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Original Article

We need a common definition and treatment algorithm for displaced rib fracture

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ABSTRACT

Background: Displaced rib fracture (DRF) definition is frequently used to draw attention to severity and importance of fracture in daily practice. DRF is associated with increased morbidity and mortality in addition patients with DRF should be followed more carefully. Despite these characteristics, we do not have a clear definition for DRF concept and big differences of opinion among physicians could be monitored. In this study, we tried to reveal these perceptual differences and emphasized the importance of creating a common language for DRF.

Materials and Methods: We used a special and inventive survey form which contains visual section, true-false section and case reports. In the visual section, real tomography images and schematic drawings were presented to participants and asked which were compatible with DRF. In the true-false section, propositions about the definition of DRF were presented. Finally, imaginary trauma cases were presented and the minimum follow-up period was questioned.

Results: 156 physicians from 23 different center were included in the study. Of the participants, 56 (35.9%) were emergency physicians, 54 (34.6%) were thoracic surgeons and 46 (29.5%) were radiologists. The answers were statistically different for 3 tomography image ($p = 0.056$, $p < 0.001$, $p = 0.001$) and for 1 schematic drawings ($p = 0.001$). Again in 4 of the 7 true-false questions, there were significant differences between answers ($p = 0.001$, $p = 0.001$, $p = 0.005$, $p < 0.001$). The minimum follow-up period for a patient with DRF was also different between physicians, and have been recommended as 15.9 ± 2.2 (2-72 hours) by emergency physicians, 27.3 ± 5.5 (2-120) by radiologist and 31.5 ± 3.1 (2-120) by thoracic surgeons.

Conclusions: Our study clearly demonstrates a big conflict about DRF defination and treatment among physicians. There is also no consensus on the minimum follow-up time. We believe that our study will be a guide for multidisciplinary clinical studies on this subject.

Keywords: fractures, injuries, radiology, ribs, questionnaires, emergencies

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Introduction

Rib fracture is detected in about 10% of patients with thoracic trauma and the number of fractured ribs is an important indicator for determine the severity of trauma [1-3]. Similarly, displaced rib fractures (DRF) are known to be associated with severe thoracic organ injury and also with increased morbidity-mortality [1,4-7]. Additionally, late complications such as delayed hemothorax may develop, so longer hospital stays are recommended for patients with DRF. [1,4,8]. Despite these important features, the concept of ''DRF'' in daily practice seems to be interpreted differently by physicians. The same tomography image can be interpreted differently by different clinical physicians like radiologist/ thoracic surgeons and sometimes same clinical physicians also can not reach to a consensus. Similarly there are different definitions for DRF in the literature [1,3,9]. In this study, we aimed to reveal this disagreement concretely. In this respect, we used a unique and detailed survey form which consist of 3 stages (visual section, true/false section and case report). Participants were selected from, the emergency department physicians, thoracic surgeons and radiologist who were interested in thoracic trauma and the rib fractures. By revealing this disagreement and relativity about defination, we tried to explain why a "gold standard" definition is needed for DRF. We hope that, similar studies with clinical correlation about DRF is required for a correct definition and our study will be a pioneer for this ideas.

Material and Methods

Our study was organized as a prospective survey study. Ethic approval was obtained from the Health Sciences University, Izmir Bozyaka Training and Research Hospital Ethics Committee. Participants were chosen from faculty members, lecturers, specialist doctors and assistant doctors (who completed at least one year) who were employed in the thoracic surgery, emergency department and radiology clinics. All questionnaires were surveyed by a thoracic surgeon and all interviews were conducted face to face. Informed volunteer consent was obtained from all participants. We reached physicians working in different cities, different hospitals across the country and as a result, a total of 23 different clinics were included in the survey.

