AUDIT, RESEARCH AND GUIDELINE UPDATE

Ultrasound-guided pneumothorax induction prior to local anaesthetic thoracoscopy

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ABSTRACT

Local anaesthetic thoracoscopy (LAT) is performed by a growing number of respiratory physicians in the context of an expanding population with pleural disease. Most LATs occur in patients with moderate to large effusions where the presence of fluid allows safe access to the pleural space. Patients with little or no fluid, but other features concerning for pleural disease, are usually investigated by surgical means. Advanced LAT practitioners can also provide this service through pneumothorax induction, although there is little published data on the safety or efficacy of this technique. We present data from a series of 77 consecutive patients in whom ultrasound-guided pneumothorax induction and LAT were attempted. 67 procedures (87.0%) were successful, with the most common histopathological diagnoses being chronic pleuritis (58.2%) and mesothelioma (16.4%). No adverse events were reported secondary to the procedure. These findings demonstrate the utility of this approach and should inform future practice and guidelines.

INTRODUCTION

Local anaesthetic thoracoscopy (LAT) is used by an increasing number of respiratory physicians for diagnostic and therapeutic purposes in the setting of pleural disease. The widening availability of LAT has helped to streamline the investigation of patients who might otherwise have required referral to tertiary thoracic surgical units. Recent guidelines[1 2] have defined the role of LAT in the diagnostic algorithm for pleural disease and provided direction on how such a service should be delivered.

The majority of LAT practitioners will only intervene when enough pleural fluid is present to allow safe blunt dissection and trocar placement through the chest wall—classified by the British Thoracic Society (BTS) as level 1 competence.[2] However, more advanced (level 2) practitioners may undertake LAT in patients with little or no pleural fluid by inducing a pneumothorax prior to trocar placement. This would previously have required a chest X-ray, fluoroscopy or other radiology-based test to confirm pneumothorax formation prior to proceeding—potentially incurring a delay between two stages of the LAT procedure, as well as exposing the patient to ionising radiation. The advent of physician-led thoracic ultrasound (TUS) offers an alternative approach for the safe delivery of advanced LAT. TUS can exclude the presence of significant pleural adhesions that might prevent pneumothorax induction[3 4] before being used to guide instrumentation of the chest wall and confirm the successful development of a pneumothorax prior to trocar insertion.

There is a shortage of published data regarding the efficacy and safety of LAT in the absence of pleural fluid, either with or without use of TUS as a procedural adjunct. We reviewed cases from our centre where pneumothorax induction and LAT were attempted during the investigation of patients for pleural disease.

METHODS

Case identification and data collection

Medical records and prospectively collected data from the Oxford Pleural Unit procedural database were reviewed for all patients undergoing LAT between July 2011 and June 2014. Cases of patients undergoing pneumothorax induction to facilitate LAT were identified and reviewed for data, including demographics, clinical indication for LAT, TUS findings, procedural complications and final diagnosis. Ethical approval was not sought as this was considered a review of clinical practice.

Clinical management

All patients being considered for LAT were assessed in a specialist pleural clinic by either a consultant or registrar with a minimum of Royal College of Radiologists level 1 competence in TUS. TUS features including the presence or absence of pleural fluid, pleural thickening and lung sliding in B-mode were systematically evaluated across both hemithoraces and correlated with cross-sectional imaging results. Where appropriate—as determined by clinical indication, patient characteristics (including performance status) and TUS findings including the presence of lung sliding to exclude pleural adhesions—patients were triaged to a LAT procedural list within 2 weeks.

