JCS Journal of Chest Surgery
https://doi.org/10.5090/jcs.23.134
pISSN: 2765-1606 eISSN: 2765-1614
J Chest Surg. 2024;57(5):430-439

Clinical Research

Routine 6-Week Outpatient Radiography and Visit in Patients with Conservatively Treated Multiple Rib Fractures: Valuable or a Waste of Resources?

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ARTICLE INFO
Received September 25, 2023
Revised January 26, 2024
Accepted February 5, 2024

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Background: This study investigated the incidence and clinical consequences of abnormal radiological and clinical findings during routinely performed 6-week outpatient visits in patients treated conservatively for multiple (3 or more) rib fractures.
Methods: A retrospective analysis was conducted among patients with multiple rib fractures treated conservatively between 2018 and 2021 (Opvent database). The primary outcome was the incidence of abnormalities on chest X-ray (CXR) and their clinical consequences, which were categorized as requiring intervention or additional clinical/radiological examination. The secondary focus was the incidence of deviation from standard treatment in response to the findings (clinical or radiological) at the routine 6-week outpatient visit.
Results: In total, 364 patients were included, of whom 246 had a 6-week visit with CXR. The median age was 57 years (interquartile range, 46–70 years) and the median Injury Severity Score was 17 (interquartile range, 13–22). Forty-six abnormalities (18.7%) were found on CXR. These abnormalities resulted in additional outpatient visits in 4 patients (1.5%) and in chest drain insertion in 2 (0.8%). Only 2 patients (0.8%) with an abnormality on CXR presented without symptoms. None of the 118 patients who had visits without CXR experienced problems.
Conclusion: Routine 6-week outpatient visits for patients with conservatively treated multiple rib fractures infrequently revealed abnormalities requiring treatment modifications. It may be questioned whether the 6-week outpatient visit is even necessary. Instead, a more targeted approach could be adopted, providing follow-up to high-risk or high-demand patients only, or offering guidance on recognizing warning signs and providing aftercare through a smartphone application.

Keywords: Multiple rib fractures, Conservative treatment, Follow-up, Radiography

Introduction

Rib fractures are a common occurrence in blunt thoracic trauma [1]. The standard treatment for multiple (3 or more) rib fractures, excluding flail chest, is conservative management, which consists of adequate analgesics, pulmonary physiotherapy, and respiratory support if needed [2]. Once patients are discharged, many hospitals in the Netherlands and Switzerland routinely plan an outpatient visit with a chest X-ray (CXR) after 6 weeks [3]. This time point is based on the standard intervals advised by the *Arbeitsgemeinschaft für Osteosynthesefragen* for all fractures. The clinical and radiological examinations performed during this visit are typically aimed at detecting potential

complications and assessing pain levels [4].

There is increasing evidence challenging the value of routine outpatient clinic visits and follow-up X-rays after traumatic fractures. A recent example is a randomized trial comparing routine 6-week X-rays to a reduced imaging approach in patients treated operatively for ankle fractures. This study showed no benefit of routine X-rays with regard to complications, functional outcomes, and pain [5]. This adds to existing evidence regarding the environmental impact of healthcare. In the Netherlands, a substantial 22% of all CO_2 emissions from the healthcare sector are attributed to the travel movements of healthcare staff and patients [6].

To the best of our knowledge, no studies have specifically investigated the value of CXR performed at the 6-week outpatient visit in patients with conservatively treated (multiple) rib fractures. Furthermore, the overall clinical value of this visit—both clinical and radiological—has not been examined. With healthcare burdens and costs on the rise, it is important to re-evaluate established clinical pathways, such as the routine 6-week visit and CXR, in order to determine whether they are still truly necessary in modern times.

The primary objective of this study was to determine the incidence of abnormalities observed on CXRs at the routine 6-week outpatient visit and evaluate their clinical consequences in patients treated conservatively for multiple rib fractures. The secondary outcome of interest was the incidence of deviation from normal management protocols in response to findings (clinical and/or radiological) at the routine 6-week outpatient visit.

