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The effect of cervical spine surgery on respiratory parameters

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Research Report

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Purpose: The aim of this study was to evaluate the effect of cervical spine surgery on respiratory function. **Material and methods:** Totally 46 patients who had undergone cervical spine surgery (30 patients in physiotherapy group and 16 patients in control) were evaluated in this study. Thoracic mobility, arterial blood gas analysis, pulmonary function parameters, and pain intensity were assessed preoperatively, postoperatively on the 7th day and the 8th week. Patients in the physiotherapy group were treated with chest physiotherapy program including deep breathing exercises, modified postural drainage, percussion, vibration, coughing, stimulation techniques and postural exercises twice a day, five days a week for two weeks. After being discharged, patients were given a home exercise program for 8 weeks. **Results:** When preoperative, postoperative 7th day and 8th week outcomes were compared, both physiotherapy and control groups showed statistically significant decrease in respiratory parameters on the postoperative 7th day ($p<0.05$). Respiratory parameters were significantly lower in the control group than the physiotherapy group ($p<0.05$). At the 8th week postoperatively, respiratory parameters were increased in both groups ($p<0.05$). There was no difference between the groups ($p>0.05$). On the postoperative 7th day, pain severity was significantly high in both groups ($p<0.05$); however, there was no significant difference between the two groups ($p>0.05$). **Conclusion:** Respiratory functions can be negatively affected in the patients who undergo cervical spine surgery. However, pulmonary parameters can be improved with the application of chest physiotherapy.

Key words: Surgery; cervical, Respiratory function, Physiotherapy; chest.

Servikal omurga cerrahisinin solunum parametreleri üzerine etkisi

Amaç: Bu çalışmanın amacı servikal omurga cerrahisinin solunum fonksiyonları üzerine etkisini değerlendirmekti. **Gereç ve yöntem:** Servikal omurga cerrahisi geçirmiş 30 hasta fizyoterapi grubunda ve 16 hasta kontrol grubunda olmak üzere, toplam 46 olgu çalışmaya dahil edildi. Torakal mobilite, arterial kan gazı analizi, solunum fonksiyon testi ve ağrı şiddeti cerrahi öncesi ve sonrası 7. gün ve 8. haftada değerlendirildi. Fizyoterapi grubundaki olgulara derin solunum egzersizleri, modifiye postüral drenaj, perküsyon, vibrasyon, öksürme ve postür egzersizlerini içeren göğüs fizyoterapisi programı günde 2 kez, haftada 5 gün ve 2 hafta süresince uygulandı. Olgular taburculuk sonrası 8 hafta süresince ev egzersiz programı ile takip edildi. **Sonuçlar:** Preoperatif dönem, postoperatif 7. gün ve postoperatif 8. hafta sonuçları değerlendirildiğinde, her iki grupta da postoperatif 7. gün solunum fonksiyon parametrelerinin istatistiksel olarak anlamlı derecede azaldığı bulundu. Gruplar arasındaki fark incelendiğinde cerrahi sonrası 7. gün kontrol grubunun solunum fonksiyonlarının fizyoterapi grubundan daha düşük olduğu belirlendi ($p<0.05$). Cerrahi sonrası 8. hafta ölçülen sonuçlara bakıldığında, her iki grupta da solunum fonksiyon testi parametrelerinin arttığı gözlendi ($p<0.05$). Gruplar arasında anlamlı bir fark yoktu ($p>0.05$). Ağrı şiddeti her iki grupta da cerrahi sonrası 7. günde anlamlı derecede yüksekti ($p<0.05$). Ancak, gruplar arasında ise anlamlı fark gözlenmedi ($p>0.05$). **Tartışma:** Servikal omurga cerrahisi geçiren hastalarda solunum fonksiyonları olumsuz yönde etkilenebilir. Ancak erken dönemde verilecek göğüs fizyoterapi uygulamaları ile solunum fonksiyonları geliştirilebilir.

