








Correlation between respiratory muscle strength and peripheral muscle strength in patients with closed thoracic drainage

Correlação entre a força muscular respiratória e a força muscular periférica dos pacientes com drenagem torácica fechada

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ABSTRACT

Introduction: Thoracic trauma comprises a variety of injuries to the rib cage, tissues and organs located therein. In cases of pneumothorax, hemothorax or hemopneumothorax, the most common treatment is the placement of an intercostal drain to restore pleural pressure. The presence of drains, pain and rib fractures may favor the decline in respiratory muscle strength in these patients. **Objective:** To correlate respiratory muscle strength and peripheral muscle strength in patients with closed thoracic drainage (CTD). **Methods:** This is an analytical cross-sectional study. The participants were given the demographic and clinical evaluation form, Visual Analog Scale, then the Peak cough flow test, MIP, MEP, palmar grip dynamometry in both limbs and the Medical Research Council Scale (MRC) for strength assessment. **Results:** 17 patients participated, 82.4% male, with a mean age of 32.3 years. There was a strong correlation between right handgrip dynamometry and MEP (p.0.00; r = 0.72), between MEP and MRC (p. 0.001; r = 0.79), in addition to a weak association between MEP and left handgrip strength (p.0.04; r = 0.54). Regarding the average of predicted values, the participants obtained 46.3% of MIP and 47.4% of MEP. Of the Peak Cough Flow values performed by the patients, 70.6% were classified as effective cough. The pain according to the VAS was mostly moderate. **Conclusion:** We found a correlation between expiratory muscle strength and peripheral muscle strength in patients after chest trauma and with CTD. The strength parameters evaluated were lower than those expected in the literature.

Keywords: thoracic injuries; drainage; maximum inspiratory pressure; maximum expiratory pressure; Physical therapy.

RESUMO

Introdução: O trauma torácico compreende uma variedade de lesões na caixa torácica, tecidos e órgãos nela localizados. Nos casos de pneumotórax, hemotórax ou hemopneumotórax o tratamento mais utilizado é o posicionamento de um dreno intercostal para restabelecer as pressões pleurais. A presença de drenos, dor e fraturas de costelas podem favorecer o declínio da força muscular respiratória desses pacientes. **Objetivo:** Correlacionar a força muscular respiratória e força muscular periférica dos pacientes com drenagem torácica fechada (DTF). **Métodos:** Trata-se de um estudo transversal analítico. Aos participantes foram aplicados o formulário de avaliação demográfica e clínica, Escala Visual Analógica. Em seguida, foram realizados o teste de Pico de fluxo de tosse, $PI_{máx}$, $PE_{máx}$, a Dinamometria de preensão palmar em ambos os membros e a Escala Medical Research Council (MRC) para avaliação da força. **Resultados:** Participaram 17 pacientes, 82,4% do sexo masculino, com idade média de 32,3 anos. Houve correlação forte entre dinamometria de preensão palmar direita e $PE_{máx}$ (p.0,00; r = 0,72), entre a $PE_{máx}$ e o MRC (p. 0,001; r = 0,79), além de associação fraca entre a $PE_{máx}$ e a força preensão palmar esquerda (p.0,04; r = 0,54). Em relação à média dos valores preditos, os participantes obtiveram 46,3% da $PI_{máx}$ e 47,4% da $PE_{máx}$. Dos valores do Pico de Fluxo de Tosse realizados pelos pacientes, 70,6% foram classificados em tosse eficaz. A dor segundo a EVA foi em maioria, moderada. **Conclusão:** Encontramos correlação entre a força muscular expiratória e a força muscular periférica em pacientes pós-trauma torácico e com DTF. Os parâmetros de força avaliados se mostraram inferiores aos esperados na literatura.

Palavras-chave: traumatismos torácicos; drenagem; pressão inspiratória máxima; pressão expiratória máxima; Fisioterapia.

Introduction

Chest trauma comprises a variety of injuries to the rib cage, tissues and organs located therein. The costal arches and lungs are the most affected. In addition to them, the heart, great vessels, trachea and esophagus are among the structures that can also be affected [1]. Thoracic traumas are classified according to their trauma mechanism, as closed and penetrating [2,3].

In relation to the total number of traumas that occur in the world, 15% are closed thoracic, and among polytrauma patients, traumas to the rib cage of both types are present in 60% of cases [2]. In Brazil, these lesions occur predominantly in young and adult men. The most common fractures are of the spine and ribs, complicated by pneumothorax and hemothorax with low mortality [4].

