote(s): Flumazenil (Anexate[®]) for benzodiazepine reversal and Naloxone (Narcan[®]) for opioid reversal as described above.
 9. Examine the patient to detect presence of stridor, bronchospasm, asymmetrical chest expansion or breath sounds, angio-edema, skin rashes etc.
 - Administer short-acting bronchodilators (inhalation or subcutaneous) if bronchospasm is detected or suspected
 - Urgent portable chest radiograph should be taken if pneumothorax is suspected (e.g. asymmetrical chest expansion or breath sounds where TBBx or transbronchial needle aspiration for peripheral lung nodules has been performed).
 - Emergency needle decompression can be considered if the clinical suspicion of pneumothorax is strong and a chest radiograph not immediately available in very unstable patients. Otherwise, pneumothorax can be managed accordingly (conservative, aspiration or intercostal drainage)
 - Suspected or diagnosed anaphylaxis should be treated with subcutaneous/intramuscular adrenaline (1:1000 dilution) 10mcg/kg (0.5ml in 50kg adult), together with IV chlorpheniramine, IV hydrocortisone and intravenous fluids. Severe or life-threatening anaphylaxis might require IV adrenaline injection or infusion.
 10. Consider the possibility of severe bleeding as a cause of hypoxemia and manage in accordance to Section XII.
 11. Contact senior pulmonologist or another respiratory specialist for assistance.
 12. Perform manual bagging to support ventilation if there is persistent desaturation despite the above measures and consult anesthetist for elective intubation.
 13. Consider emergency intubation if anesthetic support is not immediately available and if the clinical situation demands immediate resuscitation.
 14. Commence CPR and follow ACLS steps if patient develops circulatory arrest.
 15. Consult ICU if necessary (e.g. patient requiring intubation and mechanical ventilation)

XII. Management of endobronchial bleeding during FB (1,9,24,28)

1. The variability of definitions has led to the widely variable incidence of bleeding during bronchoscopy. In the largest series from Italy, minor bleeding occurs in 0.19% while severe bleeding occurs in 0.26% (9). Another study from USA revealed clinically significant bleeding in 0.83% amongst all bronchoscopic cases and in 1.9% of biopsy/brush cases during bronchoscopy over a 9-year period (28).
2. While there is yet no universally accepted way of classifying the degree of bleeding, the amount of blood loss may not be accurate as blood collected may be mixed with saline, adrenaline and secretions. The type of clinical interventions necessary to manage the bleeding had also been employed as a classifying method, where “moderate” bleeding was defined as those necessitating the use of endoscope “wedging”, topical adrenaline or cold saline while “severe” bleeding as those requiring the use of bronchus blocker or catheter in applying fibrin sealant, or where resuscitation, blood transfusion, admission to critical care unit, or death occurs.
3. While caution should be given in patients with clinical risk factors for abnormal coagulation (e.g. anticoagulant therapy, liver disease, personal or family history of bleeding tendency, active bleeding or pre-procedure transfusion etc.), bleeding after bronchial biopsy can occur in the absence of such prevailing risk factors. Severe

bleeding is more common with TBLB than EBBx.

