

Cough-induced rib fractures: A comprehensive analysis of 90 patients in a single center

Öksürüğe bağlı kaburga kırıkları: Tek merkezli 90 hastalık kapsamlı bir analiz

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ABSTRACT

Background: This study aims to evaluate clinical and radiological characteristics of the patients with cough-induced rib fractures.

Methods: Between January 2008 and December 2022, a total of 90 patients (35 males, 55 females; mean age: 58±20 years; range, 20 to 92 years) who had cough-induced rib fractures were retrospectively analyzed. Patients' characteristics, findings of physical and radiological examination, and patients' outcomes were recorded.

Results: Of the patients, 64% were postmenopausal, 37% had metabolic disease of the bone, and 21% had chronic cough. Cough etiology was acute upper respiratory tract infection (32%), followed by chronic obstructive pulmonary disease. Thoracic computed tomography documented 154 fractures. Cough-induced rib fractures were mostly on the right side (58%). Multiple fractures were more commonly seen in older patients (p=0.007), in the presence of novel coronavirus disease-2019 (COVID-19) pneumonia (p=0.03), and metabolic disease of the bone (p=0.01). Mostly the sixth rib was affected (23%). Most fractures (81.3%) affected the fourth to ninth ribs. Most fractures developed on the anterolateral aspect of the rib (51%). The mean duration of hospital stay was 5.0±1.6 days. Morbidity developed in one patient (1.1%) (hemothorax). Mortality occurred in two patients (2.2%) due to COVID-19 pneumonia and acute myocardial infarction.

Conclusion: Localized pain after cough should be investigated in terms of cough-induced rib fractures. Cough-induced rib fractures are mostly seen in the presence of acute upper respiratory tract infection, chronic obstructive pulmonary disease, and pneumonia. Postmenopausal women are more risky to develop cough-induced rib fractures. Multiple cough-induced rib fractures are common in the presence of metabolic disease of the bone, older age, COVID-19 pneumonia.

Keywords: Chest pain, cough, outcomes, rib fracture.

ÖZ

Amaç: Bu çalışmada öksürüğe bağlı kaburga kırığı olan hastaların klinik ve radyolojik özellikleri değerlendirildi.

Çalışma planı: Ocak 2008 - Aralık 2022 tarihleri arasında öksürüğe bağlı kaburga kırığı olan toplam 90 hasta (35 erkek, 55 kadın; ort. yaş: 58±20 yıl; dağılım, 20 to 92 yıl) retrospektif olarak incelendi. Hastaların özellikleri, fizik ve radyoloji muayene bulguları ve hasta sonuçları kaydedildi.

Bulgular: Hastaların %64'ü menopoz sonrası dönemdeydi, %37'sinde kemik metabolik hastalığı vardı ve %21'inde kronik öksürük vardı. Öksürüğün etiyojisi akut üst solunum yolu enfeksiyonu (%32) idi ve bunu kronik obstrüktif akciğer hastalığı takip ediyordu. Toraks bilgisayarlı tomografide 154 kırık belgelendi. Kırıklar çoğunlukla sağ taraftaydı (%58). Yaşlı hastalarda (p=0.007), yeni koronavirus hastalığı-2019 (COVID-19) pnömonisi (p=0.03) ve metabolik kemik hastalığı (p=0.01) olanlarda çoklu kırıklar daha sık görüldü. Çoğunlukla altıncı kaburga (%23) etkilenmişti. Kırıkların çoğu (%81.3) dördü ila dokuzuncu kaburgaları etkilemişti. Kırıkların çoğu (%51) kaburganın anterolateral kısmındaydı. Ortalama hastanede kalış süresi 5.0±1.6 gündü. Bir hastada (%1.1) morbidite (hemotoraks) gelişti. İki hastada (%2.2) COVID-19 pnömonisi ve akut miyokart enfarktüsü nedeniyle mortalite görüldü.

Sonuç: Öksürük sonrası lokalize ağrı, öksürüğe bağlı kaburga kırığı açısından araştırılmalıdır. Öksürüğe bağlı kaburga kırıkları çoğunlukla akut üst solunum yolu enfeksiyonu, kronik obstrüktif akciğer hastalığı ve pnömoni varlığında görülür. Menopoz sonrası kadınların öksürüğe bağlı kaburga kırığı geliştirme riski daha yüksektir. Birden çok öksürüğe bağlı kaburga kırığı metabolik kemik hastalığı, ileri yaş ve COVID-19 pnömonisi varlığında yaygındır.