In cases of pneumothorax, hemothorax or hemopneumothorax, the most used treatment is the placement of an intercostal drain to restore pleural pressures [1]. Closed chest drainage (CTD) is a minor surgical treatment. Only 10% of blunt trauma and 30% of penetrating trauma require major surgery [5]. The presence of drains, pain and rib fractures may favor the decline in respiratory muscle strength in these patients [6-8].

In view of changes in ventilatory mechanics caused by trauma and associated injuries, there is a high risk of ventilatory complications, and the patient may progress to acute respiratory failure with the need for ventilatory support in more severe cases. Thus, it is important to know what degree of ventilatory compromise is expected and what is the influence on the length of stay and complications in these patients [9].

Due to pain and immobility, patients may have reduced inspiratory and expiratory muscle strength, with a decrease in peak cough flow. In addition to reduced muscle strength in the upper limbs due to the presence of the chest drain. The aim of this study is to correlate respiratory muscle strength and peripheral muscle strength in patients with CTD. It is expected to observe that patients are predominantly male, with chest trauma due to traffic accidents and falls.

Methods

This is an analytical cross-sectional study, carried out in the wards of the Hospital de Urgências de Goiás (HUGO), which is a public unit linked to the Goiás State Secretary, based on the authorization of the Research Ethics Committee of the HUGO (CAAE: 53746321.8.0000.0033). Patients admitted to the HUGO wards participated in the study.

Based on the number of patients admitted to the ward of the participating center, in a time interval similar to that of our collection, in the historical series of the service, we estimate that during the study period 48 patients would be evaluated for inclusion, assuming a possible total population of 54 patients. For this sample, a

confidence interval of 95% and a margin of error of 5% were used.

The inclusion criteria for the study were: 1) age greater than or equal to 18 years; 2) have a clinical diagnosis of chest trauma associated with any lung injury, whether pneumothorax, hemothorax or pulmonary contusion, with or without rib fractures; 3) in use of closed thoracic drainage; 4) sign the Informed Consent and Free Term (ICFT).

Patients with 1) non-traumatic lung injuries, such as: spontaneous pneumothorax, iatrogenic injuries and others, were excluded from the study; 2) patients with cognitive impairment or Glasgow Coma Scale (GCS) less than 15; 3) patients diagnosed with spinal cord injury without release for movement; 4) having undergone laparotomy or having lesions in regions that make it impossible for the testicles to perform ventilatory muscle strength, such as the mouth and face; 5) population with deprivation of liberty; 6) incomplete medical record.

Data collection was carried out by two duly trained evaluators, lasted five months and was divided into three moments. Initially, a screening of patients in the wards was carried out, through the electronic medical record system, to identify those who were admitted due to chest trauma and then the inclusion and exclusion criteria were applied. Soon after, the patient able to participate in the research was invited and explanations about the research were made, reading of the ICFT, clarification of the evaluations that would be carried out and signature of the ICFT. Then, the demographic and clinical evaluation form, Scale Visual Analog (VAS), according to the patient's possibilities, either at the bedside or with the headboard raised, the Peak Cough Flow test, Maximum Inspiratory Pressure (MIP), Maximum Expiratory Pressure (MEP), Dynamometry of palmar grip in both limbs and the Medical Research Council (MRC) strength scale were applied.

The Demographic and Clinical Evaluation Form contained abbreviation, medical record number, sex, date of birth, age, height, lifestyle habits (alcoholism, smoking, use of illicit drugs and physical activity), hospitalization data (day of admission in the hospital, total days of hospitalization and others), trauma-related data (trauma mechanism, associated factors and others) and clinical data (severity, radiological findings, peripheral O₂ saturation, heart rate and others).

The VAS is a simple and sensitive self-assessment scale of pain perception. It is represented by a numerical line in ascending order of 10 cm, its score varies from 0, which means complete absence of pain, to 10, unbearable pain. The examiner showed the scale to the patient, asking him to grade his pain. Mild pain was considered between 1 and 2, moderate between 3 and 7 and severe pain between 8 and 10 [10].

The Cough Flow Peak test was performed using a Medicate® device that ranges from 60 L/min to 900L/min. After the due explanations about the test, the patient performed a learning test, just to learn how the device works, then the examiner asked the patient to perform a maximum inspiration, followed by the closure of the glottis and a cough. Three measurements were performed with a rest interval according to the patient's needs between measurements, the best result was considered for

data analysis. Cough was classified as ineffective (less than 160 L/min), weak (160 L/min to 269 L/min) and effective (greater than 270 L/min) [11].