The questionnaire form was composed of three sections as: visual section, true-false section and case report section. The visual section consists two sub-section; in first part real tomography images used and in second part, a schematic rib drawing used. Tomography images were selected from patient's radiological exams who were followed-up in our clinic before (A written informed consent was also obtained from all patients for using tomography images). A total of 9 high resolution images were selected from patient's tomographies. These images were aligned from the minimally fracture to the severe displaced rib fracture (Figure 1). Participants were asked to choose the ones of these images which they think compatible with DRF. In second visual section (containing schematic drawings) the participants were asked to choose the options that were compatible with DRF (Figure 2). In this schematic drawing part, a descriptive drawing was also included to be used in the next part of survey (Figure 2). After these sections, the participants were asked about the definition of DRF and adjacent lung injury findings, and the participants were asked to mark propositions as ''true or false'' (Figure 3).

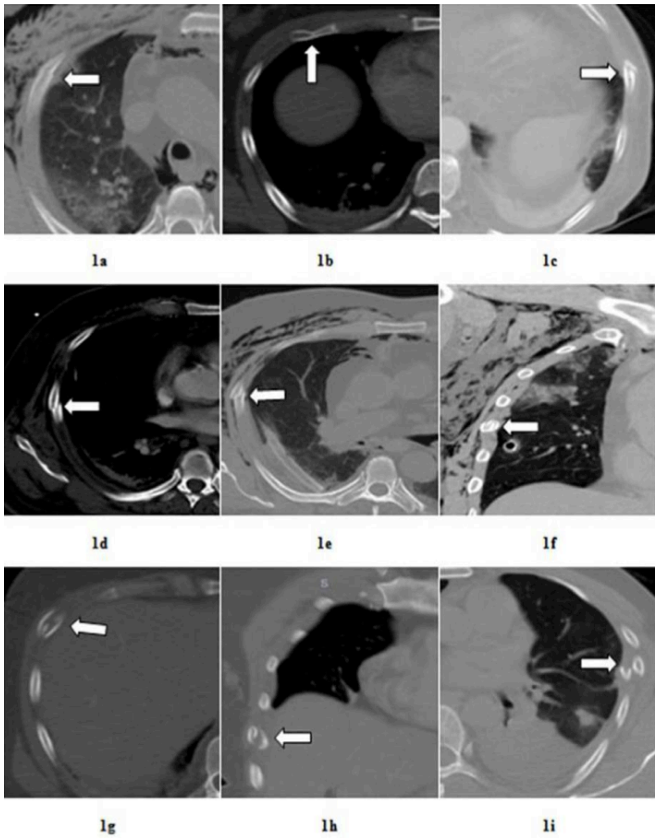

Figure 1. First visual section of the questionnaire generated from the actual tomography sections. The participants were asked to mark the tomography images that they found compatible with displaced rib fractures.

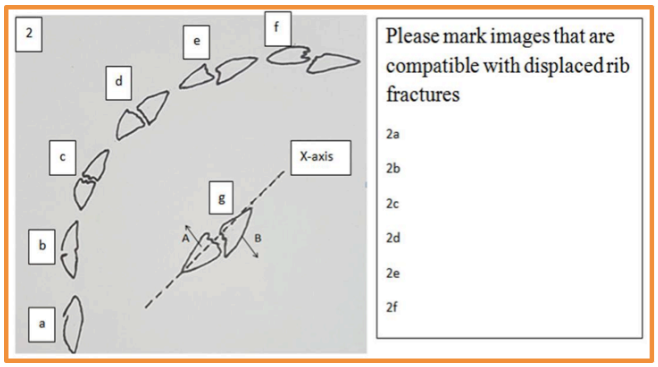

Figure 2. Questionnaire form, 2th question.

Please mark the following statements with "True" or "False"

3. If **pulmonary contusion** accompanied near the fractured rib, this evidence indicates a DRF

4. If **pulmonary laceration** accompanied near the fractured rib, this evidence indicates a DRF

5. If **traumatic bullae and blebs** accompanied near the fractured rib, this evidence indicates a DRF

Please mark the following statements with"True" or " False" by using schematic drawing 2g

6. If there is any angulation on fractured rib, this evidence is sufficient for the diagnosis of DRF

7. If the fracture line is limited on the single surface of the ribs (only A or B only surface), this fracture can not be diagnosed as DRF.

