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PURPOSE: The aim of this systematic review was to assess the necessity of routine chest radiographs after chest tube removal in ventilated and nonventilated trauma patients.

METHODS: A systematic literature search was conducted in MEDLINE, Embase, CENTRAL, and CINAHL on May 15, 2020. Quality assessment was performed using the Methodological Index for Nonrandomized Studies criteria. Primary outcome measures were abnormalities on postremoval chest radiograph (e.g., recurrence of a pneumothorax, hemothorax, pleural effusion) and reintervention after chest tube removal. Secondary outcome measures were emergence of new clinical symptoms or vital signs after chest tube removal.

RESULTS: Fourteen studies were included, consisting of seven studies on nonventilated patients and seven studies on combined cohorts of ventilated and nonventilated patients, all together containing 1,855 patients. Nonventilated patients had abnormalities on postremoval chest radiograph in 10% (range across studies, 0–38%) of all chest tubes and 24% (range, 0–78%) of those underwent reintervention. In the studies that reported on clinical symptoms after chest tube removal, all patients who underwent reintervention also had symptoms of recurrent pathology. Combined cohorts of ventilated and nonventilated patients had abnormalities on postremoval chest radiograph in 20% (range, 6–49%) of all chest tubes and 45% (range, 8–63%) of those underwent reintervention.

CONCLUSION: In nonventilated patients, one in ten developed recurrent pathology after chest tube removal and almost a quarter of them underwent reintervention. In two studies that reported on clinical symptoms, all reinterventions were performed in patients with symptoms of recurrent pathology. In these two studies, omission of routine postremoval chest radiograph seemed safe. However, current literature remains insufficient to draw definitive conclusions on this matter, and future studies are needed. (*J Trauma Acute Care Surg.* 2021;91: 427–434.

LEVEL OF EVIDENCE: Systematic review study, level IV.

KEY WORDS: Chest tubes; postremoval chest radiograph.

Traumatic injuries are one of the leading causes of death, also in Western countries, with thoracic trauma being one of the main causes.[1,2] Injuries to the chest have a described mortality rate varying between 5% in patients with isolated injuries and 30% in multiple injuries patients.[2–4] More than half of the multiple injuries patients who suffer an injury to the chest require a chest tube to treat a pneumothorax or hemothorax.[5]

Chest tubes may cause complications, during drainage and after removal, with recurrence of the pneumothorax being one of the major postremoval complications.[6–9] For that reason, it is common practice to routinely take chest radiographs after placement but also after removal to evaluate residual or recurrent pathology.[10,11] There has been debate about the optimal timing of post removal chest radiography but also whether a postremoval chest radiograph is indicated at all.[12,13] Several studies in pediatric and cardiothoracic surgery suggest that the clinical value of the routine postremoval chest radiographs is low, as compared with selective use of chest radiographs only, and that it may be cost effective to only use selective chest radiographs in patients who demonstrate clinical symptoms.[14–21] Evidently, as global health care costs are rising, avoidable costs such as irrelevant diagnostics, which may lead to a prolonged hospital length of stay, should be prevented as well as unnecessary radiation exposure.[22]

Even though there seems to be a trend toward omission of the postremoval chest radiograph in various disciplines, studies on this subject in trauma patients are scarce, and so consensus remains absent. Therefore, this systematic review aims to assess the necessity of routine chest radiographs after chest tube removal in ventilated and nonventilated trauma patients.

PATIENTS AND METHODS

In this systematic review, the Preferred Reporting Items for Systematic Reviews and Meta-analyses and Meta-Analysis of Observational Studies in Epidemiology guidelines were

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followed.[23,24] These checklists were followed to improve transparent and complete reporting in this review. A research protocol for this study has not been published.

Search Strategy and Eligibility Criteria

A structured literature search was conducted for studies reporting on chest radiograph findings after chest tube removal in trauma patients in the MEDLINE, Embase, CENTRAL (Cochrane Central Register of Controlled Trials), and CINAHL (Cumulative Index to Nursing and Allied Health Literature) databases on May 15, 2020. Keywords in the literature search were chest tubes, removal, chest radiography, and synonyms of these search terms. The complete search syntax is described in Appendix 1 (Supplemental Digital Content, http://links.lww.com/TA/B917).