Measurements of MIP and MEP were performed using an analog manovacuometer device from the Murenas® brand, to measure the patient's maximum inspiration and expiration force. The patient was advised that, in order to assess maximum inspiration, he should actively perform a complete expiration outside the device, followed by a maximum inspiration with the lips attached to the mouthpiece. Similarly, to assess maximal expiration force, a full free inspiration and after a maximal expiration with lips tightly sealed in the device. Both tests had to be performed with a nose clip, preventing air leakage through the nose during the procedure. After the proper guidance on the test, the patient performed a maximum inspiratory and expiratory test that was not recorded, just to learn how the device was working. Three attempts were requested with an interval of at least one minute between them, and only the best result was considered for data analysis. The reference values were obtained through the equations for men $MIP = -0.80(\text{age})+155.3$; $MEP = -0.81(\text{age})+165.3$; and women $MIP = -0.49(\text{age})+110.4$; $MEP = -0.61(\text{age})+115.6$ [11,12].

Handgrip strength was measured using a Saehan® hand held hydraulic dynamometer device, duly calibrated. The patient was placed in a sitting position with the forearm extended in a lateral position away from the body, with the wrists in a neutral position. Maximum grip strength was requested 3 times on each limb, with a 30-second rest interval between repetitions. Only the best result of each member was considered [13]. The values that were used as a reference are described in the study by Schlüssel [14].

The MRC strength scale assesses the muscle strength of some muscle groups. They are: shoulder abductors, elbow flexors and wrist extensors in the upper limbs; and hip flexors, knee extensors and foot dorsiflexors in lower limbs. The patient was asked to perform the movement, the degree of strength was graded according to the criteria 0 (zero) total paralysis, 1 (one) sketch of contraction, 2 (two) complete movement as long as gravity was removed, 3 (three) movement against gravity, 4 (four) overcomes minimal resistance and 5 (five) overcomes normal resistance. The points were added and the results were graded from 0 (tetraplegia) to 60 (normal) [15].

Data were categorized and tabulated in an electronic spreadsheet in Microsoft Excel 2016 software and then analyzed in the statistical program Statistical Package for Social Sciences, (IBM Corporation, Armonk, USA) version 26.0. For analysis of categorical variables, absolute frequency and relative frequency were used, and for continuous variables, mean and standard deviation. Data normality was verified using the Shapiro-Wilk test. The relationship between the study's exploratory variables was tested by applying Spearman's correlation. The significance level adopted was 5% ($p < 0.05$). With regard to correlations, the following classification was adopted for positive and negative values: strong correlation, $r \geq 0.70$; moderate, $0.31 < r < 0.70$; and weak, $0.1r \leq 0.30$ [16].

Results

Figure 1 shows the inclusion flowchart of the study population. Demographic and clinical data are summarized in Table I. The mean age of participants was 32.3 years (standard deviation: 15.5; minimum: 18; maximum 72). Regarding the type of trauma, 52.9% were open and 47.1% were closed. Among the causes, traffic accidents represent 41.2%, stab wounds 41.2%, perforation by firearms 11.8% and beatings 5.9%. Rib fractures occurred in 52.9% of cases, of which 55.6% fractured more than one rib. Lung injuries were pneumothorax (47.05%), hemothorax (11.8%), hemopneumothorax (41.2%) and pulmonary contusion (29.4%).

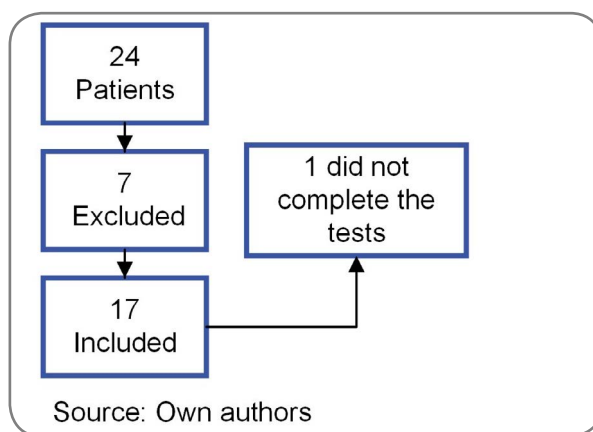


Figure 1 – Population inclusion flowchart

The main associated injuries were traumatic brain injury, face, injury in upper limbs, lower limbs and abdominal injury. Complications occurred in two patients, one being a spontaneous pneumothorax and a large-volume empyema. In this study, there were no deaths among the participants.

The test results are described in table II. Regarding the mean of the predicted values, the participants obtained 46.3% of MIP and 47.4% of MEP. The Peak Cough Flow values performed by the patients were classified as effective cough 70.6% (n:12), weak cough 23.5% (n:4) and ineffective cough 5.9% (n:1).

