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The Effects of the Position Changes of Critical Care Patients on Respiratory and Cardiac Parameters

Yoğun Bakım Hastalarının Pozisyon Değişikliklerinin Solunum ve Kardiyak Parametreler Üzerindeki Etkileri

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ABSTRACT *Objective:* Position changes in patients requiring critical care aimed to mobilise secretions, prevent compression wounds and decrease the risk of ventilator-related pneumonia. This study aimed to investigate the effects of supine, left lateral, right lateral and Fowler positions on the respiratory and cardiac parameters with the CO_2 rebreathing technique using non-invasive cardiac output monitor.

Materials and Methods: Forty patients aged 18-65 years who were on invasive mechanical ventilator support and had a hospitalisation time >24 h were included in the study. Cardiac output was monitored with non-invasive cardiac output monitor. Patients were assisted on supine, left lateral, right lateral and Fowler positions. Respiratory and hemodynamic parameters of patients were measured at these positions with 1-h intervals.

Results: A significant difference was found among the measurements when the mean arterial pressure values measured at different times at the left lateral position were compared. Similarly, a significant difference was noted among SpO_2 values measured at the supine position at different times. However, this difference was not clinically significant. No significant differences were found within the groups as regards to other respiratory and cardiac parameters.

Conclusion: Position changes did not lead to a clinically significant change on respiratory mechanics, hemodynamic parameters and oxygenation in patients with stable hemodynamic who were on mechanical ventilator support.

Keywords: Critical care, patient position, cardiac output, hemodynamic monitoring, airway resistance

ÖZ *Amaç:* Yoğun bakım hastalarında pozisyon değişiklikleri ile sekresyonların hava yolunda mobilizasyonu, basınç ülserlerinin önlenmesi ve ventilatör ilişkili pnömoni riskinin azaltılması hedeflenmektedir. Sırtüstü (supin), sol lateral, sağ lateral ve Fowler pozisyonlarının solunum ve kardiyak parametreler üzerine etkilerini CO_2 yeniden soluma tekniği kullanan non-invaziv kardiyak debi (output) monitörü ile araştırmayı amaçladık.

Gereç ve Yöntem: Çalışmaya 24 saatten uzun süredir yoğun bakımda takip edilen, invaziv mekanik ventilatör desteği altındaki 18-65 yaş arası 40 hasta dahil edildi. Hastaların sırasıyla sırtüstü, sol yan, sağ yan ve Fowler pozisyonunda non-invaziv kardiyak debi monitörü ile kalp debisi izlendi. Hastaların solunum ve hemodinamik parametreleri bu pozisyonlarda bir saatlik aralıklarla ölçüldü.

Bulgular: Sol lateral pozisyonda farklı zamanlarda ölçülen ortalama arter basıncı değerleri karşılaştırıldığında ölçümler arasında anlamlı fark bulundu. Sırtüstü pozisyonlarda farklı zamanlarda ölçülen SpO_2 değerleri arasında önemli bir fark vardı. Ancak bu fark klinik olarak anlamlı değildi. Farklı zamanlarda ölçülen diğer solunum ve kalp parametreleri açısından gruplar arasında anlamlı farklılık bulunmadı.

Sonuç: Hemodinamisi stabil olan mekanik ventilatör desteği altındaki hastalarda pozisyon değişikliklerinin solunum mekanikleri, hemodinamik parametreler ve oksijenasyonda klinik olarak anlamlı bir değişikliğe yol açmadığını gördük.

Anahtar Kelimeler: Yoğun bakım, hasta pozisyonu, kardiyak debi, hemodinamik monitörizasyon, hava yolu direnci

Introduction

Critical care patients are given different positions during the hospitalization due to several reasons including prevention of the compression wound, avoiding infections, clearing the respiratory tract secretions, increasing oxygenation, and improving blood circulation. Respiratory and hemodynamic changes may be seen during position changes (1,2).

Sustainable oxygen delivery is essential in order to maintain metabolism and vital functions in the organism. Oxygen delivery is determined by cardiac output (CO) and the changes in the oxygen content (3). Although thermodilution technique using pulmonary artery catheter is the gold standard for CO monitorization, there has been an increasing tendency to use alternative and non-invasive methods, because thermodilution is an invasive and difficult technique which measures with intervals and may cause severe complications during insertion of the catheter (4).