Methods

Study design

This study is a retrospective analysis of all patients treated conservatively for multiple rib (non-flail) fractures included in the Opvent database in 2 out of the 6 level-1 trauma centers. The Opvent study is an international observational multicenter prospective study that included all patients with multiple rib fractures (treated both surgically and conservatively) between 2018 and 2021 [3]. In the Opvent study, patients with clinical flail chest or thorax deformity were treated operatively. Patients where a numerical rating scale score <5 could not be achieved with oral, intravenous and/or epidural analgesic treatment were also treated operatively. For patients without clear indications for surgery, treatment allocation (conservative or operative) was determined by the geographical location of the trauma and natural variation in preferred treatment methods among hospitals and countries [2,3,7]. Three centers treated these patients conservatively and 3 centers operatively. Thus, only 2 out of 6 trauma centers were selected for this study, as they were found to have included the majority of conservatively treated patients (598/873). The patients included in the present study were aged 18 years or older, were diagnosed with 3 or more computed tomography (CT)-confirmed rib fractures after blunt trauma, treated conservatively, and had an outpatient visit at 6 weeks after trauma. The exclusion criteria were surgical treatment and clinical flail chest. All patients, including those who did not visit the hospital at 6 weeks, were contacted by phone to ascertain whether their course of disease was uneventful 1 year after trauma. Patients were considered lost to follow-up when they had no physical 6-week check-up for any reason. Patients without a physical check-up were contacted by telephone to determine the reason for their absence.

This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [8]. Institutional review board approval of the University Medical Center Utrecht was obtained (NTR6833). Informed consent was obtained from all individual participants included in the study.

Baseline characteristics

The following patient and trauma characteristics were collected: sex, age, and American Society of Anesthesiologists score. The injury-related characteristics were the Injury Severity Score (ISS), the number of rib fractures, and the incidence of polytrauma and concomitant injuries (e.g., pneumothorax, hemothorax, pulmonary contusion, and sternum and clavicle fractures) [9-11]. Polytrauma was defined as an ISS≥16 and isolated thoracic injury as an Abbreviated Injury Scale score >2 for the thorax ≤2 for the other regions [12].

The following in-hospital parameters were collected: length of hospital stay, length of intensive care stay, incidence of invasive mechanical ventilation, insertion of chest drainage, and complications (i.e., pneumonia, pleural effusion, hemothorax, and pneumothorax). Pleural effusion, hemothorax and pneumothorax were classified as complications in case of any increase after the initial imaging post-trauma, independent of any treatment that was initiated. Pneumonia was defined as an infection of the lower respiratory tract with clinical signs and symptoms (temperature >38.5°C, auscultation suspected of infiltrate, pu-

rulent sputum, leukocytosis, and elevated C-reactive protein levels) requiring antimicrobial treatment [13].

Outcomes

The primary outcome of interest was the incidence of abnormalities seen on 2-plane CXR 6 weeks after trauma (e.g., rib dislocation, pleural effusion, or pneumothorax). An abnormality was defined as any new finding on the 6-week CXR compared to the last CXR taken before discharge. CXRs were administered as part of routine care at 6 weeks after trauma; however, all CXRs between 4 and 8 weeks after trauma were considered eligible. All abnormalities were categorized according to their clinical consequences, which included "no consequence," "additional examination" (clinical and/or radiological) or "intervention."

The secondary outcome of interest was the incidence of deviation from normal treatment protocols in response to findings (clinical and/or radiological) at the routine 6-week outpatient visit. As it was normal policy to discharge patients from outpatient follow-up after 6 weeks, all additional visits, interventions, or radiological examinations were considered a deviation. All outcomes are described separately for patients with isolated thoracic injuries and patients with combined injuries (thoracic injuries and concomitant injuries in other regions).

Statistical analysis

Statistical analyses were performed using IBM SPSS ver. 26.0 (IBM Corp., Armonk, NY, USA). All categorical variables are presented as counts with percentages (%). Continuous variables are presented as means and standard deviation for parametric data, or as median with interquartile range for nonparametric distributed data. The Shapiro-Wilk test was performed and Q-Q plots were drawn to evaluate the distribution of continuous variables. Nonparametrically distributed variables were compared using the Mann-Whitney U test (for ordinal/continuous variables) and the Pearson chi-square test (for dichotomous variables).

Results

In total, 598 patients managed conservatively for multiple rib fractures were identified from the database between January 2018 and March 2021. Of these, 233 patients were excluded (49 flail chest patients and 80 patients with surgically treated rib fractures). Of the 469 eligible patients, 104 were lost to follow-up; thus, 364 patients were included in the final analysis, of whom 246 (67.6%) had an outpatient visit with CXR and 118 patients (32.4%) had a visit without CXR. Fig. 1 shows a flowchart of patient inclusion.