The mean of the group in relation to the predicted values was 85.6% of the grip strength on the right and 89.0% grip strength on the left. The mean MRC was 89.0% of the predicted value for this sample. Pain reported by patients was classified as none 23.5% (n:4) VAS 0, mild pain 23.5% (n:4), moderate pain 47.1% (n:8) and only 5.9% (n:1) said they felt severe pain at the time of the assessment.

Table I - Characterization of the demographic and clinical profile of patients (n = 17)

	N	%
Gender		
Female	3	17.6
Male	14	82.4
Hospitalization days		
< 7 days	12	70.6
≥ 7 days	5	29.4
Life habits		
Smoker	13	76.5
Alcoholic	5	29.4
Use of illicit drugs	11	64.7
Sedentary lifestyle	5	29.4
Physical activity	2	11.8
Complications	15	88.2

Able to walk

N = absolute frequency; % = relative frequency; *prevalences shown only

Table II - Test results (n = 17)

Variable	Média ± DP
SpO ₂	95.76 ± 2.14
HR	88.06 ± 12.21
MIP	-62.81 ± 32.48
MEP	69.06 ± 32.10
Peak cough flow	345.29 ± 127.82
Right hand grip strength	34.80 ± 12.65
Left hand grip strength	34.86 ± 13.64
MRC	55.75 ± 6.32
VAS	2.71 ± 2.44

SD = standard deviation; SpO₂ = Peripheral O₂ saturation; HR = Heart rate; MIP = Maximum inspiratory pressure; MEP = Maximum expiratory pressure; MRC = Medical Research Council; VAS = Visual Analog Scale

Table III presents the correlations between the MIP and MEP tests with the handgrip dynamometry and the MRC. When the respiratory muscle strength variables were correlated with peak cough flow, there was a moderate association with MEP (p. 0.01; r = 0.62) and with MIP (p. 0.01; r = 0.60), in addition to these, an association was found between peak cough flow and peripheral muscle strength, which was also moderate both with the right palmar grip dynamometry (p. 0.04; r = 0.51) and with the dynamometry of left palmar grip (p. 0.03; r = 0.58).

Table III - Result of the correlation between MIP and MEP with handgrip strength and MRC (n = 17)

	MIP	MEP
Right hand grip strength	r = -0.41; p = 0.13	r = 0.72; p = 0.00
Left hand grip strength	r = -0.27; p = 0.35	r = 0.54; p = 0.04
MRC	r = -0.30; p = 0.25	r = 0.79; p = 0.001

The significance level adopted was 5% ($p < 0.05$). MIP = Maximum inspiratory pressure; MEP = Maximum expiratory pressure; MRC = Medical Research Council

Discussion

We observed, through this analytical cross-sectional study, that only the MEP test results had a strong correlation between the right handgrip strength and the MRC, and a moderate correlation with the left handgrip strength. MIP, on the other hand, was not related to any of the peripheral muscle strength tests.

There was a predominance of open chest trauma, the main causes being stab wounds and gunshot wounds. This finding had already been described in a study carried out at the same institution, published in 2013. These data are linked to the increasing violence registered in developing countries such as Brazil [17]. In relation to blunt trauma, traffic accidents that occur mainly in the younger portion of the population [1,3] stand out, aggravated by the increased circulation of motorcycles and bicycles, poor road conditions and the recklessness of drivers [18].

Regardless of which lung injury, they can generate complications, in this study, they occur in only two cases, one empyema and one spontaneous pneumothorax after discharge. Some factors may predispose to complications, such as the poor positioning of the drain and drainage conditions, such as those performed at the emergency room in pre-hospital care. Both increase the risk of inadequate drainage of the contents, either air or pleural fluid, requiring a thoracostomy. In cases where drainage is performed outside the hospital environment, it favors the occurrence of infectious processes such as empyema, pneumonia and infection at the site of the drain [5].

Although smoking and the use of some types of illicit drugs are predisposing factors for spontaneous pneumothorax [19], they were not associated with an increased risk of complications in this sample. However, it is already known that other factors, such as fractures in the first rib, increase the rate of complications, as they can cause more serious damage, such as injuries to large vessels such as the subclavian, tracheobronchial, pulmonary and cardiac injuries. Rib fractures have been found in all patients with blunt chest trauma, but they alone are not fatal. In view of this, early assessment and identification is essential for the proper management of injuries due to their potential risk to life [20]. There were no deaths in our sample, which can be explained by the fact that thoracic traumas have a low mortality rate [4], in addition, our sample included patients evaluated in the ward, possibly at low risk.