On the day of the procedure, written informed consent for LAT was obtained prior to a further in-depth TUS assessment of the relevant hemithorax with all patients in the lateral decubitus position. Key features of the underlying anatomy including location of the hemidiaphragm and cardiac structures, as identified on TUS, were physically drawn out on the chest wall. For patients in whom it was considered that pneumothorax induction was unlikely to succeed (determined by the absence of lung sliding in the mid-axillary line), the procedure was either postponed or converted

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on-table to TUS-guided cutting needle pleural biopsies in the event of failure to develop an adequate pneumothorax.[5]

Pneumothorax induction was performed with a 16-gauge Boutin needle (Richard Wolf, London, UK) under direct TUS guidance, using an in-plane approach to allow visualisation of the entire needle throughout the procedure. Local anaesthetic (20 mL 1% xylocaine with adrenaline 1:100 000) to the chest wall and intravenous sedation (midazolam 1–2 mg) were administered beforehand. Successful introduction of air into the pleural space was confirmed audibly and using real-time observation of pneumothorax development on TUS. Blunt dissection, trocar placement and thoracoscope introduction then proceeded as normal with at least eight pleural biopsies collected from multiple sites in each patient for diagnostic purposes. Postprocedure lung re-expansion was confirmed on plain chest radiograph and TUS, and where appropriate, the patient was discharged home the same day.

RESULTS

A total of 207 LATs were attempted during the 3-year study period, of which 77 (37.2%) required TUS-guided pneumothorax induction. Demographics for the study population are included in table 1. In all cases, there was little or no pleural fluid in the mid-axillary point where the pneumothorax was induced, with real-time in-plane TUS guidance considered essential to maintain patient safety. A total of 67 (87.0%) of these procedures were successful with sufficient pneumothorax development to allow the practitioner to continue with LAT. The majority of patients (70.1%) were able to be discharged home on the day of the procedure. The most common diagnosis from pleural biopsies was chronic pleuritis or fibrosis (58.2% of patients); 32.8% of patients had malignant disease with mesothelioma accounting for half of these.

Of the 10 (13.0%) procedures where a pneumothorax could not be induced, seven were documented as having limited or poor lung sliding suspicious for pleural adhesions. Six patients were converted on-table to TUS-guided pleural biopsies, all of which allowed a histological diagnosis to be made. Four patients were referred on for surgical biopsies to further investigate their pleural disease.

When using TUS to predict whether pneumothorax induction would work, 67 of 70 patients (95.7%) with clear lung sliding had their lung collapse successfully. All seven patients documented as having limited or poor lung sliding failed pneumothorax induction. Proportional analysis of this population gave a χ^2 value of 51.6 (2 df, $p<0.01$).

No significant or unexpected complications including cardio-respiratory instability, bleeding, uncontrolled pain and damage to underlying lung or other intrathoracic structures were reported either during or immediately after any of the procedures.

DISCUSSION

A significant proportion of patients with pleural disease being considered for LAT do not have enough pleural fluid in the lateral decubitus position to facilitate a straightforward intervention. These individuals require pneumothorax induction to safely access the pleural space, a technique classified by the BTS as part of advanced (level 2) practice. While practical guidance relating to this procedure is available, there is little published data relating to either its efficacy or safety. This is of particular importance given the increasing number of centres widening their scope of clinical practice by offering LAT. Of note, this development has occurred at the same time as the recommendation of routine TUS use during pleural interventions.

Published data already exists to support the novel use of TUS to improve access to the pleural space and successful LAT.[3 4] However, these studies focused on patients where pleural fluid, although with shallow depth, remained visible at the site of planned intervention in the lateral decubitus position. Our series demonstrates that in experienced hands TUS can be successfully employed using the same principles in both this population and also patients with suspected pleural disease without any fluid. This latter group would previously have been referred

Table 1 Summary of demographic and clinical data for patients (n=77) undergoing ultrasound-guided pneumothorax induction prior to local anaesthetic thoracoscopy