8. If the fracture line is extending from surface A to Surface B, this evidence is enough for DRF diagnosis.

9. For the diagnosis of DRF it is absolutely necessary that the fractured rib was moved on the X-axis.

10. In order to diagnose the DRF the fractured rib should be displaced at least 50% of the rib diameter on the X-axis.

Please indicate the minimum follow-up period in hours / days for the case presented below

11. A 25-year-old male patient without any additional disease / drug use was admitted with the complaint of falling. No pathological examination findings were observed except right side pain. In thoracic computed tomography, no pathological finding was found in the right 5th rib except for non-displaced rib fracture. What is the minimum follow-up period for this patient?

12. If the computed tomography of the same patient shows a displaced rib fracture, what should be the minimum follow-up period

Figure 3. Questionnaire form, 3-12 questions.

In the last part of survey, we tried to learn the minimal needed follow-up period which participants thought to be ideal for DRF and non-DRF patients. For this purpose, two imaginary cases were presented (Figure 3). In first case we presented a 25-year-old male patient with single and non-DRF in11th question, then we presented the same case in 12th question but this time with DRF. Firstly we asked whether the patient needed be hospitalized, if they recommended, we asked the minimum requirement length of hospitalization.

For each tomography image, the opinion of each physician was recorded as DRF/non-DRF. Answers were grouped as emergency physician's, thoracic surgeon's and radiologist's answers. The same process was applied for schematic drawing questions and ''true-false'' section too.

The post-hoc power value was also calculated. At 5% Type 1 error level for a total of 156 patients in 3 groups; the power achieved for the effect size (f = 0.3352) of the question 11 score was 96.82% and for the effect size (f = 0.3984) of the question 12 score was 99.56%.

Statistical Analysis

Descriptive statistics are summarized as counts and percentages for categorical variables; mean and standard deviations and median (minimum and maximum) for others. Shapiro-Wilk test was used to test normality of the continuous variables. The differences between two groups in terms of categorical variables were compared by using Chi-Square test. Differences among three or more groups for non-normally distributed continuous variables were evaluated by Kruskal-Wallis variance analysis. When the p-value from the Kruskal-Wallis test statistics is statistically significant, Dunn test was used to know which group differs from which others. P value less than 0.05 was considered significant. After comparing the 11th and 12th questions between the groups with the Kruskal-Wallis test, the Post-hoc power value was calculated using the GPower 3.1.9.2 software.

Results

Of the 156 physicians who participated in the study, 56 (35.9%) were from emergency department, 54 (34.6%) from thoracic surgery, and 46 (29.5%) from radiology clinics. For the first image, 48 (85.7%) emergency physicians evaluated the rib fracture as a ''non-DRF'' this ratio was 51 (94.4%) for thoracic surgeons and 45 (97.8%) for radiologists. The result of the statistical analysis showed that; majority of the participants evaluated this fracture as non-DRF, they were convinced on this issue and there was no statistically significant difference between the 3 group's answers for first question (p = 0.056). The same analysis were repeated for each tomography image. The differences between answers were significant especially in 1c, 1g, and 1h images (Table 1). For 1c image; 47 of the emergency physicians (83.9%) were defined fracture as non-DRF, this rate was 43 (79.6%) in thoracic surgeons and only 19 (41.3%) in radiologists. The statistical analysis of the three groups proved that the responses were significantly different (p < 0.001). The statistical analysis for 1g and 1h images were also similar (p = 0.001) and (p = 0.013), there were not a consensus among clinics. At the end of the tomographic images, it was seen that radiologists tend to evaluate rib fractures as ''displaced'' between all groups.

For schematic rib fracture drawings; differences in opinions were concentrated especially in 2d. For this image, 32 (57.1%) of emergency physicians, 35 (64.8%) of chest surgeons and 42 (91.3%) of radiologists reported their opinions in favor of DRF (p = 0.001) (Table 1).