4. General measures to manage bleeding:
 - Check and closely monitor hemodynamic parameters including BP/Pulse/SpO₂ and cardiac rhythm monitoring
 - Fluid resuscitation, with additional large-bore intravenous access if necessary
 - Administer the appropriate blood products (fresh frozen plasma, platelet concentrate etc.) or Vitamin K for those with pre-existing borderline platelet or coagulation status. Re-check such pre-procedural parameters and drug history
 - Type and screen blood, and transfuse if necessary
 - Lateralize the side of bleeding where possible and position the bleeding side in the dependent position to avoid flooding of the non-bleeding lung and hence preserve ventilation from the non-bleeding side.
 - Titrate oxygen supplementation according to SpO₂
5. Bronchoscopic interventions:
 - Retract the bronchoscope to a more proximal location in the airway to maintain vision. Apply suction to remove blood to maintain visibility, avoid soiling of other lung segments and to preserve airway patency.
 - Avoid direct suction on the source of bleeding so that the clot formation is not impaired. Do not use suction to remove formed clot.
 - Consider application of local vasoconstrictor therapy such as aliquots of 2 ml 1:10000 adrenaline or 5-10 ml 4°C saline. Saline has the advantage that it may be administered repeatedly.
 - If bleeding continues, the bronchoscope should be wedged into the bleeding segmental bronchus and to be held in place for 10-15 minutes. This provides tamponade effect, allowing bleeding site to clot while preventing spillage to normal areas. Such “wedging” is sometimes the fastest way to handle substantial bleeding before epinephrine or ice cold saline is immediately available.
 - If bleeding continues, a balloon catheter can be used to apply pressure and isolate the segment.
 - If available and feasible, argon plasma coagulation (APC) can be considered for visible bleeding sites. Avoid direct positioning of the argon plasma opposite to the bleeding site to prevent potential gas embolism.
 - Where possible, the endoscope should be kept positioned inside the airway until bleeding is seen to be stopped under endoscopic view.
6. Seek assistance from senior pulmonologist and other specialists if necessary,
 - Anesthetists for airway control and elective intubation (+/- double lumen endotracheal intubation). Bronchial blocking devices like the Arndt endobronchial balloon blocker can be used to control bleeding by occluding the affected lobe or the affected lung, preventing the blood from spilling over to the unaffected side. This would also help to “buy time” before subsequent more definitive procedures such as bronchial artery embolization or surgery could be considered.
 - Intensive care unit for subsequent monitoring and assisted ventilation
 - Thoracic surgeon for consideration of rigid bronchoscopy +/- other surgical interventions to stop bleeding under general anesthesia.
 - Radiologist for consideration of bronchial artery embolization.

XIII. Cardiac complications during FB (1,24)

1. Cardiac complications, such as arrhythmias, myocardial ischemia and infarction, are uncommon during bronchoscopy. Causes might include: (a) stress from the bronchoscopic procedure itself; (b) adverse effects of sedation; (c) complications such as bleeding and

hypoxemia.

2. Bronchoscopy can induce cardiac ischemia by producing hemodynamic changes such as increases in heart rate and blood pressure. Underlying ischemic heart disease, uncontrolled hypertension, advanced age and heavy smoking history can also increase the risk of cardiac ischemia during bronchoscopy.
3. Common arrhythmias include sinus tachycardia, premature ventricular contractions (PVC) and premature atrial contractions. Ventricular arrhythmias (PVC, bi- and trigeminy) occur most commonly when the endoscope passes through the vocal cords and are also associated with low oxygen saturations. Tachycardia might be the first sign of impending hypoxemia or respiratory distress, while bradycardia is usually an ominous sign that signifies the endoscopist to stop the procedure and remove the endoscope immediately.
4. Continuous ECG monitoring during bronchoscopy is essential when there is a high clinical risk of arrhythmias, or with procedures such as BAL when desaturations are common.
5. Significant bleeding causing hemodynamic change is rare. Cold saline is preferred to adrenaline spray in controlling bleeding as there are case reports of significant arrhythmias after endobronchial administration of adrenaline.
6. Bronchoscopist should also take reference to the recommendations on management of arrhythmias during bronchoscopy in the ACLS protocol.

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(B) PLEUROSCOPY (also known as Medical Thoracoscopy or Local Anesthetic Thoracoscopy)

Pleuroscopy refers to thoracoscopic procedures that can be performed in endoscopy suites, operating theatres or clean treatment rooms, depending on the local availability of resources. The procedure is performed with patients maintained on spontaneous breathing under conscious sedation and local anaesthesia. It is different from VATS which is performed via several portals of entry by thoracic surgeons in intubated patients on ventilatory support under general anaesthesia. Locally most pleuroscopies are currently performed with flexi-rigid instruments, though rigid endoscopes can also be employed.

I. Indications: (1-11)

A. Diagnosis:

- Exudative pleural effusions of unknown cause, including but not limited to those of suspected malignant or tuberculous origins
- Staging for suspected pleural metastases in patients with known carcinoma of lung presented with pleural effusions.