Non-invasive Cardiac Output (NICO) technique has been recommended as an alternative non-invasive CO measurement technique in patients receiving mechanical ventilation. NICO system is a new generation device which monitors CO using the partial rebreathing technique with pre-described data at short intervals through indirect Fick principle (5,6). Despite its advantages like a rapid and easy use, it has some limitations such as the use of an algorithm during the calculation of CO and inconsistency of the measurements especially in patients with severe respiratory failure (7).

In this study, we aimed to evaluate cardiac and respiratory effects of four different positions used for the care of patients in critical care units with NICO monitor.

Materials and Methods

After approval by the Cumhuriyet University Ethics Committee (decision no: 2011-05/29, date: 31/05/2011) and informed consents of the patients, a total of 40 patients aged between 18 and 65 years old who were hospitalized in the critical care unit, intubated, and received mechanical ventilation with a hospitalization time longer than 24 hours were included in this prospective observational study. Patients receiving inotropic support, those with cardiac disease, morbid obesity, thoracic deformity, an injury that would prevent giving a position, abdominal distension, acute respiratory distress syndrome (ARDS), pulmonary infection, and patients with a history of facial surgery were excluded from the study. In addition, patients who developed a pulmonary infection, abdominal distension and ARDS, those needed cardiac support treatment, patients with disrupted hemodynamics and those with suspected pulmonary embolism were also excluded.

Sedoanalgesia was applied with fentanyl and midazolam during giving the position to the patients. Routine monitorization was performed with the electrocardiogram, peripheral oxygen saturation with a pulse oximeter probe, and invasive blood pressure with arterial cannulation using a 20 G cannula, from the radial artery. The height of the patients was measured with measuring tape, in centimeters. Patients' weight was measured with critical care patient weighing machine (RADWAG®,Wagi Elektroniczne, Poland), in kilograms.

A NICO (Novametrix Medical Systems Inc, Wallingford, CT, USA) monitor sensor was connected between the intubation tube and respiratory circuit of the patients. Patients' weight (kg), height (cm), hemoglobin values (g/dL), arterial blood oxygen pressure (PaO_2) and arterial blood carbon dioxide pressure ($PaCO_2$) values were entered to the NICO monitor and the device was reset. Measurement circuit of NICO was set based on the tidal volume (6-8 mL/kg) of the patients. The measurements were repeated at least three times and averaged. In order not to decrease the measurement precision of NICO, spontaneous respirations of the patients were suppressed and mechanical ventilation was applied in the controlled mode. Mechanical ventilator mode, respiratory rate, fraction of inspired oxygen (FiO_2), inspirium/expirium ratio and tidal volume were not changed during the study. Patients required changes were also excluded.

Patients were respectively given supine (S), 90^o left side (L), 90^o right side (R), and 45^o Fowler (F) positions, and the measurements were read. For this purpose, the measures were read with one-hour intervals when patients were in the supine position. The measures were taken at the 1st, 2nd, and 3rd hours in the patients given L, R and finally F positions for 4 hours. The patients were taken to the S position back before shifting between the positions. Arterial blood gas was collected from the patients before the study at each position. PaO_2 and $PaCO_2$ values were entered to the monitor and reset process was done. CO measurement was made with one-hour intervals and recorded for each hour.

Data of each patient were divided into four groups as the S position, 90^{o}L position, 90^{o}R position, and 45 ^{o}C F position.

During the study mean arterial pressure (MAP), heart rate (HR), stroke volume (SV), CO, cardiac index (CI), oxygen saturation (SpO_2), peak inspiratory pressure (PIP), mean airway pressure (mPaw), dynamic compliance (Cdyn), airway resistance (Raw), and end-tidal carbon dioxide ($ETCO_2$) values were measured and recorded with one-hour intervals.

Statistical Analysis

Data of our study was uploaded to the SPSS 14 Windows (Statistical Package for the Social Sciences, USA) software. Repeated measures analysis of variance was used in the comparison of the parameters measured for each position at the 1st, 2nd and 3rd hours. Bonferroni test was used to determine the measurement or groups causing the difference when significance was decided as a result of the analysis. $P<0.05$ values were considered statistically significant. In the study, considering $\alpha=0.05$ and $\beta=0.20$, $1-\beta=0.80$, we decided to include 40 patients to the study. Power of the test was found as T: 0.80032.

