


Lung sonography can improve the specificity of determination of left-sided double-lumen tracheal tube position in both novices and experts: a randomised prospective study

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Abstract

Objective: Lung sonography can be helpful to determine the position of a left-sided double-lumen tube (DLT). However, clinical experience is required for correct assessment. We investigated whether lung sonography can improve the diagnostic efficacy of determining the DLT position in novices and experts.

Methods: In this randomised prospective clinical study, 88 patients were allocated to two groups using auscultation or lung sonography for initial assessment of the DLT position. In each group, two repeated assessments were performed; the first was performed by a novice, and the second was performed by an expert. The final DLT position was confirmed by fibre-optic bronchoscopy. The primary outcome was the diagnostic efficacy (including overall accuracy, sensitivity, and specificity) in confirming the DLT position.

Results: In both the novices and experts, the specificity of determining the DLT position was significantly higher with lung sonography than auscultation (60.0% vs. 21.7% and 66.7% vs. 37.5%, respectively). Additionally, the predictability of an incorrect position was similar between the

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novices and experts using lung sonography (area under the curve of 0.665 and 0.690, respectively).

Conclusions: Lung sonography can improve the diagnostic efficacy of detecting an incorrect DLT position in both novices and experts.

Keywords

Auscultation, double-lumen tube, lung sonography, one-lung ventilation, novice, expert

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Introduction

A double-lumen tube (DLT), mainly a left-sided DLT (LDLT), is commonly used for lung isolation in one-lung ventilation during thoracic surgery. The endobronchial cuff should be located at an appropriate position to achieve effective lung separation.¹ Rapid and accurate confirmation of the DLT position is required to decrease the risk of hypoxia and airway trauma.² Fiberoptic bronchoscopy (FOB) is widely used to confirm the optimal position of the tube. However, FOB may not be possible in some clinical situations because of lack of a FOB device,^{3,4} and performance of FOB usually requires a highly trained expert with specific knowledge and clinical skills.

The findings of chest auscultation are subjective and have not been well validated for accurate identification of an incorrect DLT position.⁵ In comparison, lung sonography is a noninvasive technique that can be used to effectively check the status of the endotracheal tube even under disturbing and emergent situations.⁶ Even in thoracic surgery, lung sonography can be a superior method for determining the DLT position.⁷ However, this technique requires clinical experience, and its efficacy may thus differ between novice and expert investigators. We compared the diagnostic efficacy of lung sonography between novices and experts for verifying appropriate insertion of an LDLT.

Methods

Patients

This study comprised 90 adults aged ≥ 19 years who were scheduled to undergo thoracic surgery with one-lung ventilation and had an American Society of Anesthesiologists physical status classification of 1 to 3. The exclusion criteria were a body mass index of < 18.5 or > 35.0 kg/m², significant thoracic cage deformity due to spinal disease or other medical conditions, a history of tracheostomy, predicted airway difficulty requiring strategies other than direct or video laryngoscopy, a history of any type of pulmonary resection or pleurodesis, a history of pleural disease such as pleural effusion or tuberculous pleurisy, and the use of a right-sided DLT. This study was approved by the Institutional Review Board of Kyung Hee University Hospital at Gangdong (IRB#: KHNMC 2017-03-017-001), and written informed consent was obtained from all patients participating in the trial. The trial was registered prior to patient enrolment at the national clinical research registry (<http://cris.nih.go.kr>, KCT0002858).

Allocation and randomisation

The enrolled patients were randomly assigned according to their initial assessment technique (chest auscultation or lung

sonography). In both groups, the position of the DLT was initially identified by the corresponding technique. A computer-generated, random four- and six-block technique was used for randomisation of patients. An independent third party kept the random assignment table for 90 patients before surgery and notified the research team of the patient allocation on the day of the surgery.