B. Therapeutic:

- Talc pleurodesis for malignant pleural effusion
- Talc pleurodesis for pneumothorax
- Lysis of adhesions and drainage in early parapneumonic effusions

Other more advanced indications or interventions (i.e. above BTS level 1) might include: (1,10,11)

- Examination of pleural space with small or even absence of pleural effusion via pneumothorax induction
- Visceral pleural biopsy
- Lung biopsy
- Lysis of adhesions and lavage with loculated or infected pleural space
- Talc pleurodesis in patients with secondary pneumothorax unsuitable for VATS under general anaesthesia

However, these would only be carried out by more experienced practitioners in units with a major interest in pleural disease, as these advanced indications would imply higher risk of complications and mortality. Availability of rigid instruments and if necessary, support from thoracic surgeons would be preferable in these clinical situations.

II. Contraindications (1-11)

Absolute contraindications:

1. Lung adherent to the chest wall throughout the hemithorax with the lack of pleural space
2. Hypercapnia or respiratory distress with expected inability to stand one-lung ventilation
3. Intractable cough
4. Lack of informed consent

Relative contraindications:

1. Inability to tolerate lateral decubitus position
2. Unstable cardiovascular or haemodynamic status
3. Hypoxemia that is not corrected with oxygen supplementation

4. Bleeding diathesis: coagulation and platelet abnormalities, renal failure etc.
5. Pulmonary arterial hypertension
6. Significant comorbidities such as active airway diseases and infections. Patient with recent myocardial infarction/acute coronary syndrome or cerebrovascular accident should have procedure deferred for 4 to 6 weeks.
7. Hypersensitivity to drugs used for conscious sedation and local anesthesia
8. Poor general health status with expected short survival
9. Dense pleural adhesions
10. Very severe obesity: technically difficult and inadequate cannula length may prevent entry into the thoracic cavity.
11. Conditions in which other investigations, such as bronchoscopy, can be more effective and feasible. (e.g. prominent airway lesion with very small amount of pleural effusion)

III. Complications (1,10-13)

Pleuroscopy is generally a safe procedure. Pooling data from 47 studies, the British Thoracic Society 2010 Guideline on Local Anesthetic Thoracoscopy revealed an overall mortality rate of 0.34% and major complication rate of 1.8%. Common major complications include empyema, hemorrhage, port-site tumour growth, broncho-pleural fistula, postoperative pneumothorax or air leak and pneumonia. Minor complications (subcutaneous emphysema, minor hemorrhage, operative skin site infection, hypotension during procedure, fever, atrial fibrillation) occurred in 177 out of 2411 procedures (7.3%). In a national survey carried out by the Japan Society for Respiratory Endoscopy, an overall complication rate of 1.86% was reported, including hemorrhage (1.05%), pneumothorax (0.4%), pulmonary infection (0.24%) and respiratory failure (0.08%). Other complications such as re-expansion pulmonary edema, pulmonary embolism and acute respiratory distress had also been reported.

IV. Pre-procedural preparation and work up (1-11)

1. Check and review the indications for the procedure and presence of any contraindications.
2. Informed written consent (covering both the procedure itself and the need for conscious sedation) should be obtained, with information sheets provided to subjects.
3. Check past medical, allergic and drug histories. Perform physical examination. Apart from checking the fitness for the endoscopic procedure, the assessment should also include those that would identify potential cardiovascular and respiratory risks, as well as risk of airway compromise during procedural sedation.
4. Pre-procedural investigation would include:
 - a. Blood tests like complete blood picture (including platelet count), coagulation profile, electrolytes, liver & renal functions. It may be appropriate to check arterial blood gases if significant hypercapnia is suspected.
 - b. A baseline ECG should be obtained if considered appropriate.
 - c. Up-to-date chest radiographs with decubitus view, and computed tomography (CT) scan would aid in the patient evaluation and selection of the appropriate entry site. Although CT scan is not absolutely necessary, it would allow (1) identification of pleural nodularity in the presence of pleural fluid and (2) identification of any obstructing bronchial lesion that could provide alternative target for tissue diagnosis if pleural investigation is non-diagnostic.