All studies reporting on chest radiographs, clinical symptoms, and reintervention after removal of the chest tube in trauma patients were included. Distinction was made between studies reporting on nonventilated patients only and studies reporting on a mixed cohort of ventilated and nonventilated patients. Studies reporting on a mixed cohort were reported separately, as patients with more severe chest injuries more often require mechanical ventilation and may develop worse outcomes.[25] Exclusion criteria were studies in a language other than English, German, or Dutch; studies on pediatric or nontrauma patients; case reports; and reviews or if no full text was available. Furthermore, references of included studies were screened to detect additional eligible studies.

Data Extraction

Two reviewers (A.S. and R.B.) independently extracted the following data of the included studies with a prespecified extraction file: first author, year of publication, study period, study design, country, observed study populations, number of patients, number of chest tube removals, age, sex, Injury Severity Score (ISS), mechanism of trauma, number of patients with bilateral chest tubes, indication for initial chest tube placement and indication for chest tube removal, chest tube duration and hospital length of stay, time until postremoval chest radiograph, minimum time on water seal before removal, and maximum fluid output before removal.

Outcome Measures

Primary outcome measures were abnormalities on postremoval chest radiograph, which was further specified into pneumothorax and other findings on chest radiograph (e.g., hemothorax, pleural effusion), and reintervention after chest tube removal (e.g., replacement of the chest tube, video-assisted thoracic surgery [VATS], thoracotomy, or thoracentesis). Secondary outcome measures were emergence of new clinical symptoms (e.g., chest pain, dyspnea) or new vital signs (e.g., tachypnea, tachycardia, decreased oxygen saturation, hemodynamic instability) after chest tube removal.

Quality Assessment

The methodological quality of all included studies was assessed independently by two reviewers (A.S. and R.B.), using the Methodological Index for Nonrandomized Studies (MINORS) score.[26] The MINORS is a validated instrument designed to assess the methodological quality of nonrandomized surgical studies.[26] The MINORS score ranges from 0 to 24, with higher scores representing better methodological quality. More details of the

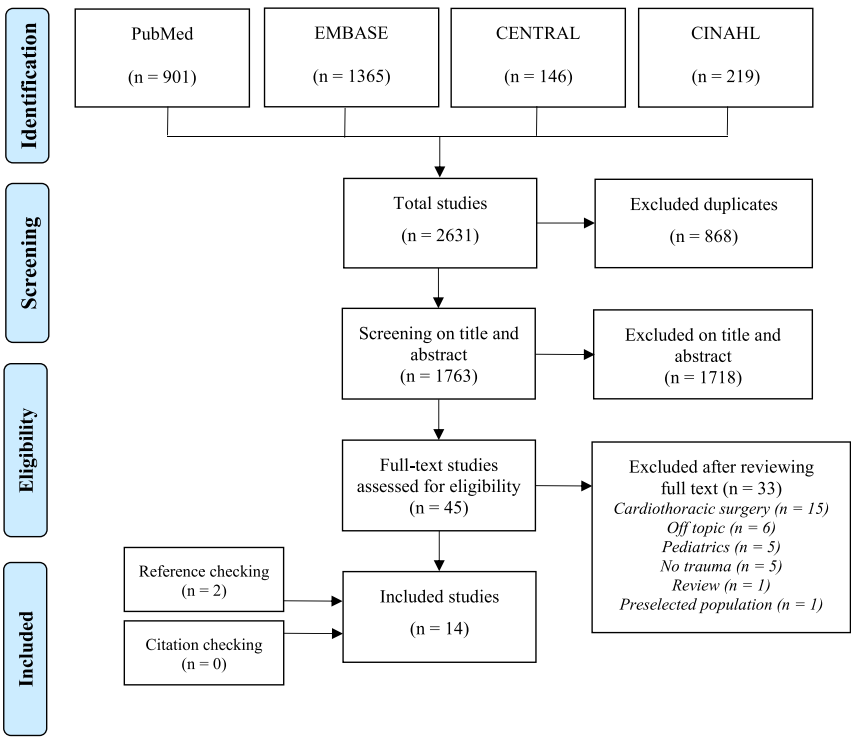

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses flow diagram representing the search and screen process of articles describing chest radiographs after chest tube removal in trauma patients.