Procedures

On arrival in the operating room, standard monitoring of the patients' electrocardiogram, peripheral oxygen saturation, end-tidal carbon dioxide concentration, bispectral index, and non-invasive blood pressure was begun. After preoxygenation with 100% oxygen for 5 minutes, anaesthesia was induced with target-controlled infusion of propofol (Schnider model; effect-site concentration, 4.0 µg/mL) and remifentanyl (Minto model; effect-site concentration, 4.0 ng/mL). Rocuronium bromide was administered to facilitate tracheal intubation. The patients were intubated with an LDLT (37 Fr for men and 35 Fr for women) using video laryngoscopy. Following passage of the endobronchial cuff through the vocal cords, the DLT was rotated 90 degrees counterclockwise and gently advanced for 28 to 30 cm according to the anaesthesiologist's decision and with consideration of the patient's height. Following intubation, both the tracheal and bronchial cuffs were inflated, and the initial depth of insertion was recorded. Tracheal intubation was confirmed by the presence of an appropriate end-tidal carbon dioxide curve in both groups.

Using lung sonography to assess the LDLT position, the patients were examined for the presence of the sliding sign without lung pulse on both sides of the chest while scanning for pleural movement in the craniocaudal direction from the anterior mid-clavicular line to the 12th rib. The tracheal

lumen was then clamped, and the examination was repeated bilaterally for the entire chest. Correct placement of the LDLT was confirmed by observation of the sliding sign detected in the whole chest area before and after clamping the tracheal lumen followed by emergence of the right lung pulse sign with loss of the sliding sign, whereas the sliding sign in the left lung was continuously observed with the absence of the lung pulse sign.

Assessment of the LDLT position using chest auscultation was made in the following conventional manner. First, the upper and lower chest sounds were auscultated bilaterally without lumen clamping. Second, auscultation was repeated after clamping the tracheal lumen. Finally, the upper and lower chest sounds of the left lung were auscultated. Correct placement of the LDLT was ensured by the presence of bilateral symmetric lung sounds before tracheal lumen clamping with a subsequent decrease in the entire right lung sound with accompanying symmetric lung sounds in the upper and lower left lung after clamping the tracheal lumen.

Whether using lung sonography or auscultation, two independent anaesthesiologists confirmed the placement and appropriate depth of the LDLT. One was a novice trainee who had been recently educated and had experience with fewer than 15 cases of lung sonography despite familiarity with auscultation. The other was an expert staff member who had experience in more than 200 cases of lung sonography and was also familiar with chest auscultation. In each case, the novice trainee performed the first assessment and the expert staff member performed the second assessment. Because each investigator recorded their result on a separate sheet and left the room immediately, each assessment result was blinded. For final confirmation of the LDLT position, FOB was performed by another blinded expert staff member who did not participate in any of the previous

procedures. A correct LDLT position was defined as follows: (1) through the tracheal lumen, the bronchial cuff was located below the carina and just slightly visible in the main left bronchus, or (2) through the bronchial lumen, the tip of the bronchial tube was located above the second carina. An incorrect LDLT position was defined as follows: (1) through the tracheal lumen, the right bronchus was visible after deflating the bronchial cuff or was covered >50% by the bronchial cuff (too shallow); (2) through the tracheal lumen, the bronchial cuff was entirely invisible (too deep); (3) through the bronchial lumen, the tip of the bronchial tube was below the second carina (too deep); or (4) the LDLT intubation procedure was abnormal (oesophageal intubation or right bronchial intubation).

Outcome measurement

The following contingency table was used to assess the diagnostic efficacy of auscultation or lung sonography in confirming the position of the LDLT.

		Auscultation or lung sonography	
		Correct	Incorrect
FOB	Correct	A	B
	Incorrect	C	D

Accuracy was calculated as follows:

$$\text{Accuracy (\%)} = (A + D) / (A + B + C + D) \times 100$$

Sensitivity was calculated as follows:

$$\text{Sensitivity (\%)} = A / (A + B) \times 100$$

Specificity was calculated as follows:

$$\text{Specificity (\%)} = D / (C + D) \times 100$$

The primary outcome was the diagnostic efficacy (including the accuracy, sensitivity, and specificity) in confirming the position of the LDLT and matching the observation of FOB by both the novices and experts.