- d. Thoracic Ultrasonography (USG) is more sensitive than CT in delineating pleural adhesions. That would provide a better assessment of technical feasibility (e.g. degree of pleural adhesions and loculations, thickness or depth of pleural effusion and subcutaneous/muscular layer) and guide the trocar entry site.
5. At least six-hour pre-procedural fasting for solid food is recommended, although small amounts of clear fluids may be allowed up to two to three hours before the procedure.
6. While the bleeding risk is not considered to be high, some might consider pre-procedural cross matching for patients with relatively high risk (e.g. chronic renal or liver failure, presence of other bleeding diathesis, potential need for substantial adhesiolysis etc.).
7. An intravenous cannula should be established on the hand on the same side of the planned procedure.
8. The planned site (hemithorax) for the procedure should be marked before patient is transferred to the procedure room, as part of the “time-out” procedure.
9. The benefit of routine administration of prophylactic antibiotics is not clearly established. Routine administration of prophylactic antibiotics is generally not warranted, except for cardiac conditions with the highest risk of adverse outcome from endocarditis, i.e. prosthetic heart valves or cardiac valve repair with prosthetic material, previous endocarditis, unrepaired cyanotic congenital heart diseases (CHD), completely repaired CHD defect with prosthetic material or device during the first six months after procedure, repaired CHD with residual defects at or near prosthetic material, and cardiac transplantation with cardiac valvulopathy. The antibiotic regimen should be active against the viridans group *Streptococci*, or should contain an anti-staphylococcal beta-lactam when an infection with *Staphylococcus aureus* is suspected or known.

V. Pre-procedural management of bleeding risk, anti-platelet and anti-coagulant treatment (1, 15-20, 27-30)

1. This is in principle similar to that for bronchoscopy. However, in contrast to the guidelines on bronchoscopy and chest drainage where INR < 1.5 were utilized as the acceptable level, the BTS pleuroscopy guideline had only recommended to have “normalization of the coagulation profile confirmed” prior to the procedure without specifying any reference value.
2. The literature and evidence in this area with pleuroscopy is scarce and the exact bleeding risk with pleuroscopy is not well defined or classified. While BTS 2010 guideline (Appendix: practical guide) recommended discontinuing aspirin for one week prior to the procedure, others did not consider aspirin will impose a bleeding risk to the procedure.
3. The proper management involves balancing the risk of peri-procedural bleeding with continued treatment against the thromboembolic risk with suspension of treatment.
4. Liaise with cardiologists and neurologists if necessary.
5. Consider also the urgency of the procedure, together with the choice of the patient and the endoscopist.

VI. Special clinical conditions

These are similar in principle to those for bronchoscopy.