Anahtar sözcükler: Göğüs ağrısı, öksürük, sonuçlar, kaburga kırığı.

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Doi: 10.5606/tgkdc.dergisi.2024.25655

Received: December 22, 2023

Accepted: December 25, 2023

Published online: January 29, 2024

Cite this article as: Özyurtkan MO, Arslan Ulukan Z, Temel U. Cough-induced rib fractures: A comprehensive analysis of 90 patients in a single center. Turk Gogus Kalp Dama 2024;32(1):69-74. doi: 10.5606/tgkdc.dergisi.2024.25655.



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Cough is an important mechanism helping the body to get rid of foreign substances or prevent their entry into the bronchial tree.^[1] Cough is usually an uncomplicated symptom, but can be related to complications, particularly when it is chronic. Occasionally, after the onset of coughing, some patients with persistent chest pain are found to have rib fracture.^[2] Nevertheless, the literature data about cough-induced rib fractures (CIRFs) have been sparse and limited primarily to case reports.^[1,3-8]

In the present study, we aimed to evaluate patients with CIRFs according to demographic characteristics, underlying pathology, radiological features of CIRF, treatment results, and complications.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Biruni University Medical Faculty, Departments of Emergency, Thoracic surgery, and Pulmonology between January 2008 and December 2022. Patients with chest pain were reviewed. Inclusion criteria were as follows: (i) acute (<3 weeks) or chronic (≥3 weeks) cough, (ii) chest pain developing after the onset of coughing, (iii) radiologically detected rib fracture, and (iv) no presence of trauma, metastatic disease, or other explanation for rib fracture were, as previously described.^[2] A total of 90 patients (35 males, 55 females; mean age: 58±20 years; range, 20 to 92 years) who met the inclusion criteria were recruited. Patients' characteristics, findings of physical and radiological examination, and patients' outcomes were recorded.

During the physical examination by palpation, increased sensitivity and pain were present in the fractured areas. All patients had both posteroanterior chest X-rays, but we obtained computed tomography (CT) of the chest to demonstrate missed fractures on chest X-ray, since we took CT of the chest as the absolute criterion in fracture diagnosis. The cause of the cough, and the site and number of fractured ribs were investigated. The rib fracture location by region (anterolateral, lateral, and posterolateral) was noted, as previously described.^[9,10] All patients were hospitalized and administered appropriate intravenous analgesics, expectorants, and oxygen therapy, if needed. Patients who developed no complications according to chest X-rays and showed improvement were discharged.

Statistical analysis

Statistical analysis was performed using the MedCalc Statistical Software version 12.7.7 (MedCalc Software BVBA, Ostend, Belgium). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max), or number and frequency. Continuous variables were compared using the Student t-test. Categorical variables were compared using the chi-square test or Fisher exact test. A *p* value of <0.05 was considered statistically significant.

RESULTS

Demographic and clinical features of the 90 patients are summarized in Table 1. Most female patients were likely postmenopausal (n=35, 64%). The

Table 1. Demographic and clinical features of 90 patients with CIRF

Variables	n	%	Mean±SD
Age (year)			58±20
Sex			
Female	55	61	
Chronic cough	19	21	
Metabolic disease of the bone (yes)	33	37	
Etiology			
Acute upper respiratory tract infection	28	32	
COPD	20	22	
Pneumonia (other than COVID-19)	20	22	
Asthma	12	13	
Pulmonary embolism	6	7	
COVID-19 pneumonia	4	4	

CIRF: Cough-induced rib fracture; SD: Standard deviation; COPD: Chronic obstructive pulmonary disease.