Analysis of missing cases

Patients who were lost to follow-up had a higher intensive care unit (ICU) admission rate (35.6% versus 20.1%, p<0.001) and more frequently acquired in-hospital pneumonia (20.2% versus 11.0%, p=0.014) or developed in-hospital pneumothorax (6.7% versus 1.1%, p=0.003). All other baseline characteristics were comparable (Table 1).

Baseline characteristics

The baseline characteristics of all included patients are described in Table 1, and the baseline in-hospital parameters are presented in Table 2. Patients attending a 6-week outpatient visit without CXR had more concomitant sternum fractures than patients attending a check-up with CXR (12.2% versus 5.1%, p=0.033).

Primary outcome

A total of 46 abnormalities (18.7%) were found in the 246 patients who had a 6-week CXR. All abnormalities and their clinical consequence are described in Table 3. These abnormalities only had clinical consequences in 6 patients (2.4%), including an additional outpatient visit (n=4) and chest drainage (n=2). These patients are listed in Appendix 1. Thirty-one of the 46 abnormalities occurred in patients with isolated thoracic injuries, while 15 were observed in patients with combined injuries.

Of the 4 patients (case numbers 2, 3, 5, and 6) who required an additional visit, 3 experienced symptoms (difficulty swallowing, dyspnea, and rib shifting; case numbers 2, 3, and 6, respectively) (Appendix 1). The other patient had asymptomatic pneumothorax (case number 5), which resolved spontaneously during follow-up and did not require any intervention.

Of the 2 patients who received a chest drain, 1 experienced light dyspnea and 1 was asymptomatic. A detailed description of the clinical course of these patients can be found in Appendix 1 (case numbers 1 and 4).

Secondary outcomes

When focusing on the 6-week outpatient visit as a whole (both clinical and radiological findings), there were 2 pa-