The secondary endpoints in this study were the assessment time, total intubation attempts, abnormal LDLT position, tracheal or bronchial cuff injury, and bronchial cuff leakage following a position change. The assessment time was defined as the total time from the end of intubation to completion of the first assessment by each anaesthetist. Abnormal LDLT intubation included right bronchial intubation (loss of left sliding sign after tracheal lumen clamping in lung sonography or only right chest sound in auscultation) and oesophageal intubation (absence of both the sliding sign in lung sonography or no chest sound with gastric air sound in auscultation). When oesophageal intubation or right bronchial intubation was confirmed, the patient was immediately re-intubated. The patient was assessed for cuff injury when the ventilatory volume leaked continuously and when spontaneous tracheal or bronchial cuff deflation occurred. When tracheal or bronchial cuff injury was suspected, the LDLT was immediately changed using a tube exchanger or video laryngoscope. The patient was assessed for bronchial cuff leakage following a position change when the ventilatory volume leakage rate was ≥ 200 mL/min. When cuff leakage was suspected, the cuff was deflated and the LDLT was repositioned using FOB. Intubation-related complications, including postoperative sore throat and hoarseness, were assessed in the postoperative anaesthesia care unit. After having fully recovered, the patients were interviewed regarding whether symptoms of sore throat and hoarseness were present or absent in the postoperative anaesthesia care unit. Sore throat was scored using a 10-cm visual analogue scale.

Sample size calculation and statistical analyses

Based on a previous study,⁶ we calculated that 41 patients were required per group for this experimental design. Considering the

possibility of 10% loss due to unexpected circumstances, we elected to recruit 45 patients per group into the study. Demographics and intubation-related data were compared using intention-to-treat analysis. Diagnostic efficacy, including the accuracy, sensitivity, and specificity, were calculated by per-protocol analysis because the real number of analysed patients can affect the outcome values. Continuous data were analysed by Student's t-test or the Mann-Whitney U test depending on the presence of normality. Categorical data were analysed using chi-square analysis or Fisher's exact test when applicable. In the receiver operating characteristic curve analysis, the area under the curve (AUC) was used to assess the predictability of an incorrect LDLT position. Statistical analyses were performed using a standard statistical program (IBM SPSS Statistics for Windows, Version 21.0; IBM Corp., Armonk, NY, USA). All values are expressed as mean \pm standard deviation, median (quartile), or number (percent).

Results

Ninety patients were enrolled, and 88 patients were allocated because 2 patients refused participation after the surgery. However, in the novice group using chest auscultation for the initial assessment, two patients were missed because of the busy operating schedule. Additionally, in the novice group using lung ultrasonography, two patients were not evaluated because the ultrasound device was temporarily unavailable. Finally, 43 and 41 patients were assessed by novices using auscultation and lung ultrasonography, respectively, and 45 and 43 patients were assessed by experts using auscultation and lung ultrasonography, respectively (Figure 1). The patients' demographic data, secondary outcomes, and intubation-related complications are shown in Table 1. With the exception of the assessment time, there were no significant differences between the patients using chest auscultation and lung sonography.

A contingency table between novices and experts using lung sonography or

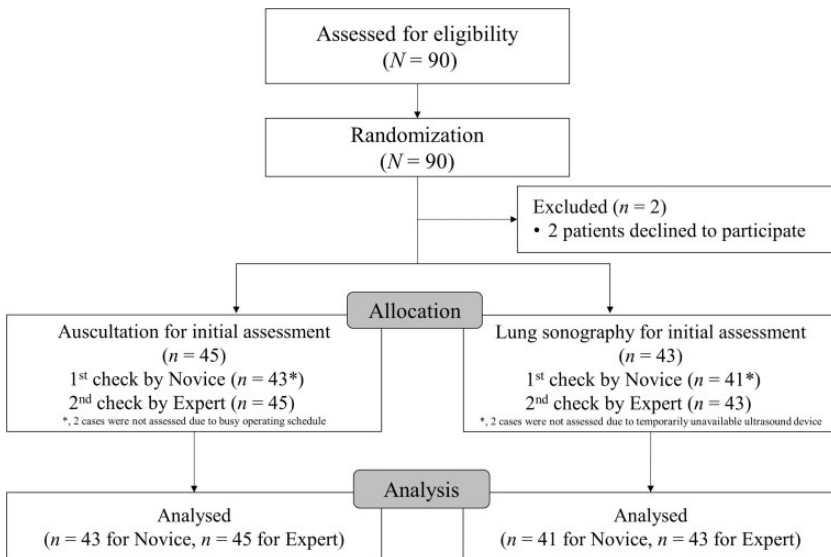


Figure 1. CONSORT flow chart.