Table 2. Characteristics of rib fractures

Variables	n	%
Laterality		
Right	52	58
Left	33	37
Bilateral	5	5
Region of fracture		
Anterolateral	46	51
Lateral	28	31
Posterolateral	16	18
Multiple rib fracture	38	42
Number of fractured ribs		
1	52	58
2	21	23
3	10	12
4	4	4
5	2	2
6	1	1

median duration of cough was acute in most patients (n=71, 79%) ranging from 1 to 18 days. The mean duration of the onset of pain in these patients was 4±3 (range, 1 to 15) days. The etiology of the cough was mostly acute upper respiratory tract infection (n=28, 32%). Patients with acute upper respiratory tract infection (46 years vs. 63 years, p=0.0001) and asthma (47 years vs. 59 years, p=0.017) were

significantly younger, whereas patients with chronic obstructive pulmonary disease (COPD) (69 years vs. 54 years, p<0.001) and pulmonary embolism (70 years vs. 57 years, p=0.005) were significantly older. Thirty-three patients (37%) had previously known metabolic disease of the bone under treatment. Chest X-ray of 10 patients (11%) revealed fractured ribs, whereas CT of the chest demonstrated all rib fractures in 90 patients (100%).

Table 2 outlines the characteristics of rib fractures. A total of 154 fractured ribs were documented in 90 patients. Most rib fractures occurred on the right side (n=52, 58%). Five patients (5%) had bilateral rib fractures. Single rib fracture was mostly observed (n=52, 58%). Multiple rib fractures were significantly common in patients with older age (64 years vs. 53 years, p=0.007), with novel coronavirus disease-2019 (COVID-19) pneumonia (11% vs. 0%, p=0.03), and with previously known metabolic disease of the bone (53% vs. 25%, p=0.008). Also, postmenopausal women had significantly higher risk for developing multiple rib fracture (p=0.03). Coughing due to acute upper respiratory tract infection resulted less commonly multiple rib fracture (16% vs. 41%, p=0.01). Fracture on the anterolateral aspect of the rib predominated (n=46, 51%). Patients with rib fracture on the lateral aspect of the rib were significantly younger (49 years vs. 62 years, p=0.003). Details about the distribution of rib fractures to rib number are given in Figure 1. The sixth rib was the most commonly fractured rib (23%), followed by the fifth rib (16%). About 81.3%

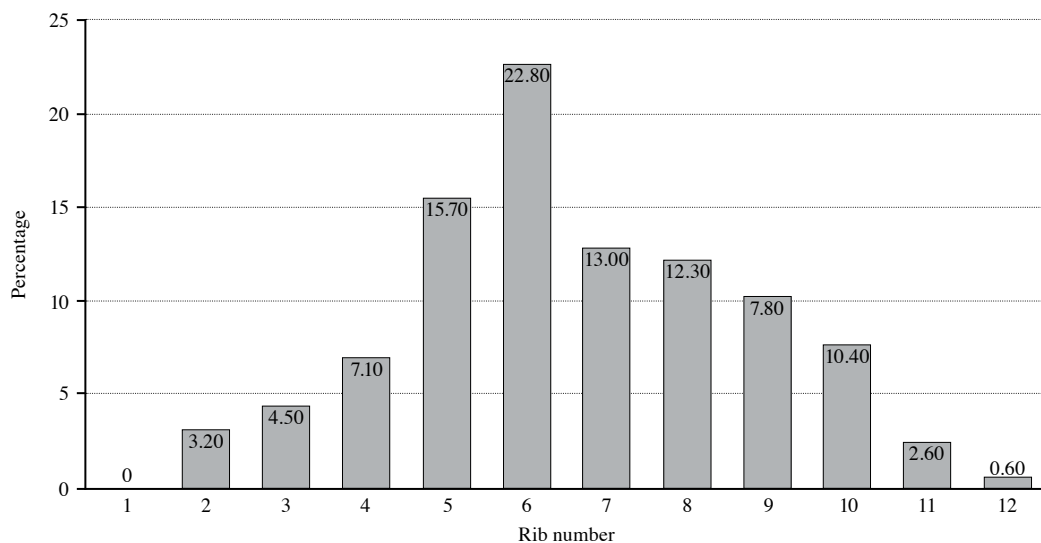


Figure 1. The distribution of rib fractures to rib number.