Results

Forty patients included in the study. Demographic data are given in Table 1.

Comparison values of cardiac parameters (MAP, HR, CO, CI, SV) within each group and among groups are given in Table 2. No statistically significant difference was found among the groups in terms of the cardiac parameters ($p>0.05$). Evaluation of the parameters within the groups showed only a significant difference MAP values at different times at the L position ($p=0.006$). MAP measurements at the L position in the paired comparisons, there was a significant difference between the 1st and 3rd hours ($p=0.008$) and between the 2nd and 3rd hours ($p=0.011$), while there was no significant difference between the 1st and 2nd hours ($p=0.370$).

Comparison values of respiratory parameters ($ETCO_2$, PIP, MAP, mPaw, Cdyn and Raw) within each group and among groups are given in Table 3. No significant difference was found between the groups in terms of the respiratory parameters ($p>0.05$). Evaluation of the parameters within the groups demonstrates a significant difference among SpO_2 values at different times at the S position ($p=0.017$).

Table 1. Demographic distribution of the cases

Age (year)	Weight (kg)	Height (cm)	Body mass index	Gender male/female
57.00±10.27	58.7±8.3	164±8.3	21.9±1.9	17/23

SpO_2 measurements at the S position in the paired comparisons, there was a significant difference between the 1st and 2nd hours ($p=0.027$) and between the 1st and 3rd hours ($p=0.036$), while there was no significant difference between the 2nd and 3rd hours ($p=0.624$). There was a significant difference between 1st hour SpO_2 values in all four groups ($p=0.025$). First-hour SpO_2 measurements in the paired comparisons, there was a significant difference between the S and L positions ($p=0.007$). There was also a difference between the S and R positions ($p=0.050$), while there was no difference between the other measurements ($p>0.05$). Whereas the highest SpO_2 values were obtained in the S position, the lowest measures were read at the R position.

Discussion

The patient group in our study consisted of the patients without a pathology that would prevent pulmonary gas exchange and those we monitored with controlled respiration. In our study, we did not find a statistical or clinical difference with the position change in CO, CI and HR values that were measured with NICO. Although there was a statistically significant difference in MAP values measured at different times at the L position, and SpO_2 values measured at different times at the S position, these differences were not clinically significant as they did not affect the oxygen delivery to the tissues.

In a study by Giuliano et al. (8) with 26 critical care patients, no significant changes were found in CO, CI, SV, MAP and HR values measured at the 0th, 5th, and 10th minutes after giving 0 °C, 30 °C, and 45 °C semi-F position to the patients. In our study, S and 45 °C F positions were similar to that study. In our results also we did not found significant changes in CO, CI, SV, and HR values. Although there was a statistically significant difference in MAP values at the L position, this difference was not significant clinically. In a study by Banasik and Emerson (9) on 12 critical care patients with $PaO_2\leq70$ mmHg and/or CI≤2.0, no significant effects of the right and left 45 °C lateral and supine position were found on CO, HR, and SPO_2 that are the main determinants of the tissue oxygen delivery. In our study, R and L positions were 90 °C, while no effects of S, F and L positions were found on CO and HR values. Although there were statistically significant differences between the groups and within group comparisons for each group in respect of

SpO_2 values, these differences were not clinically significant. Fink (10) reported that turning critical care patients from S position to the other positions with intervals significantly increased functional residual capacity and oxygenation. Whereas in the present study position changes significantly affected SPO_2, although this was not significant clinically. Unlike our study, in their study investigating effects of body positions on oxygen consumption and hemodynamics in critically ill patients, Jones and Dean (11) found HR higher in the F position compared to the L position. In another study investigating the effects of the L position on HR, there was a significant increase in HR at the L position, although this was not clinically significant (12). Since HR is one of the major determinants of CO, there is a direct association between oxygen delivery and CO. Whereas turning to the lateral position causes minimal physiological outcomes in healthy persons, this may lead to dramatic effects in the physical status in critical patients. Giving position to the critically ill patients may affect O_2 consumption, CO and gas exchange of the patient in a positive or negative direction. Increased HR upon turning to the lateral position and during the position changes is results from the increases in oxygen need and sympathetic stimulation. In general, positioning may lead to an increase in HR due to the stimulation ofthe autonomic nervous system and complex relationship of the stretch receptors. A decrease in mixed/central venous oxygen saturation (SvO_2) and an increase in HR response are expected with the increasing activity (12).