Table 1. Demographics and postoperative outcomes.

Variables	Using auscultation (n = 45)	Using lung sonography (n = 43)	P
Age, years	62 [55–70]	66 [60–75]	0.102
Sex, male/female	17 (38) / 28 (62)	19 (44) / 24 (56)	0.543
Body mass index, kg/m ²	23.6 [21.4–25.6]	23.0 [22.1–25.4]	0.884
Intubation-related data			
Total intubation attempts	1 [1–1]	1 [1–2]	0.311
Abnormal left double-lumen tube position			
<i>Oesophageal intubation</i>	4 (8.9)	1 (2.2)	0.186
<i>Right bronchial intubation</i>	1 (2.2)	1 (2.2)	0.974
<i>Too deep intubation</i>	10 (22)	6 (14)	0.318
<i>Too shallow intubation</i>	8 (18)	7 (16)	0.853
Tracheal or bronchial cuff injury	1 (2.2)	0 (0)	0.328
Bronchial cuff leakage after position change	4 (8.9)	3 (7.0)	0.742
Assessment time, seconds*			
<i>Assessment by novice</i>	47 [40–55]	110 [80–161]	<0.0001
<i>Assessment by expert</i>	43 [36–52]	104 [80–125]	<0.0001
<i>Confirmed by fibre-optic bronchoscopy</i>	74 [54–127]	117 [69–180]	0.027
Initial left double-lumen tube depth, cm	29.0 [27.5–29.0]	29.0 [28.0–29.0]	0.972
Final left double-lumen tube depth, cm	29.0 [28.0–30.0]	28.5 [27.3–29.4]	0.508
Intubation-related complications at postoperative care unit			
<i>Sore throat incidence</i>	23 (51)	20 (47)	0.668
<i>Sore throat score†</i>	2.6 [0.9–5.1]	2.0 [0.0–4.0]	0.200
<i>Hoarseness incidence</i>	5 (11)	10 (23)	0.132

Data are expressed as median [interquartile range] or number (%).

*Assessment time indicates the time from the end of intubation to completion of the first assessment by each anaesthesiologist.

†Sore throat score was measured using a 10-cm visual analogue scale.

auscultation is shown in Table 2. Changes in the diagnostic efficacy parameters (overall accuracy, sensitivity, and specificity) in the novices and experts using chest auscultation or lung sonography are shown in Figure 2. Compared with auscultation, lung sonography significantly increased the specificity of determining the LDLT position from 21.7% to 60.0% in the novice group ($P=0.003$) and from 37.5% to 66.7% in the expert group ($P=0.006$). The sensitivity decreased after using lung sonography in both the novice and expert groups. The overall accuracy was slightly improved after using lung sonography in the novice group, but the difference was not statistically significant.

In the receiver operating characteristic curve analysis for predicting an incorrect LDLT position by lung sonography, the AUC was not significantly different between the novices and experts (0.665 and 0.690, respectively). For the prediction of an incorrect LDLT position using auscultation, experts showed an AUC of 0.664 ($P=0.044$) but novices showed an AUC of 0.559.

Discussion

In both novices and experts of the present study, the specificity of lung sonography for detecting an incorrect LDLT position was higher than that of chest auscultation.

Table 2. Contingency table between auscultation or lung sonography and fibre-optic bronchoscopy to assess left-sided double-lumen tube position in novices and experts.

	Using auscultation		Using lung sonography	
	Correct	Incorrect	Correct	Incorrect
Novice*				
Fibre-optic bronchoscopy				
Correct	18	2	19	7
Incorrect	18	5	6	9
Expert				
Fibre-optic bronchoscopy				
Correct	20	1	20	8
Incorrect	15	9	5	10

*In novices using auscultation, two patients were missed because of a busy operating schedule. In novices using lung sonography, two patients were not evaluated because the ultrasound device was temporarily unavailable.