Table 1. Answers to questions 1 and 2, and statistical analysis results.

Q. No	Emergency physicians				Thoracic surgeons				Radiologist				p
	DRF		Non-DRF		DRF		Non-DRF		DRF		Non-DRF		
	n	%	n	%	n	%	n	%	n	%	n	%	
1a	8	14.3	48	85.7	3	5.6	51	94.4	1	2.2	45	97.8	0.056
1b	16	28.6	40	71.4	11	20.4	43	79.6	11	23.9	35	76.1	0.603
1c	9	16.1	47	83.9	11	20.4	43	79.6	27	58.7	19	41.3	<0.001
1d	51	91.1	5	8.9	49	90.7	5	9.3	43	93.5	3	6.5	0.868
1e	51	91.1	5	8.9	48	88.9	6	11.1	45	97.8	1	2.2	0.225
1f	23	41.1	33	58.9	20	37.0	34	63.0	24	52.2	22	47.8	0.294
1g	12	21.4	44	78.6	16	29.6	38	70.4	26	56.5	20	43.5	0.001
1h	46	82.1	10	17.9	42	77.8	12	22.2	45	97.8	1	2.2	0.013
1i	56	100	0	0	53	98.1	1	1.9	45	97.8	1	2.2	0.561
2a	0	0	56	100	1	1.9	53	98.1	2	4.3	44	95.7	0.282
2b	1	1.8	55	98.2	2	3.7	52	96.3	4	8.7	42	91.3	0.231
2c	6	10.7	50	89.3	11	20.4	43	79.6	9	19.6	37	80.4	0.326
2d	32	57.1	24	42.9	35	64.8	19	35.2	42	91.3	4	8.7	0.001
2e	54	96.4	2	3.6	53	98.1	1	1.9	46	100	0	0	0.425
2f	56	100	0	0	54	100	0	0	46	100	0	0	-

Abbrev.: DRF: Displaced rib fracture. Non-DRF: Non-displaced rib fracture.

For 3th question ("true-false" section) similar answers were given between both clinics (p = 0.063) but there was a significant difference between the 4th question's answers. 45 (80.4%) of emergency department physicians described lung injury in the neighborhood of rib fracture as a finding in favor of DRF, this ratio was 27 (50.0%) among thoracic surgeons and 23 (50.0%) among radiologists (p = 0.001).

7th-10th questions were related to the defination of DRF and we obtained disagreement again. The statistical analysis result was (p = 0.047) for the 7th question, (p = 0.005) for 8th question, and (p < 0.001) for the 10th question (Table 2).

For patients who presented in 11th question; 31 of the emergency physicians (56.4%), 45 of thoracic surgeons (83.3%) and 18 of the radiologists (42.9%) thought that the patient should be hospitalized; other doctors declared that it was not necessary to hospitalize this patient. The results were statistically significant (p < 0.001). The suggested follow-up periods were also different. Median follow up period recemmonded by the emergency physicians was 6 (1-72) hours (95% CI: 2.71-12.13). These values were 12 (1-48) hours (95% CI: 7.46-19.20) for radiologists and 12 (2-48) hours (95% CI: 11.25-17.95) for thoracic surgeons. Differences among these groups were statistically significant (p < 0.001). In multi-group comparison, the answers of the emergency physicians for this question were found

Table 2. Answers to questions 3-10 and statistical analysis results.

Q. No	Emergency physicians				Thoracic surgeons				Radiologists				p
	True		False		True		False		True		False		
	n	%	n	%	n	%	n	%	n	%	n	%	
3	16	28.6	40	71.4	6	11.1	48	88.9	8	17.4	38	82.6	0.063
4	45	80.4	11	19.6	27	50	27	50	23	50	23	50	0.001
5	10	17.9	46	82.1	2	3.7	52	96.3	7	15.2	39	84.8	0.058
6	23	41.1	33	58.9	11	20.4	43	79.6	26	56.5	20	43.5	0.001
7	19	33.9	37	66.1	31	57.4	23	42.6	21	45.7	25	54.3	0.047
8	15	26.8	41	73.2	17	31.5	37	68.5	26	56.5	20	43.5	0.005
9	47	83.9	9	16.1	37	68.5	17	31.5	34	73.9	12	26.1	0.161
10	45	80.4	11	19.6	34	63.0	20	37.0	19	41.3	27	58.7	<0.001

to be significantly different from those of radiologists and thoracic surgeons (respectively $p = 0.030$ and $p < 0.001$). The answers of radiologists and thoracic surgeons did not make a significant difference ($p > 0.05$).