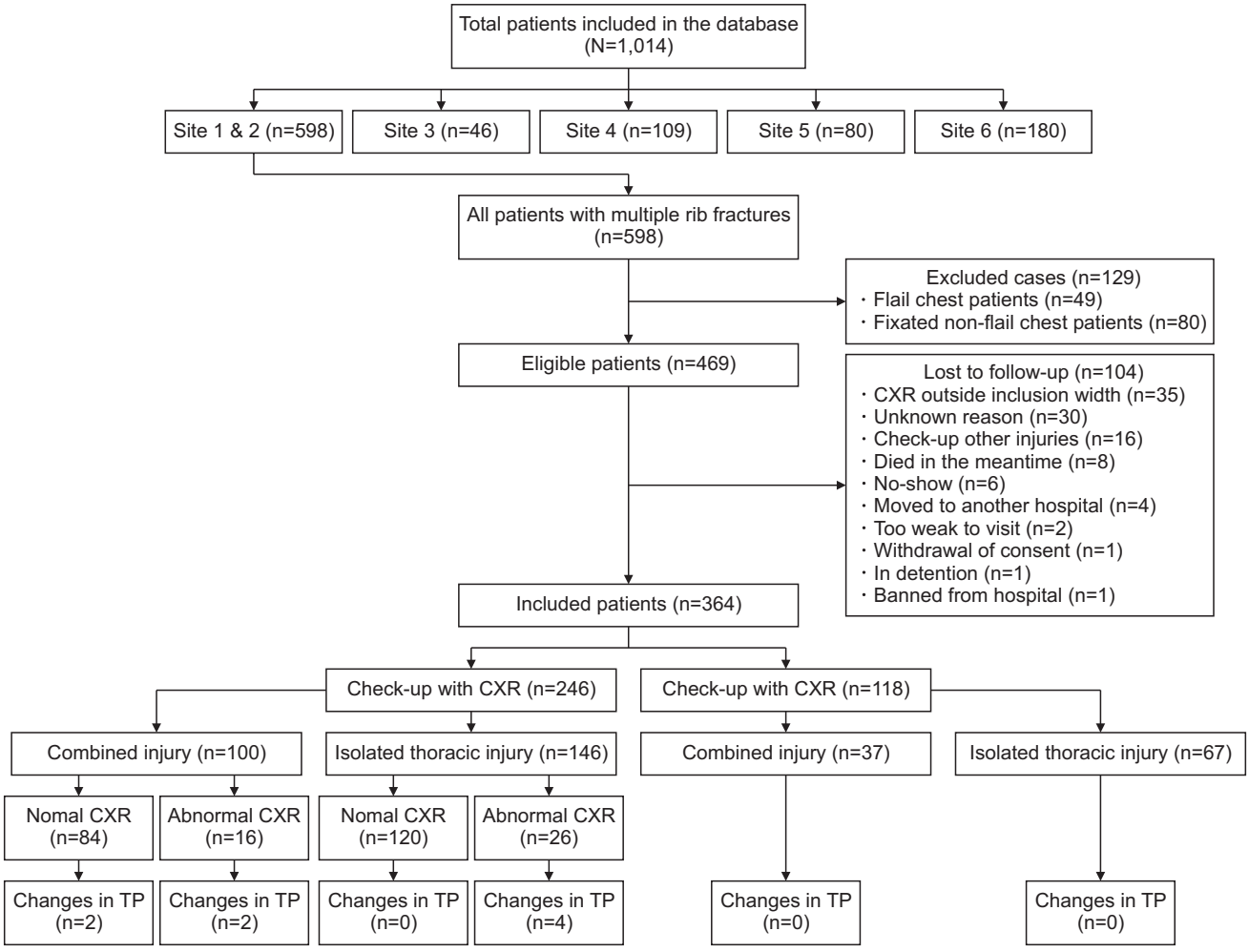

Fig. 1. Flow chart of patients in the study. CXR, chest X-ray; TP, treatment protocol.

tients with normal CXR findings who still experienced severe pain, prompting an additional outpatient visit to be scheduled (case numbers 7 and 8). These patients add up to the 7 previously described patients whose management changed based solely on their CXR. Eventually, 1 patient (case number 8) was treated for non-union of rib fractures. A detailed description of all patients whose treatment changed can be found in Appendix 1.

None of the 118 patients who had a 6-week visit without CXR experienced any problems. These patients were all discharged from outpatient follow-up.

Discussion

Summary of results

This study included 364 patients, of whom 246 had a follow-up visit with CXR and 118 patients had a follow-up visit without CXR. In 46 patients, an abnormality was found on CXR. These abnormalities had clinical consequences in only 6 patients, of whom 2 received chest drainage for pleural effusion and 4 had an additional visit planned. Notably, 4 of these 6 patients had symptoms indicating an abnormal course of disease. Additionally, there were 2 patients with severe pain and a normal CXR, who eventually were diagnosed with non-union of rib fractures based on a CT scan.

Comparison to previous literature

To our knowledge, only 2 studies have been published thus far that provide information on the value of follow-up CXR following rib fractures. In a retrospective study conducted by Deluca et al. [14] in 2022, a low incidence rate of pneumothorax/hemopneumothorax requiring tube thoracostomy (1.6%, n=6) was observed at 1-week CXR in pa-

https://doi.org/10.5090/jcs.23.134

Table 1. Baseline patient and trauma characteristics

Characteristic	Total	Included patients				Missed cases	p-value
		Total	Check-up with CXR	Check-up without CXR	p-value		
Total	468	364	246 (67.6)	118 (32.4)		104	
Demographic data							
Age at trauma (yr)	57 (46–70)	57 (46–68)	58 (46–70)	55 (42–66)	0.235	57 (47–72)	0.687
Male sex	327 (69.9)	256 (70.3)	170 (69.1)	86 (72.9)	0.460	71 (68.3)	0.686
ASA score							
1–2	352 (75.2)	281 (77.2)	183 (74.4)	98 (83.1)	0.065	71 (68.3)	0.063
3–4	116 (24.8)	83 (22.8)	63 (25.6)	20 (16.9)	0.065	33 (31.7)	0.063
Smoker[a]	89 (19.0)	71 (19.5)	46 (18.7)	25 (21.2)	0.585	18 (17.3)	0.673
Injury-related characteristics							
ISS	17 (13–22)	17 (13–22)	16 (13–22)	17 (14–22)	0.440	16 (13–22)	0.404
Polytrauma (ISS=16)[a]	245 (52.4)	193 (53.0)	123 (50.0)	70 (59.3)	0.095	52 (50.0)	0.586
No. of rib fractures	5 (4–7)	6 (4–7)	6 (4–8)	6 (4–7)	0.143	5 (4–6)	0.140
Isolated thoracic injury	282 (60.3)	215 (59.1)	146 (59.3)	69 (58.5)	0.874	67 (64.4)	0.321
Abbreviated Injury Scale							
Head	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	0.435	1 (0–2)	0.819
Neck	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.364	0 (0–0)	0.973
Spine	0 (0–2)	0 (0–2)	0 (0–2)	0 (0–2)	0.255	0 (0–2)	0.272
Abdomen	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0.766	0 (0–0)	0.062
Concomitant injuries							
Pneumothorax	206 (44.0)	168 (46.2)	118 (48.0)	50 (42.4)	0.316	38 (36.5)	0.081
Hemothorax	86 (18.4)	66 (18.1)	44 (17.9)	22 (18.6)	0.861	20 (19.2)	0.799
Pulmonary contusion	170 (36.3)	140 (38.5)	101 (41.1)	39 (33.1)	0.142	30 (28.8)	0.072
Sternum fracture	46 (9.8)	36 (9.9)	30 (12.2)	6 (5.1)	**0.033**	10 (9.6)	0.934
Clavicle fracture	100 (21.4)	76 (20.9)	52 (21.1)	24 (20.3)	0.861	24 (23.1)	0.630