In a study, no significant difference was found between CO measures in supine positions reaching to 20 °C in

Table 2. The cardiac parameters

	Group S	Group L	Group R	Group F	p
MAP, (mmHg)					
1st h	87.37±19.58	84.82±18.71	80.92±18.51	84.95±21.30	0.174
2nd h	84.22±18.36	83.77±19.48	79.70±17.26	84.45±18.62	0.080
3rd h	84.22±18.66	80.97±18.51	80.72±18.55	84.50±18.82	0.128
p	0.120	0.006	0.604	0.967	
HR, (beats/min)					
1st h	97.80±19.55	97.75±18.32	95.35±21.57	94.80±19.70	0.346
2nd h	95.87±17.05	96.50±22.36	98.92±25.12	94.27±18.92	0.241
3rd h	96.70±19.79	97.27±21.84	98.17±22.31	94.40±21.93	0.291
p	0.483	0.717	0.091	0.930	
CO, (L/min)					
1st h	5.77±1.67	5.63±1.67	5.74±1.90	5.58±1.87	0.580
2nd h	5.85±1.74	5.79±1.97	5.75±1.89	5.53±1.85	0.331
3rd h	5.72±1.84	5.69±2.00	5.71±1.85	5.58±1.92	0.879
p	0.724	0.398	0.906	0.767	
CI, (L/min/m²)					
1st h	3.42±1.01	3.33±0.92	3.40±1.10	3.28±1.11	0.461
2nd h	3.44±0.94	3.42±1.13	3.40±1.07	3.28±1.08	0.471
3rd h	3.34±0.99	3.38±1.12	3.35±1.07	3.30±1.10	0.907
p	0.587	0.477	0.684	0.935	
SV, (mL)					
1st h	62.97±19.68	59.80±17.48	63.12±19.03	61.22±18.74	0.269
2nd h	61.50±16.53	61.70±20.00	62.42±19.31	62.25±20.04	0.959
3rd h	60.40±16.88	62.17±19.80	62.35±18.91	61.45±20.03	0.761
p	0.344	0.165	0.799	0.662	

MAP: Mean arterial pressure, HR: heart rate, CO: cardiac output, CI: cardiac index, SV: stroke volume, S: supine, L: left side, R: right side, F: Fowler patients receiving mechanical ventilation who were not administered positive end-expiratory pressure (PEEP) (13). In our study, the F position was 45 °C, and we administered PEEP of 5 cm H_2O in all patients. In our study, we did not find a significant effect of position changes on CO values. Unlike our results, in another study, CO measured in 20 °C F position was significantly decreased in patients receiving mechanical ventilation (14). Wilson et al. (15) found statistically significant differences in CO and CI measurements between the position changes of 0 °C, 30 °C and the 45 °C, although these values were not clinically significant. Unlike our study, in a study by Driscoll et al. (16) including critical care patients a decrease by 11% was found between CO measures taken in the S position and those taken in 45 °C position in 70% of the patients. 40% of CO values obtained at 45 °C position was 10% lower, equal, or higher than the values obtained at S position. The mean CO at 0 °C was statistically higher than the mean CO at 45 °C. The authors stated that the use