In the 12th question, most of the physicians [(92.7%) of emergency department physicians, (94.4%) of thoracic surgeons and (61.9%) of radiologists] declared that the patient should be hospitalized but results were different between clinics ($p = 0.001$) (Figure 4). Suggested hospitalization time were also different. Median suggested hospitalization time of emergency physicians was 6 (2-72) hours (95% CI: 11.63-20.33). These values were 24 (2-120) hours (95% Cl: 15.91-38.63) for radiologists and 24 (2-120) hours (95% CI: 25.38-37.60) for thoracic surgeons. Differences among these groups were statistically significant ($p < 0.001$). In multi-group comparison, the answers of the radiologists 12 th question were not found to be significantly different from those of emergency physicians and thoracic surgeons (respectively $p = 0.094$ and $p < 0.225$). The answers of emergency physicians and thoracic surgeons made a significant difference ($p < 0.01$). Average follow-up times were longer for all branches compared to the 11th question (Figure 5).

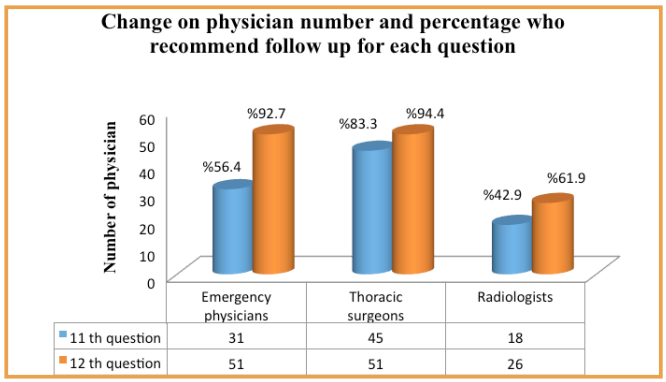

Figure 4. Change on physician number and percentage who recommend follow up for each question.

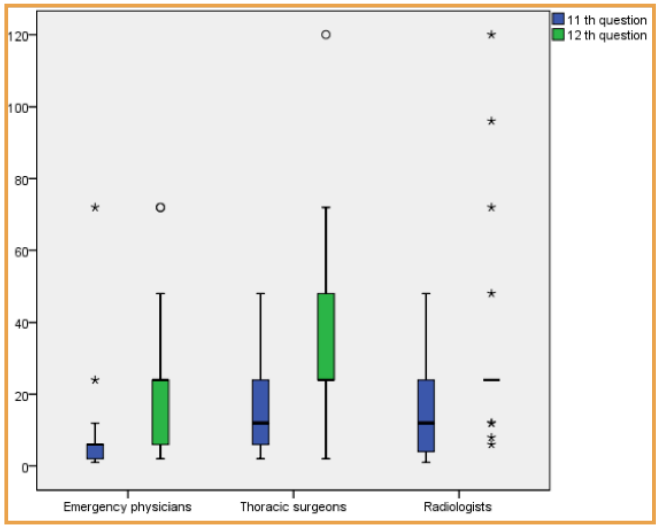

Figure 5. Recommended average follow-up times by each clinic physicians.

Discussion

Thoracic trauma is observed in 10-25% of all trauma cases and rib fracture is detected in 10% of cases with chest trauma [1-3]. As the number of fractured ribs increases, mortality and morbidity also increase. [9-12]. Similar to the number of fractured ribs, location of fracture (unilateral-bilateral), presence of flail chest, presence of displacement are also closely related with the severity of the trauma and the prognosis of the patient [1,3,13,14]. Due to these characteristics, rib fractures have started to be used in trauma scoring systems [1-3,9,13,14].