Patient demographics	
Gender	
Male, n (%)	53 (68.8)
Female, n (%)	24 (31.2)
Age	
Years, mean (SD)	67.8 (12.4)
Side of procedure	
Right, n (%)	41 (53.2)
Left, n (%)	36 (46.8)
Procedural data	
Main clinical indication for LAT	
Pleural thickening or nodularity on CT, n (%)	48 (62.3)
Pleural effusion with known malignancy at distal site, n (%)	7 (9.1)
Unexplained cytology negative exudative effusion, n (%)	22 (28.6)
Intravenous analgo-sedation	
Midazolam, mg, mean (SD)	2.7 (1.2)
Fentanyl, mcg, mean (SD)	52.5 (44.6)
Presence of pleural fluid on TUS	
None visible throughout hemithorax, n (%)	22 (28.6)
None visible in AAL/MAL but seen elsewhere, n (%)	24 (31.2)
<3 cm depth visible in AAL/MAL, n (%)	31 (40.3)
Pneumothorax induction	
Successful, able to proceed to LAT, n (%)	67 (87.0)
Unsuccessful, unable to proceed to LAT, n (%)	10 (13.0)
Reported macroscopic appearance	
Definitely malignant, n (% of successful LAT)	18 (26.9)
Uncertain, n (% of successful LAT)	34 (50.7)
Definitely benign, n (% of successful LAT)	15 (22.4)
Postprocedural care	
Discharged same day, n (% of successful LAT)	47 (70.1)
Admitted to hospital, n (% of successful LAT)	20 (29.9)
Histology results	
Non-malignant disease	
TOTAL, n (% of successful LAT)	*40 (59.7)*
Chronic pleuritis/fibrosis, non-specific, n (% of successful LAT)	39 (58.2)
Pleural sarcoidosis, n (% of successful LAT)	1 (1.5)
Malignant disease	
TOTAL, n (% of successful LAT)	*22 (32.8)*
Mesothelioma, all subtypes, n (% of successful LAT)	11 (16.4)
Metastatic lung cancer, all subtypes, n (% of successful LAT)	6 (9.0)
Other metastatic cancer, all subtypes, n (% of successful LAT)	5 (7.5)
Biopsies not taken	
TOTAL, n (% of successful LAT)	*5 (7.5)*

All percentages expressed as fraction of total number of patients (77) unless otherwise specified.
AAL, anterior axillary line; MAL, mid axillary line; LAT, local anaesthetic thoracoscopy.

for surgical thoracoscopic biopsies under general anaesthetic, potentially precluding more frail patients from having a gold-standard diagnostic procedure as well as delaying case progression in centres without direct on-site access to thoracic surgical services. Furthermore, this surgical pathway incurs an additional burden for patients and healthcare providers (eg, increased financial cost and length of hospital stay) when compared with LAT.

The use of TUS to facilitate pneumothorax induction prior to LAT presents several advantages. Identifying the presence or absence of lung sliding allows a practitioner to both exclude significant pleural adhesions that might otherwise prevent the lung from collapsing and choose an appropriately safe site for Boutin needle insertion and subsequent blunt dissection. TUS-guided insertion of the Boutin needle as it is passed through the chest wall reduces the risk of injuring the underlying lung by allowing the clinician to identify when the parietal pleura is about to be breached. Finally, confirmation of successful pneumothorax formation can be achieved without resorting to traditional methods such as plain chest radiograph, through the real-time observation of loss of lung sliding on TUS. In the event of a failed pneumothorax induction, there remains the option of using TUS to facilitate cutting-needle pleural biopsies as an alternative diagnostic strategy.

As competence and experience in the use of TUS becomes widespread, it is probable that respiratory physicians with a subspecialty interest in pleural disease will be required to perform complex interventions including those requiring real-time TUS guidance on a more frequent basis. Although this is a single-centre study with limited numbers, our work shows that TUS-guided pneumothorax induction is feasible and also safe in the hands of experienced LAT practitioners using an in-plane TUS approach. None of our patients suffered an injury to the underlying lung or other complication directly related to Boutin needle introduction or pneumothorax formation.

In summary, physician-led TUS can enhance the delivery of an LAT service by safely facilitating pneumothorax induction in selected patients with suspected pleural disease but either minimal or no accompanying fluid, and who are deemed to have sufficient physiological reserve to undergo the procedure. This technique can reduce the number of patients referred for diagnostic procedures outside the respiratory department, thereby streamlining the care pathway for patient and clinician benefit. Future guidelines relating to LAT will need to take this approach into account and offer direction on training requirements alongside how, when and where it should be used.

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