Values are presented as number of patients (%) or median (interquartile range). Statistically significant results are marked in bold.
CXR, chest X-ray; ISS, Injury Severity Score.
[a]Might not add up due to missing data.

Table 2. Baseline in-hospital parameters

Variable	Total	Included patients				Missed cases	p-value
		Total	Check-up with CXR	Check-up without CXR	p-value		
Total	468	364	246 (67.6)	118 (32.4)		104	
Hospital length of stay	8 (4–13)	8 (4–13)	8 (4–13)	6 (3–13)	0.168	8 (4–16)	0.717
Need for ICU admission	110 (23.5)	73 (20.1)	46 (18.7)	27 (22.9)	0.351	37 (35.6)	**<0.001**
ICU length of stay	2 (1–5)	3 (1–5)	2 (2–5)	3 (1–6)	0.884	2 (2–5)	0.977
Need for IMV	67 (14.3)	49 (13.5)	33 (1.4)	16 (13.6)	0.970	18 (17.3)	0.323
Need for chest drainage	126 (26.9)	100 (27.5)	72 (29.3)	28 (23.7)	0.470	26 (25.0)	0.154
Complications							
Pneumonia	61 (13.0)	40 (11.0)	31 (12.6)	9 (7.6)	0.155	21 (20.2)	**0.014**
Pneumothorax	11 (2.4)	4 (1.1)	1 (0.4)	3 (2.5)	0.508	7 (6.7)	**0.003**
Hemothorax	13 (2.8)	9 (2.5)	7 (2.8)	2 (1.7)	0.067	4 (3.8)	0.452
Empyema	0	0	0	0	NA	0	NA
Pleural effusion	9 (1.9)	5 (1.4)	5 (2.0)	0	0.119	4 (3.8)	0.105
Other complications	115 (24.6)	86 (23.6)	65 (26.4)	21 (17.8)	0.070	29 (27.9)	0.374

Values are presented as number of patients (%) or median (interquartile range). Statistically significant results are marked in bold.
CXR, chest X-ray; ICU, intensive care unit; IMV, invasive mechanical ventilation; NA, not available.

Table 3. Number of abnormalities found on 6-week X-rays and their consequences

Variable	Pleural effusion	Pneumothorax	Secondary dislocation	Total
Deviations from the standard protocol for patients with isolated thoracic injury (n=146)				
No clinical consequences	19 (13.0)	0	8 (5.5)	27 (18.5)
Additional outpatient visit	1 (0.7)	1 (0.7)	1 (0.7)	3 (2.1)
Chest drainage	1 (0.7)	0	0	1 (0.7)
Deviations from the standard protocol for patients with combined injuries (n=100)				
No clinical consequences	9 (9.0)	2 (2.0)	2 (2.0)	13 (13.0)
Additional outpatient visit	1 (1.0)	0	0	1 (1.0)
Chest drainage	1 (1.0)	0	0	1 (1.0)

Values are presented as number of patients (%).

tients with fewer than 3 traumatic rib fractures. Sixty-five percent of the patients presented with respiratory distress, indicating the presence of a complication. Other symptoms were not mentioned. Based on their findings, the authors concluded that scheduled follow-up CXR examinations appear to be unnecessary. Instead, they recommended "symptom-triggered reappearance" for follow-up evaluations.

Bansidhar et al. [15] in 2002 also performed a comparable retrospective study. Among the 58 participants, only 2 individuals experienced a change in management as a direct consequence of the CXR. Regrettably, the authors neither provided the time interval between trauma and follow-up CXR, nor reported on whether the 2 patients were symptomatic or asymptomatic. They concluded that it is not necessary to perform routine follow-up CXR unless there is evident clinical deterioration.