Even in the case of a less severe group, the MIP and MEP values obtained were more than 50% below the predicted value. MIP and MEP values within the predicted range exclude the presence of weakness, however values below the ideal do not unquestionably confirm it, since factors such as the technique used in the measurement and the patient's underexertion can influence the results [21]. To carry out these tests, it is necessary to use the inspiratory muscles in MIP and the external and abdominal intercostals in MEP, the weakness of these muscles can lead to a feeling of tiredness, functional impairment and worsening of quality of life [22].

Thoracic geometry favors the conversion of force into pressure. To assess this variable, it is important to consider the interaction of muscles in the rib cage and abdominal wall. Chest injuries can cause damage to the two functions of the respiratory muscles, which are to shorten and develop strength. The measurement of MIP and MEP reflects the sum of the pressure generated by the muscles and the elastic recoil force of the lungs from the thoracic cage [23].

Some studies have shown an association between peripheral muscle strength and respiratory muscle strength. Research has been carried out both in healthy individuals and in certain groups of patients, showing moderate correlation between them. To measure the strength of the peripheral muscles, some tests are performed including: handgrip dynamometry and the MRC strength scale, which are used in the evaluation of patients in the hospital environment, as they are easy to apply and inexpensive [24-26].

Peripheral muscle training has benefits on respiratory function, providing strength gains and inspiratory muscle endurance [27]. Similarly, in patients undergoing phase II cardiac rehabilitation, the increase in respiratory muscle strength through inspiratory muscle training reflects an improvement in systemic vasodilation and peripheral muscle perfusion [28]. Whenever there are no limiting factors, these patients should be encouraged to mobilize their limbs, sit down and walk [29], in addition to reducing complications such as deep vein thrombosis and pneumonia, it also results in an increase in functional capacity and a return to their routines after discharged [30].

The reduction in respiratory muscle strength has an impact on the tolerance to perform exercises, activities of daily living and on the sensation of dyspnea. In the treatment of pathologies such as COPD, as well as in healthy individuals, training the inspiratory muscles leads to gains in the functioning of both these muscles and the expiratory muscles, but it is already known that the abdominal muscles are also related to the performance of the inspiratory muscles. Therefore, it is enough that one of the muscle groups has problems; the patient may have potential functional impairment, since there is a significant correlation between the MIP and MEP values, and the peak cough flow [22].

As for cough, the participants of this study predominantly obtained a cough classified as effective (70.6%). Coughing is a reflex mechanism for protecting the airways. This process depends on the generation of large volumes and the length of the

total lung capacity (TLC) pause before initiating forced expiration. The combination of these factors displaces secretion or a foreign body to the pharynx and mouth, where they are eliminated [10]. In the same institution, in 2018, a study was carried out that evaluated the effectiveness of the cough of patients hospitalized in the ward, those with thoracoabdominal injuries stood out with a higher percentage of ineffective cough compared to the other profiles of injuries and pathologies [31].

We found no correlation between pain complaints and respiratory function tests. Pain was assessed using the VAS scale, and 47.1% of participants in our study reported moderate pain. Pain is a significant symptom in the presence of rib fractures, due to the existence of costal nerves located at their edges [32]. Even individuals who do not need surgical interventions report deep pain, mainly in the first three days following the injury. Pain management improves vital capacity, chest expansion and inspiratory capacity. This implies a shorter hospital stay and more efficiency in performing breathing exercises and mobilization [7,33].

The present study has a marked limitation that must be highlighted. The sample calculation predicted 48 patients. For reasons beyond our control, in the period foreseen for data collection, the incidence of patients with FTD was lower than that observed in the historical series of the hospital service. The low number of patients enrolled in this study may not actually reflect the findings presented here.

Conclusion

We found a correlation between expiratory muscle strength and peripheral muscle strength in patients after chest trauma and with CTD. The strength parameters evaluated were lower than those expected in the literature.

Conflicts of interest

The authors declare that they have no conflicts of interest in the publication of this study.

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Authors' contributions

Conception and design of the study: Moreira SS, Souza LP, Gardenghi G; **Data collection:** Moreira SS, Campos MLS; **Statistical analysis:** Silva LSB, Gardenghi G; **Data interpretation:** Moreira SS, Nunes ELG, Nogueira AP, Gardenghi G; **Text composition:** Moreira SS; **Approval of the final version to be published:** Moreira SS, Pereira LS, Campos MLS, Silva LSB, Nogueira AP, Nunes ELG, Gardenghi G.

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