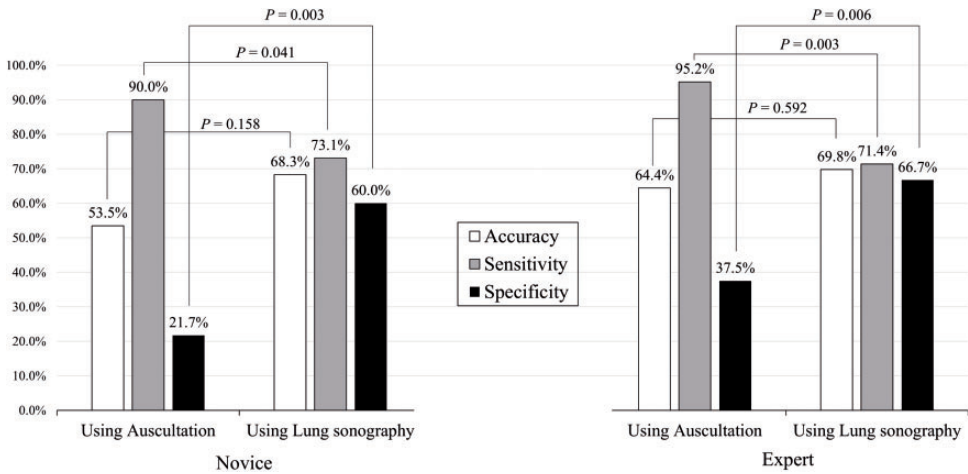


Figure 2. Comparison of accuracy, sensitivity, and specificity between patients using auscultation and lung sonography for initial double-lumen tube position assessment. *Left:* results of novices. *Right:* results of experts.

Moreover, by using lung sonography, novices showed diagnostic efficacy similar to that of experts.

The overall accuracy in our results was similar between novices and experts regardless of the use of auscultation or lung sonography. However, the sensitivity and specificity showed different clinical significance. The sensitivity refers to the degree to which a correct finding on auscultation

or lung sonography indicates the true correct DLT position in FOB, and the specificity refers to the degree to which an incorrect finding indicates a true incorrect position in FOB. Because an incorrect DLT position may cause intraoperative hypoxia or increased airway pressure, it is crucial to detect an incorrect position of the DLT in lung isolation techniques.² Clinically, When using a DLT, it is more important to

confirm an incorrect than position because an incorrect position of the DLT may cause more serious problems than a correct position.² Our study revealed two main implications of lung sonography using in an LDLT for intubation. First, it increased the specificity for determining an incorrect LDLT position in both novices and experts; that is, an incorrect finding was significantly more highly correlated with a true incorrect position of the LDLT in lung sonography than in auscultation, thereby helping to avoiding lung injury or hypoxia. Second, novices with less experience may perform lung sonography and produce results similar to those of experts. Using lung sonography, the overall accuracy was 68.3% in the novice group and 69.8% in the expert group, whereas these rates using auscultation were 53.5% and 64.4%, respectively. Despite the lack of statistical significance, this may suggest that even for novices with less clinical experience, lung sonography is beneficial for detection of an incorrect LDLT position. Furthermore, lung sonography can provide investigators with additional information such as the presence of lung consolidations, pneumothorax, and atelectasis.^{6,8}

Interestingly, in both novices and experts, the sensitivity of detecting the DLT position decreased when using lung sonography in contrast to a remarkable increase in specificity. The presence of pleural movement, which is critical to determine the correct location of the DLT in lung sonography, may not be clearly identified when the ultrasound probe is not appropriately applied or the tidal volume is insufficient. Such conditions of small or obscure pleural movement may be related to the decreased sensitivity of lung sonography. However, lung sonography increased the specificity of detecting the DLT position because direct visualisation of the pleural movement can be independent. In contrast, using auscultation, the sound from another

lung field can affect the assessment of an incorrect position and contribute to lower specificity.