Anahtar kelimeler: Cerrahi; servikal, Solunum fonksiyonu, Fizyoterapi; chest.

Despite recent developments in anesthesia and surgery, pulmonary complications have remained a serious postoperative problem due to a number of factor including age, weight, smoking, surgery type and technique used, surgery duration, incision site, thorax deformities, air pollution, and preoperative pulmonary functions.[1-4] Pneumonia is the main complication especially in patients who suffer trauma.[5,6] Furthermore, cervical spondylosis, which is a common disease, can impair phrenic nerve function by compressing the C4 neuronoma and/or the nerve. The change in the breathing pattern predominantly from diaphragmatic to intercostal may be another factor that can limit respiratory function as a result of reflex inhibition of the diaphragm.[7] Therefore, pulmonary functions may change after cervical spine surgery.[8,9]

Cervical spine surgery causes loss of muscle strength and elasticity in the neck and shoulder region. Additionally, limitations in neck movement occur due to neck pain and spasm.[6,10] Therefore, we hypothesized that respiratory parameters would be negatively affected after cervical spine surgery. To our knowledge, only one study in the literature was available about the effect of cervical spine surgery on respiratory parameters.[7] The purpose of this study was to evaluate the effect of cervical spine surgery on respiratory function and to determine if changes in respiratory parameters are associated with postoperative early chest physiotherapy application.

Materials and methods

Subjects

Forty-six patients from the Neurosurgery Department, Dokuz Eylül University, İzmir, Turkey, who had undergone cervical spine surgery due to cervical disk degeneration, cervical stenosis, cervical cot or cervical neuronoma were included in the study. Thirty patients were in the physiotherapy group and sixteen patients were in the control group. Dokuz Eylül University Medical Ethics Committee approved the study. All of the patients gave a written informed consent before the study.

Patients who had undergone cervical spine surgery were included in the study. Patients older than 65 years of age, patients with decompensated depression, vascular encephalopathy (dementia, hemiparesis, aphasia), those with significant osteoporosis, uncertainty about the presence of significant additional diseases (e.g,. motor neuron disease, multiple sclerosis, progressive polyarthritis), severe neck pain, severe cardiac disease, and uncontrolled hypertension (>160/95 mmHg).

Assessment

At the time of enrollment, a complete history was obtained from each patient about his/her age, sex, height, profession, smoking history, lung pathology, history of previous surgery, and other potential risk factors.

Circumference measurement

Thoracic expansion of patients was assessed using circumference measurements.[10] A standard one inch, retractable, fiberglass tape measure was used to perform the circumference measurement. Thoracic circumference at axillary, epigastric and subcostal levels in a relaxed position, at deep inspiration and deep expiration were measured, and the difference between maximum inspiration and maximum expiration was calculated. The physiotherapist measured each patient twice. All measurements were recorded in centimeters.

Pulmonary function test

Pulmonary function tests were included forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, and peak expiratory flow (PEF).[11,12] These tests were performed using Jeager pneumascope flow sensitive spirometry. All spirometric measurements were performed with the patient in an upright sitting position by the same research assistant. Patients were instructed to inhale until their lungs were completely full, seal their lips around the mouthpiece of the spirometry, exhale as hard and fast as possible until they could not push any more air out, and inhale fully immediately after the expiration maneuver. The each test was performed three times and the highest value was selected for analysis.

Arterial Blood Gas Analysis

Arterial blood gases (ABG) were analyzed by radial artery puncture using a Radiometer ABL3 blood gas analyzer.[13,14] ABG included partial arterial oxygen pressure (PaO_2), partial arterial

carbon dioxide pressure ($PaCO_2$), arterial pH, and oxygen saturation ($satO_2$).

Pain Assessment

Pain perception was assessed using a self-rating visual analogue scale (VAS) ranging from 0 (no pain) to 10 (worst possible pain).[15-17] The VAS scores at rest, during coughing, and during mobilization were obtained.