Table 3. Studies about cough-induced rib fractures consisting of more than 10 patients

Study	Year	Male		Mean age of the patients (years)	Acute cough	Chest X-ray positivity	Laterality		Mostly affected ribs	Multiple fractures	Region of the fracture
		n	%				n	%			
Hanak et al. ^[2]	2005	54	22	55±17	15	58	Right	31	6 th	50	Lateral (50)
							Left	43			
Katrancıoğlu et al. ^[11]	2015	12	58	56±12	NG	100	Bilateral		4 th to 9 th	41.7	NG
Sano et al. ^[12]	2015	14	71	40	NG	NG	Right	57	10 th	35.7	NG
							Left	43			
<i>This study</i>	2023	90	39	58±20	21	11	Right	58	6 th	42	Anterolateral (51)
							Left	37			
							Bilateral		5		

SD: Standard deviation; NG: Not given.

of the fractures (125 out of 154) affected the fourth to ninth ribs.

Treatment of rib fractures was supportive, no patients necessitated rib fixation. The mean duration of hospital stay was 5.0±1.6 (range, 2 to 11) days. One patient who was under the treatment of anticoagulation due to previous coronary artery disease developed mild hemothorax and pulmonary contusion which resolved without further intervention. Mortality occurred in two patients (2.2%). The first patient had COVID-19 pneumonia and died on Day 10, despite appropriate treatment. The second patient had severe COPD disease and died on Day 17 due to acute myocardial infarction. No further complication developed in the remaining 88 patients. All patients were followed at least two months without further complaints.

DISCUSSION

In the present study, we evaluated 90 patients with CIRFs. Their demographic characteristics were outlined. Fractured ribs were radiologically documented and detailed according to laterality, sites and number of fractures. Possible risk factors of CIRF were investigated. To the best of our knowledge, our study represents the largest case series of CIRF reported to date. There are only three more studies about CIRF consisting of more than 10 patients, as far as we know, and Table 3 outlines their results.^[2,11,12]

Rib fractures can be detected radiologically using several modalities. The simple modality is plain chest X-ray. However, standard radiography may not reveal up to 60% of rib fractures.^[13] Although it is easier to perform, fractures of the lower ribs and costal arch fractures are difficult to be detected due to intervening abdominal organs.^[1,12] Chest CT helps to diagnose rib fractures and it can also demonstrate other pulmonary diseases, although its disadvantages include higher cost and higher radiation exposure.^[12,14] Bone scintigraphy may show abnormal radionuclide concentrations on hidden fractures and in case of suspicion of CIRF in the presence of normal chest X-ray.^[13] We obtained chest X-rays for all our patients, which demonstrated obvious rib fracture in only 10 of them (11%). Then, CT of the chest was taken for all patients to better document rib fractures and look for additional pulmonary pathology. We did not have bone scintigraphy, since CT of the chest was enough to demonstrate all the fractures.

In our series, only one patient (1%) developed complication related to CIRF (mild hemothorax) related CIRF. Katrancıoğlu et al.^[11] and Sano et al.^[12]

reported no complications resulting from CIRF in their series. However, Hanak et al.^[2] reported several pathologies related to CIRF including hemothorax, pneumomediastinum, subcutaneous emphysema, chest wall hematoma, and intercostal pulmonary herniation in 14.8% of their patients. Other reported accompanying pathologies related to CIRF included diaphragmatic rupture and abdominal visceral herniation into the thoracic cavity,^[3,5,15] empyema,^[4] and pneumothorax.^[6]

We demonstrated the most frequently fractured rib was the sixth rib, similar to the study of Hanak et al.^[2] Contrary to this, the 10th rib was the most fractured one according to Sano et al.^[12] In general, CIRF mostly affect the fourth to ninth ribs.^[2,3,11,12] In our study, the distribution of CIRF was similar to the literature. About 81.3% of the fractures (125 out of 154) affected the fourth to ninth ribs. We detected multiple rib fractures in 42% of the patients (n=38). There are similar results in the literature.^[2,11,12] Most CIRF occurred in the lateral aspect of the rib.^[3,6-8] Hanak et al.^[2] reported that, in 50% of the fractured ribs, lateral aspect of the rib was affected. In our study, 31% of fractures were on the lateral aspect of the rib, but the majority of the fractures (51%) occurred in the anterolateral region of the rib.