VII. Checklist and Monitoring immediately before and during pleuroscopy (1-2,4-7)

1. “Time-out” procedure: Confirm the correct patient identity, clinical and imaging records, the intended procedure, the side to be operated on and the duly signed informed consent forms. The process should involve the patient, endoscopist and the assistant.
2. Re-confirm the pre-procedural actions taken (e.g. NPO, patent IV line etc.)
3. Regular heart rate & blood pressure, together with continuous cardiac rhythm and oxygen saturation (via pulse oximetry) monitoring beginning immediately before, during and immediately after bronchoscopy until patient returns to a stable state.
4. Supplemental oxygen (e.g. 2L/min) via nasal catheter during the procedure, aiming to keep SpO₂ > 92%.
5. Level of sedation should be monitored, with instrument such as Modified Ramsay Score if applicable.
6. Documentation of the following items:
 - a. Vital signs (blood pressure, heart rate and oxygen saturation): at baseline and at regular intervals.
 - b. Name of administered drugs, with the time, dosages and the route of administration, with signatures of the applied and checking personel(s).
 - c. The venue, names of endoscopist(s), duration and specific endoscope employed.
 - d. Pleuroscopic findings, and if facilities available, images (electronic or hard copy) and video clips of the procedure.
 - e. Procedure performed and complications, if any.
7. The correct side for the procedure should be re-checked and site of entry re-confirmed, preferably with bedside thoracic ultrasound, with the patient placed in the decubitus position prior to commencement of the procedure.
8. The lateral decubitus position is commonly used and with patient lying on the healthy side. The patient’s head is rested on a pillow, with the hands positioned in front of patient’s face. The position should be comfortable and allows clear access to both the thoracic wall and the intravenous cannula when the patient is covered with a sterile drape. Padding placed beneath the elbow and between the legs can avoid possible nerve injury, while placing a roll beneath the mid-chest can help to expand the intercostal space.
9. Full aseptic technique should be observed in skin preparation. The skin over the whole hemi-thorax of the side to be examined should be prepared with skin sterilizing solution.
10. Suction for both the pleurosocopic examination and airway, if necessary, should be available. The amount of pleural fluid removed should be measured and monitored.
11. Depending on the availability of the equipment and expertise, APC/ electrocautery/diathermy can be set up as standby ancillary equipment and endoscopists should have adequate training related to the use of these equipments in case emergency situation arises.
12. Intercostal tube and the underwater seal drainage system should be available and ready once the procedure begins, in case rapid re-expansion of the lung is necessary.

VIII. Procedural sedation, Staffing and Equipment Requirements (1-11, 21-23, 31)

These are in principle similar to those for bronchoscopy.

IX. Local anesthesia (LA) (21-22, 24-27)

1. Site of entry: although the “safety triangle” (4th or 5th intercostal space in mid-axillary line, delineated by the anterior border of the latissimus dorsi, lateral border of pectoralis major and above the line horizontal to the nipple in the male) is recommended by BTS, 4th to 7th intercostal space in the mid-axillary line is commonly employed, particularly for the investigation of pleural effusion. In certain cases (e.g. with pleural adhesions or loculations), the best site would have to be identified with thoracic ultrasonography.
2. The dose of lignocaine utilized should not exceed 3mg/kg body weight.
3. Duration of action for lignocaine: variable, usually 60-90 min
4. If available, lignocaine combined with adrenaline would allow a higher maximum dosage of 7mg/kg body weight, longer duration of action and might aid better visualization by preventing blood from oozing from the entry site.
5. LA should be administered into the various layers at the entry site that lead to the pleural cavity (epidermis, aponeurosis, intercostal muscles and parietal pleura), usually involving an adequate skin area in the intercostal space just above the upper margin of the lower rib. In obese patients and those with thick chest walls, a systemic 4-step LA administration and incision from skin to parietal pleura has been proposed.
6. Dosage of LA required would vary depending on the expected nature and length of procedure, type of instruments (e.g. semi-rigid vs. rigid instruments) and patient characteristics. Lower dosages might be advisable for patients with active liver and cardiac diseases, significant renal impairment, advanced age, atherosclerosis, debilitated states, impaired conscious level etc.
7. Apart from excessive dosage, inadvertent LA administration to blood vessels is a common cause of LA toxicity. As the LA needle is slowly advancing through the chest wall, serial aspirations should be carried out before each injection of LA to avoid direct injection into a punctured vessel.
8. Additional intercostal block with infiltration of LA above and below the periosteum of the rib and then the intercostal space has been proposed to minimize post-procedural pain. While this can be considered by operators who are familiar with the procedure, the total dosage of LA should not exceed the maximum recommended level.
9. Administration of 1% lignocaine using a spray catheter introduced through the working channel of a semi-rigid pleuroscope had also been reported for pain control before chemical pleurodesis with talc.
10. LA toxicity:
 - a. Central Nervous System: can be absent or non-specific (e.g. dizziness, blurred vision, nystagmus, tinnitus, paraesthesia, etc.) particularly if early. Toxic effects may be (a) depressive: drowsiness, coma, respiratory suppression, etc. or (b) excitative: confusion, restlessness, seizure, myoclonus, etc.
 - b. Cardiovascular System: hypotension, bradycardia (leading to asystole), ventricular ectopics and arrhythmias (VT, VF)
 - c. Concomitant use of sedating agents might mask the clinical manifestations of LA toxicity

X. Post-procedural monitoring (1,7)

1. The patient should be monitored for an appropriate amount of time after pleuroscopy, in an adequately equipped and staffed “recovery” area that can monitor unconscious and hemodynamically unstable patients.
2. Endoscopist would decide the timing of discharge of the patient from procedure room.