Study Design

Patients were randomly divided into two groups using cards in unmarked envelops, to receive either physiotherapy or control groups. Physiotherapy group had a therapy program twice a day, five days a week for two weeks. The patients were treated with chest physiotherapy applications including 3-5 minutes of short sets of deep breathing exercises (apical, basal, and diaphragmatic breathing exercises). After the breathing exercises, modified postural drainage, percussion, vibration, and coughing were used to mobilize secretions. Additionally, patients were asked to practice posture exercises with 10 repetitions. After being discharged, patients were given a home exercises program for 8 week.

All measurements were performed at three different times for each patient in both of the groups (preoperatively, 7th day and 8th week, postoperatively).

Statistical analysis:

All values are expressed as mean±standard deviation. A one-way analysis of variance (ANOVA) with repeated measures on one factor (testing phase) was employed to determine the main effect of testing phase in the physiotherapy group. Kruskal Wallis Variation Analysis was applied for the control group. Differences between the groups were analyzed using the Wilcoxon Rank Sum Test. Mann Whitney U test for dependent samples was used to determine the differences in the before and after measurements. The level of significance was set at 5%. Statistical procedures were performed using a statistical package, SPSS 10.0 for windows.

Results

Demographic data

Demographic data of patients are presented in Table 1. Initially, in the physiotherapy group we had taken 37 patients but seven patients were excluded from the study as they did not complete all components of the study. Therefore, only 30 patients (13 females and 17 males) were included into statistical analysis. Their mean age was 46.8±9.00 (range 30-65) years. Patient's compliance during the treatment program was good. There were sixteen patients (7 females and 9 males) in the control group. Their mean age was 47.3±5.04 (range 34-65) years.

The distribution of the study subjects according to diagnosis was as follows: 58.7% (n=27) cervical disk degeneration, 30.4% (n=14) cervical stenosis, 4.3% (n=2) cervical cot, and 6.6 % (n=3) cervical neuronoma.

Table 1. Demographic characteristics of the patients.

	Physiotherapy Group (N=30) X±SD	Control Group (N=16) X±SD
Age (years)	46.8±9.0	47.3±5.0
Body weight (cm)	69.6±10.0	71.1±7.1
Body height (kg)	166.8±10.0	168.1±11.0
	N (%)	**N (%)**
Gender		
Female	13 (43)	7 (44)
Male	17 (57)	9 (56)
Smokers	22 (73)	12 (75)

Thoracic excursion

The mean difference between maximum inspiration and expiration from axillary, epigastric and subcostal regions, decreased on the 7th day after surgery within both groups ($p<0.05$). All the values were significantly increased in both of the groups at 8th week after surgery ($p<0.05$). When both groups were compared, thoracic mobility of the control group were significantly lower on the 7th day postoperatively only in the subcostal region ($p<0.05$). There were no significant differences in the epigastric and axillary region between the two groups ($p>0.05$).

Pain assessment

There was a statistically significant increase in the pain severity on the 7th day postoperatively for both groups during coughing and mobilization ($p<0.05$). However, there was no significantly difference between the groups on the 7th day postoperatively with respect to coughing and mobilization ($p>0.05$) (Table 2). At 8 weeks after surgery, pain severity decreased in both groups ($p<0.05$).

Pulmonary function test

All spirometric values on the 7th day after surgery were significantly decreased within each groups ($p<0.05$). It was found that only FEV_1 and PEF values were significantly different in favor of physiotherapy group in pulmonary function test on the 7th day postoperatively ($p<0.05$) (Table 3). Although pulmonary parameters increased in both groups 8 weeks after surgery, there were no differences between the groups ($p>0.05$).

Table 2. Thoracic excursion measurements and pain perception scores (visual analogue scale-VAS) in physiotherapy and control groups.