Both lung sonography and auscultation have advantages and disadvantages in assessment of the DLT position. Auscultation is easy and quickly accessible, but evaluation can be subjective because it is based on the investigator's findings.^{5,9,10} Lung sonography can provide visible, objective results of pleural movement with less inter-observer variance^{11,12}; it can also be useful in paediatric patients who show more ambiguous findings in auscultation.¹³ However, as shown in the present study, lung sonography can require a longer time for assessment and be affected by various clinical conditions such as a small tidal volume and pleural adhesion. Furthermore, lung sonography may have a risk of device unavailability, and well-trained experts are required for its performance. Even in obese patients, ultrasonography with the sliding sign showed higher accuracy than auscultation in confirming tracheal intubation.¹⁴ In the present study, the difference in specificity between novices and experts was smaller when using lung sonography than when using chest auscultation. These findings also support the notion that even novices may easily use lung sonography and achieve relatively accurate results. Although not a main focus of our study, we also found that the diagnostic efficacy of lung sonography in the expert group increased after we excluded patients with undiagnosed pleural effusion (overall accuracy of 81.8%, sensitivity of 89.5%, and specificity of 71.4%). This implies that lung sonography can achieve more reliable results in both well-trained experts and novices.

Although lung sonography showed higher specificity than auscultation for detecting an incorrect DLT position, evidence that lung sonography can replace FOB is still lacking. Compared with lung sonography, which is an indirect technique

using pleural movement in a ventilating lung, FOB can be used to directly visualise the tube and anatomical structures; thus, it remains the gold standard for confirmation of the DLT position. We also used lung sonography or auscultation for the initial assessment of the LDLT position and confirmed the findings by FOB. Moreover, despite the usefulness of lung sonography, several previous studies have shown that the diagnostic efficacy of lung sonography in determining the LDLT position can be variable (accuracy of 70% or 84%–89%, sensitivity of 88% or 94%, and specificity of 75% or 56%).^{6,7,15} These variable results of diagnostic efficacy with lung sonography may imply that despite providing useful and accurate information in lung isolation techniques, the findings of lung sonography may be affected by various factors such as the investigator's skill, the device used, or the patient's condition.

Our study has several limitations. First, we did not perform pre-assessment using lung sonography to exclude patients with a negative lung sliding sign before the initial assessment. Pre-assessment using lung sonography may exclude patients with undiagnosed pleural adhesion before surgery, thereby increasing overall accuracy or sensitivity. Although less powered because of our population size, our data also showed that experts produced results superior to those of novices after excluding patients with undiagnosed pleural adhesion. A further study with a larger sample size and with highly selected patients using pre-assessment would likely produce higher diagnostic efficacy of lung sonography than that in the present study. Second, there might have been a risk of some contamination of the results by the self-training of novice trainees by repeated lung sonography. In the present study, eight novice trainees participated in turns during the entire study period, and they performed five to six cases of lung

sonography each. Although we considered that only five to six cases would be insufficient for full training of novices in lung sonography, the contamination effect may still be present. Third, as we discussed above, FOB remains the gold standard for confirming the DLT position whenever available. Lung sonography can be useful for the initial assessment, but not as a confirmative technique. Therefore, we finally used FOB to confirm the LDLT position. Fourth, extrapolation of our results is limited to patients undergoing one-lung ventilation with an LDLT. Anatomically, the right main bronchus has a side branch to the right upper lobe, and the hole for right upper lobe ventilation should be aligned to ensure the correct right-sided DLT position. Thus, special consideration is required for right-sided DLT positioning.

In conclusion, lung sonography can be helpful in determining an incorrect LDLT position in both novices and experts. Furthermore, lung sonography can help novices to obtain results similar to those of experts in the assessment of an incorrect LDLT position.

Data availability

The pre-print version of the study is present at <https://www.researchsquare.com/article/rs-7181/v1>.