MINORS criteria and scoring system are given in Appendix 2 (Supplemental Digital Content, http://links.lww.com/TA/B918).

Statistical Analysis

Analyses and data presentation were done separately for studies reporting on cohorts of nonventilated patient and on mixed cohorts of ventilated and nonventilated patients using descriptive statistics weighted by study size. For all pooled results, the ranges across studies were reported as well.

RESULTS

A flowchart of the literature search is depicted in Figure 1. Fourteen articles were included; two RCTs, two prospective cohort studies, one combined retrospective and prospective cohort study, and nine retrospective cohort studies.[9,10,27–38] In 13 studies, a chest tube management protocol was used. In these protocols, the chest tube was removed when there was no air leakage and a maximum fluid leakage of 100 to 240 mL in 24 hours, with the chest tube on water seal, followed by a preremoval chest radiograph to ensure sufficient lung expansion.[9,10,27–37]

Nonventilated Patients

There were seven studies on nonventilated patients with a chest tube after chest trauma included in this review.[10,27–30,32,38] The average MINORS score of the noncomparative studies was 10.8 (SD, 1.5; range, 10–13), and that of the comparative studies, 20 (SD, 2.0; range, 18–22). All study-specific MINORS scores are presented in Appendix 2 (Supplemental Digital Content, http://links.lww.com/TA/B918).

These 7 studies comprised 885 nonventilated patients, with a total of 920 chest tubes. The weighted average age was 40 years (range across studies, 32–54 years), and 74% of patients (range, 53–88%) were male (Table 1, 1.1). The weighted average ISS was 21 (range, 14–25), as reported by three studies.[10,29,32] The injury was caused by blunt trauma in 70% (range, 34–91%) of all patients. Two studies (n = 518) reported on hospital length of stay, showing that patients were in the hospital for a weighted average of 9 days (range, 6–10 days) (Table 2, 2.1).[29,32] Four studies (n = 652) reported on chest tube duration and demonstrated a weighted average chest tube duration of 5 days (range, 3–7 days).[10,29,32,38]

Outcomes

All seven studies (n = 920 chest tubes) reported on abnormalities on postremoval chest radiograph, showing that abnormalities were seen in 10% (range, 0–38%) of all chest tubes (Table 3.1).[10,27–30,32,38] A total of 92% of these were pneumothoraces. Of all chest tubes with abnormalities on postremoval chest radiograph, 24% (range, 0–78%) led to a reintervention. The majority (94%) of the reinterventions were replacement of the chest tube, and in one case, reintervention consisted of percutaneous aspiration of a pneumothorax. There were no reinterventions in patients who had no abnormalities on the postremoval chest radiograph.

In the two studies (n = 219 chest tubes) that reported on postremoval clinical symptoms, there were 22 chest radiographs (10%) with abnormalities, with 6 (27%) of those undergoing reintervention and all of these 6 (100%) already showed symptoms (Fig. 2).[28,38] In the two studies that reported on symptoms, there were no patients who had recurrent pathology with absence of symptoms. In the group of patients without abnormalities on