	Physiotherapy Group (N=30)			Control Group (N=16)		
	Preoperative period X±SD	Postoperative 7th day X±SD	Postoperative 8th week X±SD	Preoperative period X±SD	Postoperative 7th day X±SD	Postoperative 8th week X±SD
Thoracic excursion (cm)						
Axillar	6.4±0.7	5.5±0.7 [a]	9.3±0.8 [a]	6.4±0.8	5.0±0.7 [a]	8.8±0.8 [a]
Epigastric	6.9±1.0	6.2±1.1 [a]	9.2±0.8 [a]	7.4±3.1	5.8±0.7 [a]	9.1±0.5 [a]
Subcostal	7.0±0.7	5.7±0.7 [a,b]	8.7±0.5 [a]	6.8±0.5	5.0±0.6 [a,b]	8.4±0.5 [a]
VAS (cm)						
Resting	2.2±1.0	2.8±1.2	0.2±0.4 [a]	2.2±0.9	2.8±1.0	0.9±0.3 [a]
Coughing	3.3±1.1	7.2±1.4 [a]	0.5±0.6 [a]	3.1±1.1	6.9±0.9 [a]	0.4±0.4 [a]
Mobilization	0.8±0.8	7.1±1.0 [a]	0.1±0.3 [a]	6.8±0.5	6.7±0.6 [a]	0.2±0.4 [a]

a: $p<0.05$ within groups, according to preoperative period values; b: $p<0.05$ between the groups.

Table 3. Pulmonary function test parameters and arterial blood gas values in physiotherapy and control groups.

	Physiotherapy Group (N=30)			Control Group (N=16)		
	Preoperative period X±SD	Postoperative 7th day X±SD	Postoperative 8th week X±SD	Preoperative period X±SD	Postoperative 7th day X±SD	Postoperative 8th week X±SD
PFT (%)						
FEV_1	99.8±15.5	93.7±13.7 [a,b]	103.3±24.1 [a]	99.7±0.4	91.5±13.6 [a,b]	102.9±12.3 [a]
FVC	102.1±11.2	95.7±2.5 [a]	106.1±13.5 [a]	103.1±9.3	94.9±15.1 [a]	105.8±9.8 [a]
PEF	89.7±1.3	83.6±22.7 [a,b]	110.0±17.4 [a]	88.3±1.0	79.1±7.3 [a,b]	109.1±11.1 [a]
FEV_1/FVC	102.6±7.4	100.8±8.6 [a]	106.6±7.3 [a]	102.1±3.1	99.6±10.2 [a]	106.6±13.8 [a]
ABG						
pH	7.42±0.03	7.44±0.04	7.41±0.04	7.4±0.03	7.5±0.2	7.4±0.02
PaO_2 (mmHg)	96.8±18.5	87.6±12.8 [a]	101.2±11.4	96.2±0.9	86.1±10.6 [a]	99.8±9.6
$PaCO_2$ (mmHg)	35.4±2.8	37.5±2.7 [b]	33.5±2.7	35.1±3.8	40.3±2.1 [b]	34.1±3.5
$satO_2$ (%)	97.6±1.2	96.2±1.8 [a]	98.1±1.7	96.9±1.3	95.3± 0.8 [a]	97.8±0.5

PFT: Pulmonary function test, ABG: Arterial blood gases.
a: $p<0.05$ within groups, according to preoperative period values; b: $p<0.05$ between the groups.

Arterial blood gas

$PaCO_2$ values were significantly higher in the control group than physiotherapy group on the 7th day postoperatively ($p<0.05$) (Table 3). However, there was no statistically difference on arterial pH on the 7th day postoperatively in both two groups ($p>0.05$). PaO2 and satO2 values were lower in both of the groups on the postoperatively 7th day but this difference was not significantly different ($p>0.05$). There were no significantly difference for the values 8 week after surgery ($p>0.05$).