Declaration of conflicting interests

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References

1. Brodsky JB and Lemmens HJ. Left double-lumen tubes: clinical experience with 1,170 patients. *J Cardiothorac Vasc Anesth* 2003; 17: 289–298. DOI: 10.1016/s1053-0770(03)00046-6.
2. Purohit A, Bhargava S, Mangal V, et al. Lung isolation, one-lung ventilation and hypoxaemia during lung isolation. *Indian J Anaesth* 2015; 59: 606–617. DOI: 10.4103/0019-5049.165855.
3. Bahk JH, Lim YJ and Kim CS. Positioning of a double-lumen endobronchial tube without the aid of any instruments: an implication for emergency management. *J Trauma* 2000; 49: 899–902. DOI: 10.1097/00005373-200011000-00018.
4. De Bellis M, Accardo R, Di Maio M, et al. Is flexible bronchoscopy necessary to confirm the position of double-lumen tubes before thoracic surgery? *Eur J Cardiothorac Surg* 2011; 40: 912–916. DOI: 10.1016/j.ejcts.2011.01.070.
5. Alliaume B, Coddens J and Deloof T. Reliability of auscultation in positioning of double-lumen endobronchial tubes. *Can J Anaesth* 1992; 39: 687–690. DOI: 10.1007/BF03008231.
6. Parab SY, Divatia JV and Chogle A. A prospective comparative study to evaluate the utility of lung ultrasonography to improve the accuracy of traditional clinical methods to confirm position of left sided double lumen tube in elective thoracic surgeries. *Indian J Anaesth* 2015; 59: 476–481. DOI: 10.4103/0019-5049.162983.
7. Parab SY, Kumar P, Divatia JV, et al. A prospective randomised controlled double-blind study comparing auscultation and lung ultrasonography in the assessment of double lumen tube position in elective thoracic surgeries involving one lung ventilation at a tertiary care cancer institute. *Korean J Anesthesiol* 2019; 72: 24–31. DOI: 10.4097/kja.d.17.00081.
8. Sustic A, Protic A, Cicvaric T, et al. The addition of a brief ultrasound examination to clinical assessment increases the ability to confirm placement of double-lumen endotracheal tubes. *J Clin Anesth* 2010; 22: 246–249. DOI: 10.1016/j.jclinane.2009.07.010.
9. Sitzwohl C, Langheinrich A, Schober A, et al. Endobronchial intubation detected by insertion depth of endotracheal tube, bilateral auscultation, or observation of chest movements: randomised trial. *BMJ* 2010; 341: c5943. DOI: 10.1136/bmj.c5943.
10. Smith GB, Hirsch NP and Ehrenwerth J. Placement of double-lumen endobronchial tubes. Correlation between clinical impressions and bronchoscopic findings. *Br J Anaesth* 1986; 58: 1317–1320. DOI: 10.1093/bja/58.11.1317.
11. Ramsingh D, Frank E, Haughton R, et al. Auscultation versus point-of-care ultrasound to determine endotracheal versus bronchial intubation: a diagnostic accuracy study. *Anesthesiology* 2016; 124: 1012–1020. DOI: 10.1097/ALN.0000000000001073.
12. Werner SL, Smith CE, Goldstein JR, et al. Pilot study to evaluate the accuracy of ultrasonography in confirming endotracheal tube placement. *Ann Emerg Med* 2007; 49: 75–80. DOI: 10.1016/j.annemergmed.2006.07.004.
13. Nam JS, Park I, Seo H, et al. The use of lung ultrasonography to confirm lung isolation in an infant who underwent emergent video-assisted thoracoscopic surgery: a case report. *Korean J Anesthesiol* 2015; 68: 411–414. DOI: 10.4097/kjae.2015.68.4.411.
14. Rajan S, Surendran J, Paul J, et al. Rapidity and efficacy of ultrasonographic sliding lung sign and auscultation in confirming endotracheal intubation in overweight and obese patients. *Indian J Anaesth* 2017; 61: 230–234. DOI: 10.4103/0019-5049.202164.
15. Hu WC, Xu L, Zhang Q, et al. Point-of-care ultrasound versus auscultation in determining the position of double-lumen tube. *Medicine (Baltimore)* 2018; 97: e9311. DOI: 10.1097/MD.00000000000009311.