Table 3. The respiratory parameters

	Group S	Group L	Group R	Group F	p
SpO_2 (%)					
1st h	95.00±3.75	93.22±5.75	92.80±9.64	94.27±5.02	0.25
2nd h	93.45±6.20	93.27±7.57	93.27±7.50	94.35±4.59	0.190
3rd h	93.27±7.58	93.12±7.93	93.22±9.81	94.25±4.35	0.430
p	0.017	0.947	0.767	0.948	
$ETCO_2$, (mmH_2O)					
1st h	43.77±12.00	45.60±12.48	45.62±10.98	45.45±11.89	0.221
2nd h	45.57±11.07	44.82±9.80	45.85±11.52	45.35±10.83	0.709
3rd h	4.12±10.98	46.27±12.86	47.00±13.87	45.72±11.25	0.097
p	0.198	0.394	0.332	0.895	
PIP, (cmH_2O)					
1st h	20.17±5.39	20.50±5.58	19.60±5.82	19.20±6.30	0.291
2nd h	19.77±4.77	19.92±6.61	19.52±7.03	19.65±5.54	0.966
3rd h	19.42±4.88	20.15±6.31	20.15±5.56	19.72±6.67	0.691
p	0.288	0.686	0.610	0.632	
mPaw, (cmH_2O)					
1st h	10.27±2.07	10.37±3.00	10.45±2.52	10.10±2.57	0.819
2nd h	9.95±2.09	9.97±2.09	10.05±2.26	9.97±2.64	0.992
3rd h	9.75±2.04	10.17±2.38	10.22±2.11	10.00±2.79	0.634
p	0.305	0.492	0.395	0.871	
Cdyn, (mL/cmH_2O)					
1st h	46.30±20.64	47.97±22.77	46.30±20.64	47.85±21.89	0.622
2nd h	47.55±22.94	47.17±20.34	47.55±22.94	47.40±20.81	0.767
3rd h	45.52±20.35	47.05±19.93	45.52±20.35	46.05±20.31	0.839
p	0.529	0.886	0.529	0.425	
Raw, ($cmH_2O/L/s$)					
1st h	11.07±8.19	11.45±7.87	11.80±8.74	11.12±7.80	0.663
2nd h	11.25±8.06	10.35±6.65	11.80±9.20	11.02±7.76	0.244
3rd h	11.05±7.67	10.82±6.97	11.80±8.70	11.07±8.68	0.526
p	0.867	0.099	1	0.984	

SpO_2: Pulse oximeter oxygen saturation, $ETCO_2$: end-tidal carbon dioxide, PIP: peak inspiratory pressure, mPaw: mean airway pressure, Cdyn: dynamic compliance, Raw: airway resistance, S: supine, L: left side, R: right side, F: Fowler of vasoconstrictors might be the single variable showing a significant change in CO associated with position changes. In a study by Lange et al. (17) investigating effects of S and L positions on CO and intracardiac pressure in 24 patients, right ventricular peak systolic and end-diastolic pressures measured using a micrometer tip pigtail catheter were significantly higher at R and L positions compared to the S position in 17 patients. In addition, left ventricular end-diastolic pressures showed a higher increase in L position compared to the S and R positions. The variation between the results of different studies shows the importance of measuring CO which is among the major determinant of oxygen delivery to the tissues can be measured at bedside continuously without requiring any additional intervention. Therefore, because CO measurement can be made with NICO device easily and rapidly as in our study, CO monitoring can enable to take the necessary measures against the risk for impairment of oxygen delivery during bedsite applications such as positioning of the patients and physiotherapy.

In a study by Bein et al. (18) with critical care patients CI was significantly increased and the MAP was not changed at L position compared to the S position, while the MAP was significantly decreased and CI was not changed at R position compared to the S position. Whereas in our study there were significant changes between the MAP values measured at different times at the L position, these changes were not considered clinically significant, because the MAP values continued at a level enough to maintain tissue and organ perfusion. In our study, no significant effect of position changes was found on CI.

Thomas et al. (19) divided 34 patients receiving mechanical ventilation into three groups as those without pulmonary pathologies on chest X-ray, patients with unilateral infiltrates and those with acute lung injury/ARDS. The authors investigated theeffects of the lateral position of hemodynamics, oxygenation and respiratory mechanics of the patients. They demonstrated that the lateral position has no effect on gas exchange, HR and MAP. CI was found to be increased in the early phase of lateral position (T30). Cdyn was found to be increased at the lateral position in the group without pulmonary pathology and those with unilateral pulmonary pathology. In a study by Tanskanen et al. (20) with 56 operated patients, Cdyn was decreased in the patients turned to the prone and lateral positions from the supine position; no change occurred when given knee-elbow position, and the lowest PIP was found again in the knee-elbow position.

As a limitation of our study, we did not include patients with pulmonary pathology and hemodynamically unstable patients.

Conclusion

We found that turning the patients from S position to L, R and F positions did not cause any significant change in CO, CI, HR, Raw, Cdyn, PIP and MAP values. We concluded that the measurement of CO with NICO monitor is reliable even in position changes. Further studies are needed on this subject.