Discussion

A lot of studies have shown a wide variation (between 10 to 80%) in the incidence of postoperative pulmonary complications following abdominal, thoracic, and head-neck surgery. Volpino et al. showed that laparoscopic and open cholecystectomy had an effect on intra-and postoperative hemodynamic and respiratory function, and pain.[18] They showed that levels of pH, PaO_2, FVC, FEV_1, $FEF_{75-85\%}$ were significantly less in both groups in the postoperative period. Westerdahl et al. showed in meta analysis that the pulmonary functions 4 months after coronary artery bypass graft surgery were significantly reduced.[19] Wax et al. reported a incidence of radiographic postoperative atelectasis in patients undergoing rectus abdominus myocutaneous free tissue transfer.[20] Rao et al. claimed that the FEV_1 volume is an important indicator of pulmonary complications after head and neck surgery.[16] Mcculloch et al. found that the most important risk factor for pulmonary complication after head and neck surgery is smoking and the most frequent pulmonary problem is pneumonia.[13] Similarly, Di Pietro et al. reported that alteration in the respiratory function may be one of the postoperative complications due to especially long period of surgical time.[7]

However, there has been one report in which the authors have examined the respiratory functions after cervical spine surgery recently.[7] A few studies on diaphragmatic paralysis caused by cervical problems have been published.[8,9,21,22] In cervical spine surgery, decompression of neural tissues and providing stability are the main aims. After cervical spine surgery, decrease in neck and shoulder muscle strength and elasticity and the limitation of the range of cervical motion prevents the thoracic expansion from being within normal limits.[6,10] Additionally, the effect of general anesthesia and pain causes atelectasis up to 95% of patients with normal lungs who undergo surgery.[23]

Because of this, the respiratory function in cervical spine surgery was evaluated in this study. In this study, we showed that respiratory parameters were low in the early postoperative period (the 7th day postoperatively) compared to preoperative period for both groups. However, the reduction in respiratory function were significantly less on the postoperatively 7th day in terms of FEV_1, PEF, subcostal circumference measurement and $PaCO_2$ parameters for the control group. Thus, physiotherapy group showed statistically significant increase in these parameters with the chest physiotherapy application. Parameters measured at the 8th week after surgery, there were significant improvements for both groups. Although physiotherapy group had the higher mean values for respiratory parameters with eight week home exercise program, there were no significant difference between the groups at the postoperatively 8th week.

Pain severity during coughing and mobilization was improved after surgery but there were no significant difference between the groups. Decrease in FEV_1 and subcostal excursion measurement may be related to diaphragmatic paralysis due to reflex inhibition of the diaphragm muscle.[24,25] Thus, increase in $PaCO_2$ may be a compensatory mechanism of alveolar ventilation as a result of alterations in respiratory functions.[24]

The patients aged 65 and over were excluded from this study in order to omit effects of reduced lung volume as a result of the aging process. Thus, by eliminating the age factor, we observed the results of cervical spine surgery on pulmonary functions.

It is known that cervical pathologies are the most common injuries in vertebral column pathologies. Pain control and spasm reduction on the affected region and improvement of the functional state are the main goals of the physiotherapy program in patients who have

undergone cervical spine surgery. However, little attention has been paid to respiratory exercises with physiotherapy programs for patients of cervical spine surgery. Thus, it is advised that pulmonary rehabilitation applications should be added to physiotherapy programs for such patients.

In this study, it can be concluded that the pulmonary functions of the patients were significantly affected by anesthesia and surgical procedures that they underwent. Age, abdominal posture, inappropriate working conditions may cause long term pain, muscle spasm and limitations in movement in patients with chronic neck pain, which is a common community health problem. These factors inversely affect thoracic expansion. Additionally, thoracic expansion limitation was aggravated by anesthesia.

In conclusion, respiratory function can be negatively affected in the patients who undergo cervical spine surgery. However, pulmonary parameters can be improved with the application of chest physiotherapy.

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