

Chest ultrasound versus chest computed tomography for imaging assessment before medical thoracoscopy

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Background and objective The aim of this work was to assess the concordance between chest ultrasound (US) and chest computed tomography (CT) findings before medical thoracoscopy (MT) and the impact of the findings on the conduct and outcome of MT.

Materials and methods The study was conducted prospectively on 52 patients referred for MT. All patients received chest X-ray (CXR), chest US, and chest CT before the procedure. Images were evaluated and findings were correlated with thoroscopic findings.

Results US findings were discordant with CT findings regarding consistency, septation, and loculation of effusion in 24/52 patients, with US detecting the findings in 24/24 patients. None of these findings was detectable on CT. US was superior to CT in detection of diaphragmatic nodules (16/52, 3/52, respectively). US findings affected MT conduct in 20/52 cases and outcome in 5/40 cases, and they were consistent with MT findings in 39/40 cases; US and CT missed septation in one case. US findings were concordant with CT findings regarding site and size of effusion and pleural masses, sizable nodules, and thickening. US missed

discrete small parietal nodules in 10/52, consolidation in 2/52, mediastinal lymphadenopathy in 6/52, and mediastinal shift in 42/52 cases. CXR could identify mediastinal shift but none of other CT findings were missed by US. None of US-missed abnormalities directly altered MT management.

Conclusion US identifies more explicitly the imaging information relevant to MT compared with chest CT. Pre-MT imaging workup can be limited to CXR and US, reserving chest CT for cases in which US is technically unrevealing.

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Introduction

Chest imaging is required for assessment before medical thoracoscopy (MT). The imaging commonly used include chest X-ray (CXR), chest computed tomography (CT), and chest ultrasound (US) [1]. Chest US was found to be equally able to detect pleural fluid location when compared with chest CT and to be superior to chest CT in its ability to resolve the internal components of pleural fluid including fibrin strands [2–4].

This study was conducted to compare chest US and chest CT findings before MT and to assess the findings on MT outcome and whether US alone or with CXR is sufficient for imaging assessment before MT.

Materials and methods

The study was conducted prospectively between March 2012 and September 2012 at Abbasia Chest Hospital, Cairo, Egypt. All consecutive patients referred to the MT unit during this period for undiagnosed pleural exudates were enrolled in the study. No specific contraindications existed to the procedure. Informed consent was obtained from all patients. The study was

approved by the Research and Ethical Committee of the Chest Department, Faculty of Medicine, Ain Shams University in January 2012.

MT was performed by either one of three experienced chest physicians according to a preplanned weekly schedule. All MTs were performed in the endoscopy suite, with a rigid thoracoscope (Karl Storz, Germany) under local anesthesia and as necessary, intravenous analgo-sedation with midazolam and paracetamol, with appropriate monitoring. All patients received CXR, chest CT, and chest US before MT.

Chest computed tomographic scan

Chest CT was performed on a 4-MDCT scanner (Asteion; Toshiba, Japan). Images were obtained in the supine position from the level of the thoracic inlet to the diaphragm using a pitch of 1.0 and slice thickness of 5 mm. Image evaluation was performed in consensus by a certified radiologist and a pulmonologist. The interpreting radiologist was blinded to the results of the chest US. Images were examined for the presence of pleural effusion, fibrin strands, loculation, pleural nodules, masses, thickening, and underlying lung parenchyma. The time interval between requesting chest CT and the final interpretation was 2–3 days.

Chest ultrasound scan

Chest US scans were performed by a pulmonologist competent in chest ultrasonography. The chest abnormality was localized on the basis of CXR findings. US scanings were performed using a general imaging US machine (Samsung Medison Sono Ace R3 ultrasound system; Samsung company, Seoul, South Korea). Patients were scanned in the sitting or supine position along anterior, posterior, and midaxillary lines and in lateral decubitus position when initial scan identified thick septation and loculation to determine the best entry site. Images were obtained using an intercostal approach in transverse and longitudinal planes from the apex to the diaphragm. A 3.5 MHz curvilinear transducer was used for initial scanning followed by 5–7 MHz linear transducer for better resolution of the pleura. The time needed to complete US scanning was 15–20 min. Final interpretation and US report were available at the end of the study. The time interval between requesting US and acquisition of images was 30–60 min.