Arrangements of patient escort, clinical handover, notification of the parent ward/clinical management team should be meticulously carried out for unstable patients.

3. Overnight stay in hospital after pleuroscopy is common, particularly in patients who have received talc poudrage and hence the need for longer periods of intercostal drainage.
4. The respiratory rate, pulse, blood pressure, oxygen saturation, presence of “tidaling” of the intercostal drain (that indicates drain patency) and pleural fluid drainage should be monitored closely and recorded in the first 2 hours. The conscious level and temperature should also be monitored. The patient should be kept nil by mouth in the first 2 hours or until the vital signs return to normal.
5. Oxygen supplement can be provided on an as-needed basis.
6. Routine suction to the intercostal drain is not necessary. Low suction can be applied (5-20 cmH₂O) if necessary.
7. A routine chest radiograph should be taken on the day after the procedure and another one taken after the intercostal drain is removed.
8. Adequate post-procedural analgesia should be provided, particularly after talc pleurodesis.

XI. Issues about procedural safety (1,4-7,10)

1. In cases where there is only a small amount of pleural fluid, the trocar entry should be guided with thoracic ultrasonography. Prior to skin incision and trocar insertion, some operators would insert a needle, angiocatheter, or Boutin puncture needle and aspirate out some pleural fluid from the pleural cavity. This would be followed by induction of an “artificial pneumothorax” by opening the needle to air. This would prevent lung re-expansion and creating space for trocar entry. In general, the risk of complications (e.g. bleeding) and technical difficulties are considerably higher with a small pleural space.
2. Biopsy of the parietal pleura should be performed over a rib surface to avoid damaging the neurovascular bundle. The tip of the forceps should be first used to probe the rib and to feel for the bony under-surface before taking the biopsy.
3. Avoid biopsy or trocar insertion in close proximity to the sternum and the spinal column, in order to avoid the anterior intercostal arteries and unprotected posterior intercostal arteries (within approximately 6 cm lateral to thoracic vertebrae) respectively.
4. With large amount of pleural effusions, aspiration of pleural fluid should be done gradually, allowing air to enter the pleural space to replace the aspirated volume. This would help to maintain the intrapleural pressure to reduce the potential risk of re-expansion oedema.
5. Avoid or be very cautious in mechanical separation of dense fibrous bands and vascular adhesions, particularly in cases with dense adhesions when using flexi-rigid pleuroscope and in the absence of electrocautery.
6. Use of calibrated large-particle sterile asbestos-free talc of about 4g is usually safe in pleuroscopic talc poudrage.
7. In order to reduce the risk of subcutaneous emphysema, a chest tube with a calibre similar to the insertion port should be chosen.

XII. Management of hemorrhage during pleuroscopy (4,5,10)

General measures:

1. Monitor hemodynamic parameters (SpO₂, BP, heart rate and rhythm) and blood loss closely.
2. Give intravenous fluid resuscitation and insert additional large-bore venous access if necessary.

3. Secure airway and check breathing: intubate and mechanically ventilate if necessary.
4. Titrate oxygen supplement according to SpO₂.
5. For patients with pre-existing borderline hemostatic status, consider administration of platelet concentrates, fresh frozen plasma or Vit. K where appropriate and indicated.
6. Type and screen blood if not yet done; transfuse if necessary.