TABLE 1. Baseline Characteristics of Studies Included in This Systematic Review

Study	Study Design	Country	Observed Study Population	Patients, n	Age, Mean ± SD, y	Sex, Female/Male, n/%	ISS, Mean ± SD	Mechanism of Trauma Penetrating/Blunt, n
1.1 Studies on nonventilated patients								
Anand et al., 2012[27]	RC	United States	Post–chest tube removal	57	41	NR	NR	21/46
Farzan et al., 2018[28]	RC	Iran	Post–chest tube removal	130	33.6 ± 8.8	21/109	NR	12/118
Martin et al., 2013[29]	RC	United States	Post–chest tube removal	313	45.7 ± 21.1	98/225	24.9 ± 15.9	42/271
Palesty et al., 2000[38]	RC	United States	Post–chest tube removal	73	54.4	34/39	NR	NR
Soult et al., 2014[30]	RC	United States	Post–chest tube removal	46	45.6 ± 20.2	24%/76%	NR	NR
Adrales et al., 2002[10]	RC/PC	United States	Pre–practice guideline	14	38.0 ± 3.7	4/10	20.5 ± 2.4	4/10
			Post–practice guideline	47	31.6 ± 3.9	18/29	25.7 ± 3.3	20/27
Martino et al., 1999[32]	RCT	United States	No water seal	112	32 ± 13	14/98	16 ± 5	74/38
			Water seal	93	33 ± 12	22/71	14 ± 7	58/35
1.2 Studies on ventilated and nonventilated patients								
Goodman et al., 2010[31]	RC	United States	Post–chest tube removal	249*	37.9 ± 0.86	20%/80%	27.0 ± 0.73	50%/50%
Menger et al., 2012[9]	RC	United States	Post–chest tube removal	154	36.0 (24–53)	41/113	22.0 (14–34)	68/86
Pacanowski et al., 2000[33]	RC	United States	Post–chest tube removal	105	36.9 ± 14.6	33/72	23.4 ± 10.5	22/83
Pizano et al., 2002[34]	PC	United States	Post–chest tube removal	75	43	20/55	24 ± 11	14/53
Tawil et al., 2010[35]	RC	United States	Post–chest tube removal	190	43.0 ± 16.2	49/141	27.3 ± 10.5	0/190
Bell et al., 2001[36]	RCT	United States	End-inspiration removal	69	36 ± 2.5	1:12	27.8 ± 1.8	1:1.9
			End-expiration removal		33 ± 2.5	1:9	27.6 ± 2.3	1:0.9
Deneuville, 2002[37]	PC	Guadeloupe	Blunt trauma	83	39.5 ± 17	16/67	NR	0/83
			Penetrating trauma	45	31.4 ± 11	2/43	NR	45/0

*Estimation.
NR, not reported; PC, prospective cohort study; RC, retrospective cohort study; RCT, randomized controlled trial.

TABLE 2. In-hospital Characteristics of Studies Included in This Systematic Review

Study	Observed Study Population	Patients, n	Bilateral Chest Tubes, n (%)	Indication PTX, n (%)	Indication HTX, n (%)	Indication HPTX, n (%)	Other Indication, n (%)	CT Duration, Mean ± SD or Range, d	HLOS, Mean ± SD or Median (IQR), d	Time Until Postremoval CR, h	Minimum Time on Water Seal Before Removal, h	Maximum Fluid Output Before Removal, mL/24 h	Mechanically Ventilated, n (%)
2.1 Studies on nonventilated patients													
Anand et al., 2012[27]	Post–chest tube removal	57	NR	NR	NR	NR	NR	NR	NR	NR	24	200	n/a
Farzan et al., 2018[28]	Post–chest tube removal	130	NR	98 (75)	18 (14)	14 (11)	0 (0)	NR	NR	4	24	150	n/a
Martin et al., 2013[29]	Post–chest tube removal	313	NR	NR	NR	NR	NR	5.9 ± 4.3	10.4 ± 8.4	4	24	200	n/a
Palesty et al., 2000[38]	Post–chest tube removal	73	NR	NR	NR	NR	NR	4.2 (2–12)	NR	4–24	NR	NR	n/a
Soult et al., 2014[30]	Post–chest tube removal	46	NR	45%	NR	NR	55%	NR	NR	4–6	4–6	NR	n/a
Adrales et al., 2002[10]	Pre–practice guideline	14	NR	NR	NR	NR	NR	7.0 ± 1.3	NR	4	6	200	n/a
	Post–practice guideline	47	NR	NR	NR	NR	NR	4.2 ± 0.4	NR	4	6	200	n/a
Martino et al., 1999[32]	No water seal	112	NR	NR	NR	NR	NR	3.1 ± 2.0	6.4 ± 5.5	6–8	n/a	150	n/a
	Water seal	93	NR	NR	NR	NR	NR	3.2 ± 1.7	5.6 ± 4.1	6–8	6–8	150	n/a
2.2 Studies on ventilated and nonventilated patients													
Goodman et al., 2010[31]	Post–chest tube removal	249*	NR	44%	12%	28%	16%	5.7 ± 0.19	9.1 ± 0.61	6	24	150	NR
Menger et al., 2012[9]	Post–chest tube removal	154	NR	NR	NR	NR	NR	6 (4.6–9)	11 (7–23)	4–16	24	NR	29 (19)
Pacanowski et al., 2000[33]	Post–chest tube removal	105	8 (8)	NR	NR	NR	NR	5.0 ± 2.9	9.9 ± 6.8	7.9 and 22.1	24	100	27 (26)
Pizano et al., 2002[34]	Post–chest tube removal	75	NR	NR	NR	NR	NR	NR	NR	1	12	NR	75 (100)
Tawil et al., 2010[35]	Post–chest tube removal	190	46 (24)	113 (59)	26 (14)	51 (27)	0 (0)	NR	21.2 ± 15.6	6	NR	NR	100 (53)
Bell et al., 2001[36]	End-inspiration removal	69	NR	NR	27%	NR	NR	7.3 ± 0.8	NR	6 and 24	24	200	NR
	End-expiration removal		NR	NR	20%	NR	NR	5.5 ± 0.8	NR		24	200	NR
Deneuville, 2002[37]	Blunt trauma	83	NR	NR	NR	NR	NR	5.4 ± 2.7	15 (10–34)	NR	8	160	24 (29)
	Penetrating trauma	45	NR	NR	NR	NR	NR	4.6 ± 1.7	7 (5–12)	NR	8	160	3 (7)