Medical thoracoscopic correlation

The chest CT and chest US findings were compared with the operative findings. Operators recorded need to change the planned site of entry, presence of thick adhesions, and complications. The procedure duration from skin incision to final suturing was recorded.

Results

Fifty-two consecutive patients referred for MT were enrolled, including 28 men and 24 women with mean age 56 years (range 23–84 years).

Concordant findings

US findings totally concurred with CT findings regarding site (right 28/52, left 23/52, and bilateral 1/52) and size of effusion, pleural masses (1/52), and pleural thickening with or without nodulation (17/52 cases). US identified lung consolidation with static air bronchogram in 5/52 cases compared with 7/52 on CT (i.e. 71.4% of CT-detected consolidations) (Table 1).

Computed tomographic findings missed by ultrasound

US missed discrete small parietal pleural nodules (<10 mm) in 10/52, lung consolidation in 2/52, mediastinal lymphadenopathy in 6/52, shift of mediastinum in 42/52, and non-pleural-based pulmonary nodules in 8/52 cases. CXR could identify mediastinal shift but none of the other CT findings missed by US.

Discordant findings

US findings were discordant with CT findings regarding consistency, septation, and loculation of the

Table 1 Comparison between chest ultrasonography and chest computed tomographic findings

Findings	CCT (n = 52)	CUS (n = 52)
Location		
Right	28	28
Left	23	23
Bilateral	1	1
Septation and loculation		
Thick	0	17
Thin	0	7
Parietal pleural thickening ± nodularity	17	17
Pleural nodules		
Diaphragmatic	3	16
Parietal (discrete, <10 mm)	10	0
Visceral	0	2
Pleural mass	1	1
Lung consolidation with static air bronchogram	7	5
Non-pleural-based pulmonary nodules	8	0
Mediastinal lymphadenopathy	6	0
Mediastinal shift to contralateral side	42	0

CCT, chest computed tomography; CUS, chest ultrasound.

effusion in 24/52 patients, with US detecting the above findings in 24/24 patients (thick fibrous septation with multiloculation in 17/24 and few fibrin strands in 7/24). None of these findings was detectable on CT (Fig. 1). US-detected diaphragmatic nodules in 16/52 cases compared with 3/52 cases on CT (i.e. 18.8% of US-detected diaphragmatic nodularity) and visceral nodules in 2/52 compared with 0/52 cases on CT.

Correlation with medical thoracoscopic findings

MT findings were consistent with the US findings of fibrous septation and with loculation in all cases reported on US scan. There was only one case where thick septation was found during MT and was missed on US. The case was morbid obesity with degraded US images. The findings were even undetectable on chest CT. Diaphragmatic and costal nodules were found on MT in all cases reported on US.

Impact of ultrasound findings on medical thoracoscopy

None of CT findings missed on US directly altered MT management. In contrast, US findings of thick fibrous septa prevented MT in 12/52 cases and led to prolongation of MT (from a range of 20–30 to 45–50 min) in 5/40 and to change in port of entry in 2/40 cases. The US findings of thick fibrous septa and loculation were associated with failure to achieve full lung expansion as proved by post-MT CT in 5/40 cases. In these cases, the fibrous septa could not be completely lysed during MT. Two other cases had incomplete lung

Fig. 1



Right massive malignant pleural effusion with fibrous septation and multiloculation in chest ultrasound (a), not identified in chest computed tomography (CT) (b), but evident in medical thoracoscopy (c, d). Chest X-ray (CXR) before the procedure showed same CT findings (e), CXR performed 2 days after the procedure showed trapped right lung with failure of full re-expansion (f).

expansion, despite absence of thick adhesions on MT. Failure of full lung expansion was attributed to thick visceral pleura as shown in post-MT CT. These findings were not detectable on pre-MT US or CT.