Displaced rib fractures can affect patients prognosis alone and may even cause mortality [4,5]. In patients with DRF, complications such as delayed hemothorax-pneumothorax could develop, so it is known that patients should be follow up longer than patients with non-DRF [1,4,8]. Despite these characteristics, DRF concept is perceived differently among physicians in both daily practice and also literature studies [1,3,9]. Chien et al [1] described DRF as; a displaced rib fracture was defined as a displacement distance at least half of the rib width fracture. Chapman et al [3] described severe DRF as; a severely displaced fracture was defined as displacement greater than the diameter of the rib with a total loss of contact between the proximal and the distal segment. Talbot et al [9] used these expressions for DRF definition as, when cortical disruption and a substantial abnormality in alignment are evident, a rib fracture is classified as displaced. Displacement may be minimal or obvious. Injury to the surrounding tissues and structures can occur, and several lethal complications have been documented in the literature. The starting point of our study originated from this complexity, disagreement and paradox. These different definitions in literature are frequently encountered in daily life too. The concept of DRF is often used by radiologists to point out a severe rib fracture and to alert the clinician. Again, DRF is perceived as a pathology by emergency physicians which calls for a consultation by thoracic surgeons. However, thoracic surgeons may determine same fractures as non-DRF. Similarly, while some thoracic surgeons may describe a fracture as DRF, others may describe as non-DRF. This definition confusion between clinics may cause serious problems and malpractice legal cases.

Our study reveals different opinions among the different branches and even in the same branch physicians. Question-1f is only one of these examples. While (41.1%) of emergency physicians defined fracture as DRF, (58.9%) rated as non-DRF. As same as, while (52.2%) of radiologists defined their opinions as DRF, (47.8%) rated as non-DRF. As it is seen, for the same tomography image, there is a big disagreement up to (50.0%) among the same branch physicians. Fourth question is another prominent question which exhibited great difference in terms of views among the same-clinic physicians. Participants were asked whether parenchymal laceration could be a finding in favor of DRF or not? It is known that parenchymal laceration can develop without a rib fracture, however, DRF is often accompanied by parenchymal damage. [15-17]. Nevertheless (50.0%) of thoracic surgeons stated that they found it "true" and (50.0%) found it "false". For the same question, (50.0% true - 50.0% false) rate was observed among the radiologists too. It is a surprising result that, although no statistically significant difference was found among the different clinic doctors ($p = 0.294$), up to (50.0%) of the differences were observed among the same clinics physicians.

Our study clearly shows that there is consensus in the extreme fracture images like 1a, 1b, 1i, 2a. But there are differences of opinion in intermediate forms (1c, 1g, 1h, 2d etc.). The features of the tomography images become important at this stage. In our study, we used a series of images extending from simple linear fractures to severe displacement fractures. It was already an expected finding that participants would reached consensus on the first and last images. If more diffucult images (difficult to distinguish) were used, more surprising results could have been observed.

One of the most crucial points of our study is the section of true-false questions in which the definition of displaced rib fracture is questioned. Here, the participants were asked what features must be present in a DRF. A large proportion of the participants reported that the displacement of more than (50.0%) of the thickness of the rib was alone sufficient for DRF. This finding was promising for a common diagnosis and consensus for DRF definition. This definition also corresponds with the Chien et al's [1] DRF definition and seems practical and acceptable. At this point, the direction of the displacement is also important. In our study, mostly transverse plane sections of tomography were presented to the participants. While making a decision, displacement on sagittal or coronal plane also may be considered.

In the final stage of our study, the participants reported different opinions for the patient with a single non-DRF. There were statistically significant difference about hospitalization indication ($p = 0.002$). Average follow-up times were also different (7.4 versus 14.6 hours). The most surprising result was that for the same patient, the same clinic physicians suggested different follow-up periods ranging from 1 hour to 72 hours. Finally, our survey also revealed that; pysicans do not recommend a follow-up period of more than 72 hours for a patient with single non-DRF.