The mechanism of CIRF can be explained in several ways. First of all, CIRF is accepted as a specific and less common type of stress fracture; thus, repetitive mechanical stress on the ribs with adaptive bone remodeling and muscle fatigue is thought to play a role in the development of the CIRF.^[13] Repeated trauma due to repetitive cough may cause inelastic deformation of the middle third of the ribs between the fifth and 10th ribs, which is the most vulnerable part of the rib, as well as of the costochondral junctions.^[16,17] This may result in minor cracks in the bone and, if the trauma continues, extends to complete fracture.^[18] Even costal cartilage fracture may occur due to this mechanism.^[19] The second mechanism is thought to be linked with contrary muscle forces acting on the ribs. Opposing action of intercostal muscles and other respiratory muscles on the same rib may weaken it, leading to fracture. The simultaneous contraction of the shoulder girdle muscles, mainly the serratus anterior, pulls the ribs upward and laterally, and the abdominal muscles pull the ribs downward and medially. This may contribute to the development of rib fractures.^[5] It was also reported that high intrathoracic pressure due to coughing might play a role in the development of

CIRF. The diaphragm is attached to the lower six ribs and their cartilages. The remaining expiratory muscles, the abdominal muscles (internal and external oblique), attach to the fourth through the 10th ribs at the midaxillary line. The inspiratory muscles (serratus anterior) attach at the same line. The opposing actions of these muscles on the ribs may result in cough fractures.^[20]

Several risk factors for the development of CIRF have been reported. Osteoporosis, COPD, prolonged use of high dose steroids, and asthma are among them.^[2,11] Coughing more than three weeks is also mentioned as a risk factor.^[2] All patients in the study of Katrancıoğlu et al.^[11] had reduced bone density. Although reduced bone density carries a risk for CIRF, it may occur in the presence of normal bone density.^[2] The CIRF is also common in older age, renal failure, pregnancy, mechanical ventilation, and radiation-therapy.^[21] It is also common in elderly and postmenopausal women.^[2] In our study, some of the mentioned risk factors of CIRF were present. In summary, 22% of our patients had COPD and patients with COPD were significantly older ($p < 0.001$). However, none of them had prolonged use of high-dose steroids. Twenty-one percent of our patients presented with history of coughing more than three weeks. Metabolic diseases of the bone (including osteoporosis) were present in 37% of our patients. Most female patients (64%) in our study were postmenopausal.

Katrancıoğlu et al.^[11] identified no significant relationship among multiple CIRF and the presence of COPD, osteoporosis, high dose steroid usage and asthma. No possible risk factors of multiple CIRF were studied elsewhere. In our study, we found that multiple CIRF was significantly common in older patients ($p = 0.007$), in the presence of COVID-19 pneumonia ($p = 0.03$), and of metabolic disease of bone ($p = 0.008$). Besides, it was insignificantly higher in COPD patients ($p = 0.08$). We also observed that fracture on the lateral aspect of the rib was common in young patients ($p = 0.003$). We can speculate that, although younger patients have stronger ribs, their strong respiratory muscles may cause higher level of repetitive and opposing forces to cause CIRF.

Although our study has the highest number of cases reported so far about CIRF, more detailed and multi-center studies are needed to better understand this pathology.

The main limitation to this study is that it is a single-center, retrospective study with small size of the patients.

In conclusion, one should be aware of that cough may cause rib fracture and should be suspected, when localized chest pain develops following coughing. Computed tomography of the chest is very helpful to document CIRF. Fourth to ninth ribs are more affected. Cough-induced rib fractures are mostly observed in the presence of acute upper respiratory tract infection, chronic obstructive pulmonary disease, and pneumonia. Postmenopausal women are more risky to develop cough-induced rib fractures. Multiple cough-induced rib fractures are mostly seen in the presence of metabolic disease of the bone, older age, and COVID-19 pneumonia.

Ethics Committee Approval: The study protocol was approved by the Şişli Hamidiye Etfal Training and Research Hospital Health Application and Research Center (SUAM) Clinical Research Ethics Committee (date: 19.12.2023, no: 4212). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Concept, design: M.O.Ö.; Supervision: Z.A.U.; Data collection: M.O.Ö., Z.A.U.; Analysis: M.O.Ö.; Literature review: U.T.; Critical review: M.O.Ö., Z.A.U.; U.T.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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