It should be acknowledged that the aforementioned studies did not focus on CXR 6 weeks after trauma in patients with multiple rib fractures, as described in the present study. Nonetheless, if the likelihood of finding an abnormality 1 week after trauma on CXR is already small, the chances of finding an abnormality at 6 weeks should logically be even smaller.

Interpretation of results and clinical implications

It should be noted that changes in the treatment policy based on clinical and/or radiological findings during the 6-week outpatient visit were rare. If they did occur, the majority of patients (5 out of 7) demonstrated symptoms indicating an abnormal course of disease. Additionally, pleural effusion and small pneumothoraxes were frequently found 6 weeks after trauma. These, however, have little clinical implications when patients are asymptomatic, as they tend to resolve spontaneously [16]. The minor significance of radiological findings was also pointed out in a prospective study by Sweet et al. [17] on CXR after chest tube removal in patients with multiple rib fractures; 31% (n=68) of post-removal CXRs showed intrathoracic pathologies, but only 3% (n=2) needed re-intervention. These findings prompt the question of whether the 6-week outpatient visit and routine CXR are necessary or could be omitted.

Omitting the 6-week visit, however, would inevitably lead to missing asymptomatic patients who have a complication requiring treatment that is only detectable by CXR. Although the risk is extremely small, one should ask oneself how much one is willing to accept at the benefit of decreasing the healthcare burden and costs. Moreover, a follow-up visit also contributes to a certain level of reassurance for both the patient and the surgeon. It should also be taken into account that rib fractures are frequently accompanied by other injuries. Therefore, a follow-up appointment frequently encompasses the evaluation of not only rib fractures, but also other injuries (e.g., clavicle, sternum, scapula fractures). The decision to skip or arrange a follow-up visit, with or without CXR, should be thoughtfully considered.

There are several alternatives that might solve these problems, while simultaneously limiting the number of 6-week visits. For instance, the treating surgeon may be more selective in planning follow-up visits and only offer these visits to patients who strongly prefer them or in situations where careful monitoring is warranted due to specific reasons (e.g., comorbidities, necessary follow-up for other injuries, or difficulties during initial treatment). Secondly, physical visits could be replaced by telephone check-ups if a physical check-up is not indicated per se. Thirdly, mobile e-health applications could also be used as a replacement for routine follow-up visits during the initial weeks after treatment. These applications could assess daily questionnaires alerting patients when a visit should be

planned, while providing them with instructions on aftercare [18,19]. Several applications are already in use in other fields (e.g., for the conservative treatment of non-complicated fractures) that have proven their worth by reducing the number of outpatient clinic visits by 91% and follow-up imaging by 72% [20].

Limitations

There are several limitations that need to be considered. Firstly, there was a considerable number of patients who were lost to follow-up (104/364). Missing case analysis showed differences in baseline characteristics, with a higher need for ICU admission and a higher incidence of pneumonia and pneumothorax among the missing patients compared to the included cases. This might be a sign suggesting some degree of selection bias. These patients apparently had a more severe initial course of disease and would also be expected to have a higher chance of developing complications during follow-up, which should contribute to a higher incidence of abnormalities on CXR or clinical examination at the 6-week visit. However, we could not think of a logical explanation for why a treating physician would structurally refrain from following up with patients more strictly if the initial course was already abnormal. It might very well be possible that these differences were caused by mere chance. Additionally, the occurrence of complications such as pneumonia and/or pneumothorax are both related to the need for ICU admission. As such, it is not unexpected to find that multiple variables differ from the included cases if there is a correlation between them.

Secondly, it is essential to recognize the retrospective nature of this study and the exclusion of operated patients from the analyses and outcomes. Surgically treated patients most likely had more severe injuries and potentially were more prone to develop adverse events during follow-up. Therefore, the results in the present study, which are based on a conservatively managed group, cannot be extrapolated to surgically managed patients.

Thirdly, this study was conducted at 2 level-1 trauma centers. The results cannot be directly extrapolated to level-2 and level-3 centers, where the proportion of polytrauma patients would be lower. Nevertheless, as monotrauma patients have a lower likelihood of developing complications, the proportion of patients with abnormal findings during the 6-week follow-up visit would logically be even lower.

Conclusions

The routine 6-week outpatient visit, with or without CXR, for patients with conservatively treated multiple rib fractures seldom reveals abnormalities requiring treatment modifications. In rare cases of complications, patients almost always demonstrate symptoms prompting the need for further evaluation. It may be questioned whether, in light of these findings, the 6-week outpatient visit is even necessary. Instead, a more targeted approach could be adopted.