Endoscopic measures:

1. Identify and maintain a close and clear view of the bleeding site. Clearing of the endoscopic view can be assisted by rubbing the tip of scope to the lung or adjacent pleura, suction or normal saline flushing of working channel.
2. Exert direct pressure over the bleeding site with the endoscopic tip, which would be the fastest and easiest intervention. If possible and necessary, “bimanual” pressure from external chest wall with a gloved finger can be applied.
3. If available and necessary, the following devices/medications/aids can be considered if bleeding continues:
 - a. Instillation of topical 1:10000 adrenaline solution to the bleeding site
 - b. Electrocautery or APC application via the endoscopic channel
 - c. Pressure applied from a balloon catheter via the endoscopic channel
4. If necessary and suitable equipment available, another incision can be made to provide additional access to the pleural cavity, and thus enable the application of pressure (e.g. with gauze mounted on forceps) or electrocautery /APC under endoscopic vision.

Subsequent measures:

1. Contact senior pulmonologist/another respiratory specialist for assistance and resuscitation.
2. If available and necessary, consult thoracic surgeon to consider additional interventions such as clipping or repairing the vessels, thoracotomy etc.
3. If necessary, consult anaesthetist for airway control and intubation.
4. Re-expansion of the lung by insertion of a large-bore intercostal drain (≥ 24 F) can provide tamponade to the bleeding site and the blood loss can be continuously monitored during pleural drainage.
5. Continue close monitoring of the vital parameters and blood loss. Give intravenous fluids and blood products if necessary. Commence CPR and ACLS management steps if circulatory arrest occurs.
6. Consult ICU if patient remains haemodynamically unstable or assisted ventilation is considered necessary.
7. Careful and complete documentation (including the timing of events and various interventions) in case notes and endoscopic record is mandatory.

XIII. Oxygen desaturation/Respiratory distress during pleuroscopy (4,5,10)

General initial measures: (not necessarily in chronological sequence, and in many scenarios, these can be carried out simultaneously)

1. Monitor vital signs: SpO₂ from pulse oximetry (and the level of oxygen supplement), BP, pulse rate, conscious level, cardiac rhythm
2. Check and protect airway (e.g. insertion of oro-pharyngeal airway); suctioning where necessary (e.g. increased secretions or vomitus)
3. Escalate and titrate oxygen supplementation to keep SpO₂ $\geq 92\%$
4. If indicated (e.g. inability to obtain verbal contact due to excessive sedation), reverse the sedative effect with agents such as flumazenil and/ or naloxone, in careful small titrations

- while observing patient's response.
5. With persistent desaturation, the procedure has to be terminated with insertion of an intercostal drain to re-inflate the collapsed lung. Significant bleeding from biopsied site should be controlled as far as possible before scope removal. (Refer to section A above on the management of bleeding)
 6. Promptly perform physical examination of the chest to detect any abnormal signs such as stridor, wheezes, etc.
 7. If indicated (e.g. presence of bronchospasm), administer short-acting bronchodilators via inhalation or subcutaneous injection.
 8. Position patient to optimize breathing and/or protect airway if appropriate (e.g. semi-prone if patient is still unconscious; prop up 45%).
 9. Order urgent portable chest radiograph.
 10. If anaphylaxis is suspected or diagnosed, administer subcutaneous adrenaline (1:1000) and manage according to Section XI under flexible bronchoscopy.
 11. Other investigations to be considered: hemoglucoStix (in diabetic patients), ECG and blood tests such as troponin, D-dimer, arterial blood gas etc.

Subsequent measures if condition persists or deteriorate

1. Contact senior pulmonologist or another respiratory specialist for assistance
2. Consult anesthetist for elective intubation. Continue manual bag-mask-valve ventilation via protected airway. Order urgent chest radiograph after intubation.
3. Commence CPR and ACLS steps if cardiorespiratory arrest occurs
4. Consult ICU if patient remains hemodynamically unstable or assisted ventilation is considered necessary.
5. Consider arrangement of urgent CT thorax if pulmonary embolism is suspected (e.g. underlying malignancy, prolonged bed rest etc.)
6. Consult cardiologist or CCU with the detection of myocardial ischaemia and arrhythmias and/or if there is the need of urgent echocardiogram or other cardiac interventions.
7. Careful and complete documentation (including the timing of events and various interventions) in case notes and endoscopic record is mandatory.

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