Discussion

MT can serve as an excellent diagnostic procedure in patients with undiagnosed pleural effusions. Imaging preassessment is routinely performed before MT. Although CXR is the standard primary imaging tool before MT, in many centers including ours, patients routinely undergo chest CT for better evaluation of pleural effusion, thoracic wall, and lung parenchyma. Chest CT is, however, associated with exposure to ionizing radiations and is rather costly, and there is often a considerable time lag between requesting the study and having the final interpretation. In addition, and of relevance to the procedure of MT, the CT images are ordinarily taken in the supine position, which is not the position acquired by the patient during the procedure of MT.

Sonography overcomes the shortcomings of CT. It uses no ionizing radiation, is fast and portable to

the point of care, and it can be performed while the patient is in the supine, sitting, and lateral decubitus positions. US has the capacity to clarify the nature of pleural effusions and underlying abnormalities [5]. The role of pre-MT US examination in defining the best port of entry and its accuracy in anticipating the presence of fibrous septation and loculation and in predicting pleural adhesions was addressed by several authors [6–10]. On the basis of that, we presumed that chest US would be sufficient as the imaging modality of choice before MT and thus CT can be omitted from pre-MT imaging workup.

In our study, chest US was as sensitive as CT in detecting location and size of effusion and pleural masses and thickening in all cases and lung consolidation in 71.4% of cases. Moreover, our study verified the superiority of US in identifying the imaging findings most relevant to the procedure of MT, namely fibrin strands and multiloculation (24/25 cases on US compared with 0/25 cases on CT). The findings reported on US were consistent with MT findings reported by the thoracoscopists. US missed fibrous septation and multiloculation in only one patient in whom the findings were detected only during MT. This false-negative result is attributed to morbid obesity that degraded the image quality. This finding was also missed on chest CT. The results concur with previously published reports [7–9,11,12].

The finding of thick fibrous adhesions and loculation has a strong impact on MT, either changing or modifying the plan of the operator. Virtually, the presence of fibrous adhesions may be the most important abnormality the thoracoscopist seeks imaging assessment for. US has proved to be the best imaging modality to clarify this abnormality. In our study, the presence of thick adhesions deferred or prevented MT in 12/52 patients and led to prolongation of the procedure by an average of 20 min in 5/40 of cases who underwent MT. Most of the time was consumed in lysing adhesions and improving the operative field. Prolongation of MT has the drawback of more pain and suffering of patients when the procedure is performed under local anesthesia and conscious sedation, as the case was in our study. Furthermore, thick adhesions may result in failure of post-MT full lung expansion. In our study, five cases were left with trapped lungs after the procedure due to thick fibrous adhesions, a complication that could have been anticipated with US but not with chest CT. It is noteworthy that two cases with post-MT failure of full lung expansion did not show fibrous adhesions in pre-MT US or CT. The two events were attributed to heavily thickened

visceral pleura, findings seen in post-MT CT but not in pre-MT US or CT.

US findings of thick fibrous adhesions before MT are also likely to alter the decision about pleurodesis [13]. This impact of US was not investigated in the present study, as pleurodesis is not ordinarily performed during MT in our department.

Similar to what was reported by others [8,14], US was superior to CT in detecting diaphragmatic pleural nodules with CT in our study showing only 18.8% of diaphragmatic nodules detected on US. The findings were verified during MT. Together with clarification of the distribution of adhesions and loculations, these findings are the one most likely to influence the thoracoscopist's plan of entry and the conduct of MT. In our study, US findings resulted in a change in the planned site of entry in two of five cases in whom MT was performed, despite the identification of thick fibrous septa.

Compared with CT, chest US was not able to detect some abnormalities such as tiny parietal pleural nodules, non-pleural-based pulmonary nodules, mediastinal lymphadenopathy, and mediastinal shift. CT findings missed by US in our study, however, did not affect the procedure conduct and outcome.

Combining CXR findings with US findings added little information, namely mediastinal shift, albeit we believe that CXR should remain an integral part of the standard pre-MT imaging as it provides an overview that may not be fulfilled with US.