Ethics

Ethics Committee Approval: The study was approved by the Cumhuriyet University Ethics Committee (decision no: 2011-05/29, date: 31/05/2011).

Informed Consent: Informed consent was obtained from the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: İ.K., S.G., Concept: İ.K., İ.C., D.K., S.G., Design: İ.K., İ.C., D.K., S.G., Data Collection or Processing: İ.K., İ.C., D.K., Analysis or Interpretation: İ.K., İ.C., D.K., S.G., Literature Search: İ.K., İ.C., D.K., Writing: İ.K., İ.C., D.K.

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References

1. Krishnagopalan S, Johnson EW, Low LL, Kaufman LJ. Body positioning of intensive care patients: clinical practice versus standards. Crit Care Med 2002;30:2588-92.
2. Goldhill DR, Badacsonyi A, Goldhill AA, Waldmann C. A prospective observational study of ICU patient position and frequency of turning. Anaesthesia 2008;63:509-15.
3. Pinsky MR. Why measure cardiac output? Crit Care 2003;7:114-6.
4. Sangkum L, Liu GL, Yu L, Yan H, Kaye AD, Liu H. Minimally invasive or noninvasive cardiac output measurement: an update. J Anesth 2016;30:461-80.
5. Young BP, Low LL. Noninvasive monitoring cardiac output using partial CO(2) rebreathing. Crit Care Clin 2010;26:383-92.
6. Peyton PJ, Thompson D, Junor P. Non-invasive automated measurement of cardiac output during stable cardiac surgery using a fully integrated differential CO(2) Fick method. J Clin Monit Comput 2008;22:285-92.
7. Valiatti JL, Amaral JL. Comparison between cardiac output values measured by thermodilution and partial carbon dioxide rebreathing in patients with acute lung injury. Sao Paulo Med J 2004;122:233-8.
8. Giuliano KK, Scott SS, Brown V, Olson M. Backrest angle and cardiac output measurement in critically ill patients. Nurs Res 2003;52:242-8.
9. Banasik JL, Emerson RJ. Effect of lateral positions on tissue oxygenation in the critically ill. Heart Lung 2001;30:269-76.
10. Fink JB. Positioning versus postural drainage. Respir Care 2002;47:769-77.
11. Jones AY, Dean E. Body position change and its effect on hemodynamic and metabolic status. Heart Lung 2004;33:281-90.
12. Winslow EH, Clark AP, White KM, Tyler DO. Effects of a lateral turn on mixed venous oxygen saturation and heart rate in critically ill adults. Heart Lung 1990;19:557-61.
13. Grose BL, Woods SL, Laurent DJ. Effect of backrest position on cardiac output measured by the thermodilution method in acutely ill patients. Heart Lung 1981;10:661-5.
14. Kleven M. Effect of backrest position on thermodilution cardiac output in critically ill patients receiving mechanical ventilation with positive end-expiratory pressure. Heart & Lung 1984;13:303-4.
15. Wilson AE, Bermingham-Mitchell K, Wells N, Zachary K. Effect of backrest position on hemodynamic and right ventricular measurements in critically ill adults. Am J Crit Care 199;5:264-70.
16. Driscoll A, Shanahan A, Crommy L, Foong S, Gleeson A. The effect of patient position on the reproducibility of cardiac output measurements. Heart Lung 1995;24:38-44.
17. Lange RA, Katz J, McBride W, Moore DM Jr, Hillis LD. Effects of supine and lateral positions on cardiac output and intracardiac pressures. Am J Cardiol 1988;62:330-3.
18. Bein T, Metz C, Keyl C, Pfeifer M, Taeger K. Effects of extreme lateral posture on hemodynamics and plasma atrial natriuretic peptide levels in critically ill patients. Intensive Care Med 1996;22:651-5.
19. Thomas PJ, Paratz JD, Lipman J, Stanton WR. Lateral positioning of ventilated intensive care patients: a study of oxygenation, respiratory mechanics, hemodynamics, and adverse events. Heart Lung 2007;36:277-86.
20. Tanskanen P, Kyttä J, Randell T. The effect of patient positioning on dynamic lung compliance. Acta Anaesthesiol Scand 1997;41:602-6.