When the same case was presented with DRF, recommended follow-up period increased significantly in all clinics answers. This finding is an expected result considering that important complications like delayed hemothorax can develop in patients with DRF. Therefore, they should be treated for a longer time and more carefully compared to the patients with non-DRF and this finding is also consistent with the literature [1,4,8]. For same question, the mean follow-up period of thoracic surgeons was approximately 2-fold longer than in the emergency department physicians (15.9 hours versus 31.5 hours). In additionally, the participants concluded that, 120 hours is enough for following a patient with single DRF. Although it is an assertive conclusion, it can be concluded that, if any delayed complication develop after 120 hours, doctors should not be blamed for an incomplete or inadequate treatment about follow up duration. This is one of the important points of our study. Serious mortal late complications may develop secondary to rib fractures. At this stage, if a patient dies due to late complication, it can be questioned whether the follow-up period is enough or has enough care been given to the to displaced rib. It is also clear that, if a malpractice lawsuit is filed on this issue, different follow-up times will be suggested by the experts and an emergency physician or a thoracic surgeon could face an unjust charge. Our study has already demonstrated that there will be such a difference of opinion. Our study has already demonstrated these differences of opinion

which we may encounter in the future. In this context, establishing a common treatment time algorithm will be protective for all branch physicians.

Our study was multi-centered and had a good participatory population from the different clinics, but there was no international participation. Selected visual survey models are also open to criticism. Tomography images showing transition from simple fractures to severe fractures. Different surveys can be prepare by selecting more compelling or difficult images. Thus, differences of opinion may become more pronounced. We tried to overcome this problem by using an additional schematic drawing.

Another deficiency in our study is seen in the ''true-false'' section. Since there was no similar questionnaire study before, a new method was used in our study and the questionnaire form was created by ourselves. For this reason, some important points could not be addressed. For example the subject of flail chest, which is a strong indicator of DRF, was not questioned in our survey. We hope that our study will lead similar studies and researchers will develop their own forms. The fact that the answers were not grouped in terms of professional experience in our study is another subject open to criticism. This may be one of the reasons why there are different opinions among the same branch. While there are serious differences of opinion among assistants with less professional experience, this distinction may become more obscure among faculty or experts. However, there were not enough data collected that would demonstrate this issue in a concrete way or prove the contrary in our study. Inclusion of assistant physicians in the study is another subject open to criticism. It should not be forgotten that rib fractures that do not cause complications such as hemothorax / pneumothorax can also be followed up by general practitioners. In this respect, all assistant physicians are also general practitioners and can follow the rib fracture.

We would like to emphasize that we did not aim to investigate which clinic detected DRF more accurately in our study. Since there is not an acceptable definition for DRF, we could not make a comparison between clinic's answers as ''true or false'' and we think that such a comparison is not ethically appropriate. Likewise, we avoid to express opinion about which clinic suggest the most correct and appropriate answer for follow-up time. Emergency physicians and thoracic surgeons can treats patients by different algorithms. However, it should be kept in mind that the treatment of rib fractures is basically the subject of thoracic surgery. Similarly, we do not pretend that we have a clear definition for DRF. We have not conducted a clinical study to establish which fractures should be classified as DRF. We did not get any information about which rib fractures had a worse prognosis, were associated with late complications, or had hight mortality. However, we hope that, our study will inspire new studies which have clinical correlations about this subject.

In conclusion, DRF always refers to a serious rib fracture and requires additional attention however, there is no clear definition yet. There are serious differences of opinion among clinicians. It has become imperative to make a definitive definition for the benefit of all physicians dealing with trauma. Our manuscript is the first study which reveal this confusion clearly.

Declaration of conflicting interests

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Ethics approval

Ethic approval was obtained from the Health Sciences University, Izmir Bozyaka Training and Research Hospital Ethics Committee, İzmir, Turkey (Decision no: 05).