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Conflict of interest

No potential conflict of interest relevant to this article was reported.

Funding

This work was financially supported by DePuy Synthes; grant number DPS-TCMF-2017-036 and registered in the Netherlands Trial Register (NTR6833).

Acknowledgments

This work was part of the activities of the Natural Experiments Study Group (www.next-studygroup.org).

References

1. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. J Trauma 1994;37:975-9. https://doi.org/10.1097/00005373-199412000-00018
2. Hoepelman RJ, Beeres FJ, Beks RB, et al. Non-operative vs. operative treatment for multiple rib fractures after blunt thoracic trauma: a multicenter prospective cohort study. Eur J Trauma Emerg Surg 2023;49:461-71. https://doi.org/10.1007/s00068-022-02093-9
3. Beks RB, de Jong MB, Sweet A, et al. Multicentre prospective cohort study of nonoperative versus operative treatment for flail chest and multiple rib fractures after blunt thoracic trauma: study protocol. BMJ Open 2019;9:e023660. https://doi.org/10.1136/bmjopen-2018-023660
4. Baumgaertner M, Lambert S, Nousiainen MT. Adult trauma [Internet]. AO Surgery Reference; c2023 [cited 2023 Dec 18]. Available from: https://surgeryreference.aofoundation.org/orthopedic-trauma/adult-trauma
5. van Gerven P, Rubinstein SM, Nederpelt C, et al. The value of radiography in the follow-up of extremity fractures: a systematic review. Arch Orthop Trauma Surg 2018;138:1659-69. https://doi.org/10.1007/s00402-018-3021-y
6. De Bruin J, Houwert T, Merkus K. A steering wheel for the transition to sustainable healthcare [Internet]. Amsterdam: Gupta Strategists; 2019 [cited 2023 Aug 7]. Available from: https://gupta-strategists.nl/storage/files/1920_Studie_Duurzame_Gezondheidszorg_DIGITAL_DEF.pdf
7. van de Wall BJ, Stadhouder A, Houwert RM, et al. Natural experiments for orthopaedic trauma research: an introduction. Injury 2023;54:429-34. https://doi.org/10.1016/j.injury.2022.11.028
8. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344-9. https://doi.org/10.1016/j.jclinepi.2007.11.008
9. Palmer CS, Gabbe BJ, Cameron PA. Defining major trauma using the 2008 Abbreviated Injury Scale. Injury 2016;47:109-15. https://doi.org/10.1016/j.injury.2015.07.003
10. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma 1974;14:187-96.
11. Pape HC, Remmers D, Rice J, Ebisch M, Krettek C, Tscherne H. Appraisal of early evaluation of blunt chest trauma: development of a standardized scoring system for initial clinical decision making. J Trauma 2000;49:496-504. https://doi.org/10.1097/00005373-200009000-00018
12. Committee on Trauma American College of Surgeons. Resources for optimal care of the injured patient (2014 standards). American College of Surgeons; 2014.
13. Mani CS. Acute pneumonia and its complications. In: Long SS, Prober CG, Fischer M, editors. Principles and practice of pediatric infectious diseases. Elsevier; 2018: p. 238-49. https://doi.org/10.1016/B978-0-323-40181-4.00034-7
14. Deluca A, Deininger S, Wichlas F, et al. Follow-up chest X-rays in minor chest trauma with fewer than three rib fractures: a justifiable, habitual re-imaging industry? Healthcare (Basel) 2022;10:2471. https://doi.org/10.3390/healthcare10122471
15. Bansidhar BJ, Lagares-Garcia JA, Miller SL. Clinical rib fractures: are follow-up chest X-rays a waste of resources? Am Surg 2002;68:449-53. https://doi.org/10.1177/000313480206800511
16. Zarogoulidis P, Kioumis I, Pitsiou G, et al. Pneumothorax: from definition to diagnosis and treatment. J Thorac Dis 2014;6(Suppl 4):S372-6. https://doi.org/10.3978/j.issn.2072-1439.2014.09.24
17. Sweet AA, Kobes T, Houwert RM, et al. The value of chest radiography after chest tube removal in nonventilated trauma patients: a post-hoc analysis of a multicenter prospective cohort study. J Trauma Acute Care Surg 2023 Sep 20 [Epub]. https://doi.org/10.1097/TA.0000000000004105
18. Ding K, Sur PJ, Mbianyor MA, et al. Mobile telephone follow-up assessment of postdischarge death and disability due to trauma in Cameroon: a prospective cohort study. BMJ Open 2022;12:e056433. https://doi.org/10.1136/bmjopen-2021-056433
19. Scherer J, Keller F, Pape HC, Osterhoff G. Would patients undergo postoperative follow-up by using a smartphone application? BMC Surg 2020;20:229. https://doi.org/10.1186/s12893-020-00889-3
20. Geerdink TH, Haverlag R, van Veen RN, Bouwmeester OV, Goslings JC. Direct discharge from the ED for patients with simple stable injuries: a Dutch pilot study. Ned Tijdschr Geneeskd 2020;164:D4604.