In our study, US was performed by a pulmonologist competent in chest sonography. The reported findings correlated well with MT findings. All positive findings of interest such as distribution of loculations, extent of septations, and pleural thickening and nodulation were detected on MT as had been depicted on US. There were, however, three relevant false-negative results as US missed thick septation in a morbidly obese patient with degraded US images and diffusely thickened visceral pleura in two cases with failure of full lung expansion after MT. Performing pre-MT US by a pulmonologist, preferably the operator, is likely to save time and to avoid the conflict that may arise from different interpretations. The technique of pleural US can be easily learned by the pulmonologist.

Conclusion

Chest US identifies more explicitly the imaging information relevant to MT as compared with chest CT. Imaging workup before MT can be limited to CXR and US, reserving chest CT for cases in which US is technically unrevealing. The omission of CT scanning from routine pre-MT imaging assessment will reduce costs and potential risk for exposure to radiation.

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Conflicts of interest

There are no conflicts of interest.

References

- 1 Rahman NM, Ali NJ, Brown G, Chapman SJ, Davies RJ, Downer NJ, *et al*. Local anaesthetic thoracoscopy: British Thoracic Society Pleural Disease Guideline 2010. *Thorax* 2010; **65**:ii54–ii60.
- 2 Kim OH, Kim WS, Kim MJ, Jung JY, Suh JH. US in the diagnosis of pediatric chest diseases. *RadioGraphics* 2000; **20**:653–671.
- 3 Beckh S, Bölskei PL, Lessnau KD. Real-time chest ultrasonography: a comprehensive review for the pulmonologist. *Chest* 2002; **122**:1759–1773.
- 4 Rocco M, Carbone I, Morelli A, Bertoletti L, Rossi S, Vitale M, *et al*. Diagnostic accuracy of bedside ultrasonography in the ICU: feasibility of detecting pulmonary effusion and lung contusion in patients on respiratory support after severe blunt thoracic trauma. *Acta Anaesthesiol Scand* 2008; **52**:776–784.
- 5 Balik M, Plasil P, Waldauf P, Pazout J, Fric M, Otahal M, Pachtl J. Ultrasound estimation of volume of pleural fluid in mechanically ventilated patients. *Intensive Care Med* 2006; **32**:318–321.
- 6 Hersh CP, Feller-Kopman D, Wahidi M, Garland R, Herth F, Ernst A. Ultrasound guidance for medical thoracoscopy: a novel approach. *Respiration* 2003; **70**:299–301.
- 7 Medford AR, Agrawal S, Bennett JA, Free CM, Entwisle JJ. Thoracic ultrasound prior to medical thoracoscopy improves pleural access and predicts fibrous septation. *Respirology* 2010; **15**:804–808.
- 8 Kurian J, Levin TL, Han BK, Taragin BH, Weinstein S. Comparison of ultrasound and ct in the evaluation of pneumonia complicated by parapneumonic effusion in children. *Am J Roentgenol* 2009; **193**:1648–1654.
- 9 Jeong JY, Park HJ, Shin JS, Jo WM, Lee IS. Ultrasound for detecting pleural adhesion before video-assisted thoracic surgery. *Korean J Thorac Cardiovasc Surg* 2010; **43**:399–403.
- 10 Cassanelli N, Caroli G, Dolci G, Dell'Amore A, Luciano G, Bini A, Stella F. Accuracy of transthoracic ultrasound for the detection of pleural adhesions. *Eur J Cardiothorac Surg* 2012; **42**:813–818.
- 11 Mason A, Miller B, Krasna M, White CS. Accuracy of CT for the detection of pleural adhesions: correlation with video-assisted thoracoscopic surgery. *Chest* 1999; **115**:423–427.
- 12 Calder A, Owens CM. Imaging of parapneumonic pleural effusions and empyema in children. *Pediatr Radiol* 2009; **39**:527–537.
- 13 Medford AR, Entwisle JJ. Indications for thoracic ultrasound in chest medicine: an observational study. *Postgrad Med J* 2010; **86**:8–11.
- 14 Qureshi NR, Rahman NM, Gleeson FV. Thoracic ultrasound in the diagnosis of malignant pleural effusion. *Thorax* 2009; **64**:139–143.