Authors' contribution

ÖK; project administration, conceptualization, developed the methodology, co-write the paper, SA; conceived and designed the analysis, collected the data, BG; collected the data, contributed data analysis, SK; collected the data, performed the analytic calculations, TİA; validation, manuscript reviewing and editing, AÖ; formal analysis, contributed data/analysis tools, AGE; collected the data, formulated and evaluated research goals and aims, OA, BY; co-wrote the paper, collected the data, AAT; visualization, data presentation, AK; collected data, visualization, co-wrote the paper EZ; collected and processed the data, co-wrote the paper.

References

1. Chien CY, Chen YH, Han ST, Blaney GN, Huang TS, Chen KF. The number of displaced rib fractures is more predictive for complications in chest trauma patients. Scand J Trauma Resusc Emerg Med 2017; 25: 19-29.
2. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma 1994; 37: 975-9.
3. Chapman BC, Herbert B, Rodil M, Salotto J, Stovall RT, Biffl W et al. RibScore: a novel radiographic score based on fracture pattern that predicts pneumonia, respiratory failure, and tracheostomy. J Trauma Acute Care Surg 2016; 80: 95-101.
4. Boyles AD, Taylor BC, Ferrel JR. Posterior rib fractures as a cause of delayed aortic injury: a case series and literature review. Injury 2013; 44: 43-5.
5. Yanagawa Y, Kaneko N, Hagiwara A, Kimura T, Isoda S. Delayed sudden cardiac arrest induced by aortic injury with a posterior fracture of the left rib. Gen Thorac Cardiovasc Surg 2008; 56: 91-2.
6. Maxwell CA, Mion LC, Dietrich MS. Hospitalized injured older adults: clinical utility of a rib fracture scoring system. J Trauma Nurs 2012; 19: 168-74.
7. Chen J, Jeremitsky E, Philp F, Fry W, Smith RS. A chest trauma scoring system to predict outcomes. Surgery. 2014; 156: 988-93.
8. Simon BJ, Chu Q, Emhoff TA, Fiallo VM, Lee KF. Delayed hemothorax after blunt thoracic trauma: an uncommon entity with significant morbidity. J Trauma 1998; 45: 673-6.
9. Talbot BS, Gange CP Jr, Chatuverdi A, Klionsky N, Hobbs SK, Chaturvedi A. Traumatic Rib Injury: Patterns, Imaging Pitfalls, Complications, and Treatment. Radiographics 2017; 37: 628-51.
10. Sirmali M, Turut H, Topcu S, Gülhan E, Yazici U, Kaya S et al. A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. Eur J Cardiothorac Surg 2003; 24: 133-8.
11. Liman ST, Kuzucu A, Tastepe AI, Ulasan GN, Topcu S. Chest injury due to blunt trauma. Eur J Cardiothorac Surg 2003; 23: 374-8.
12. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM et al. Half-a-dozen ribs: the breakpoint for mortality Surgery 2005; 138: 717-23.
13. Daurat A, Millet I, Roustan JP, Maury C, Taourel P, Jaber S et al. Thoracic Trauma Severity score on admission allows to determine the risk of delayed ARDS in trauma patients with pulmonary contusion. Injury 2016; 47: 147-53.
14. Aukema TS, Beenen LF, Hietbrink F, Leenen LP. Validation of the Thorax Trauma Severity Score for mortality and its value for the development of acute respiratory distress syndrome. Open Access Emerg Med 2011; 3: 49-53.
15. Cohn SM, DuBose JJ. Pulmonary contusion: an update on recent advances in clinical management. World J Surg 2010; 34: 1959-70.
16. Wagner RB, Crawford WO Jr, Schimpf PP. Classification of parenchymal injuries of the lung. Radiology 1998; 167: 77-82.
17. Miller DL, Mansour KA. Blunt Traumatic Lung Injuries. Thorac Surg Clin 2007; 17: 57-61.