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Appendix 1. Clinical course of patients in whom was deviated from standard care protocol

Case no.	Age (yr)	ASA	Trauma mechanism	No. of fractures	Concomitant trunk injuries	Abnormalities 6-week X-ray	Symptoms	Clinical course	Deviation of standard protocol
1	46.8	1	Single-car accident	6	Long contusion	Large pleural effusion	None	At the 6-week follow-up a new large pleural effusion without symptoms was found. A thorax drain was inserted for a length of 2 days (directly drained 800 mL), and afterwards three check-ups with X-rays showed a decreasing amount of effusion. Not using anticoagulants at trauma.	Insertion of thorax drain
2	61.2	3	Single-bicycle accident	7	Pneumothorax (VATS), pneumonia	Small pleural effusion	Swallowing issues	After all, the surgeons suspected that it was not a diaphragm issue but rather a locked pleural effusion. After 12 weeks, the effusion has reduced somewhat, but not completely. No additional follow-up appointments were deemed necessary.	12-week out-patient visit with X-ray
3	46.8	2	Pedestrian vs. car	9	Lung contusion, hemothorax, spleen laceration	Large pleural effusion	Dyspnea	A thorax drain was inserted during the initial hospitalization due to pleural effusion, and was removed 11 days later. Two weeks after that, the patient was discharged with only a spleen drain. However, during a follow-up appointment 1 week later, there was a large pleural effusion again (which occurred 6 weeks after the trauma) and the patient experienced dyspnea. No thorax drain was needed. At the 12-week visit with X-ray pleural effusion was gone.	12-week out-patient visit with X-ray
4	71.8	2	Scooter/car accident	9[a)]	None	Large hemothorax and new dislocation	Only little stress dyspnea	The patient was referred by his general practitioner after 6 weeks due to an amputation wound on the toe. At the emergency department, a large pleural effusion (blood) and new dislocated rib were discovered with only little stress dyspnea. A thorax drain was inserted (for a length of 6 days), and 1,200 mL of fluid was directly drained. Antibiotics were started as a precautionary measure against empyema, but it was later confirmed that the patient did not have it. One month later, the patient underwent thoracotomy, and the thorax drains remained in place due to persisting hemothorax.	Insertion of thorax drain and eventually thoraco-tomy

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https://doi.org/10.5090/jcs.23.134

Appendix 1. Continued

Case no.	Age (yr)	ASA	Trauma mechanism	No. of fractures	Concomitant trunk injuries	Abnormalities 6-week X-ray	Symptoms	Clinical course	Deviation of standard protocol
5	45.9	1	Single-bicycle accident	6	Lung contusion, pneumothorax	Large pneumothorax and small pleural effusion	None	At the 12-week follow-up, no complaints were reported and there were no further consequences. At 1 year, everything was normal.	12-week outpatient visit with X-ray
6	57.0	3	Horse kick	7	Lung contusion, hemothorax and pneumothorax	Exacerbated dislocation	Shifted feeling of the ribs and pain	After an 18-week follow-up without X-ray, the pain had significantly decreased, and after 1 year, the ribs remained stable.	18-week outpatient visit without X-ray
7	22.1	1	Motor/car accident	5	None	None	Heavy pain	Persisting chest wall pain was reported at 6 weeks without abnormalities on X-ray. An X-ray was planned at 12 weeks and revealed non-consolidation of one rib and persisting pain. Two years later, the patient underwent planned rib fixation.	12-week outpatient visit with X-ray
8	70.1	2	Single-scooter accident	7	Lung contusion	None	Heavy pain	Due to severe pain in the ribs and arm, a 12-week check-up was scheduled without an X-ray. The pain has since decreased, and no additional follow-up was deemed necessary.	12-week outpatient visit without X-ray

ASA, American Society of Anesthesiologists; VATS, video-assisted thoracoscopic surgery.
[a]Radiological flail chest.