*Estimation.
CR, chest radiograph; CT, chest tube; IQR, interquartile range; HTX, hemothorax; HPTX, hemopneumothorax; HLOS, hospital length of stay; n/a, not applicable; NR, not reported; PTX, pneumothorax.

TABLE 3. Outcome Measures of Studies Included in This Systematic Review

Study	Observed Study Population	Patients, n	Chest Tubes, n	Abnormalities on CR, n (%)	Pneumothorax on CR, n (%)	Other Finding on CR, n (%)	Clinical Symptoms, n (%)	Reintervention, n (%)	Replacement of Chest Tube, n (%)	Other Reintervention, n (%)
3.1 Studies on nonventilated patients										
Anand et al., 2012[27]	Post–chest tube removal	57	67	20 (30)	20 (100)	0 (0)	NR	4 (6)	4 (100)	0 (0)
Farzan et al., 2018[28]	Post–chest tube removal	130	NR	14 (11)	14 (100)	0 (0)	5 (4)	5 (4)	NR	NR
Martin et al., 2013[29]	Post–chest tube removal	313	NR	2 (1)	2 (100)	0 (0)	NR	0 (0)	0 (0)	0 (0)
Palesty et al., 2000[38]	Post–chest tube removal	73	89	8 (9)	2 (25)	6 (75)	2 (2)	2 (2)	2 (100)	0 (0)
Soult et al., 2014[30]	Post–chest tube removal	46	55	21 (38)	21 (100)	0 (0)	NR	1 (2)	1 (100)	0 (0)
Adrales et al., 2002[10]	Pre–practice guideline	14	NR	0 (0)	0 (0)	0 (0)	NR	0 (0)	0 (0)	0 (0)
	Post–Practice guideline	47	NR	3 (6)	2 (67)	1 (33)	NR	2 (4)	1 (50)	1 (50)
Martino et al., 1999[32]	No water seal	112	NR	9 (8)	9 (100)	0 (0)	NR	7 (6)	7 (100%	0 (0)
	Water seal	93	NR	13 (14)	13 (100)	0 (0)	NR	1 (1)	1 (100)	0 (0)
3.2 Studies on ventilated and nonventilated patients										
Goodman et al., 2010[31]	Post–chest tube removal	249*	387	73 (19)	43 (59)	30 (41)	NR	33 (45)	17 (52)	16 (48)
Menger et al., 2012[9]	Post–chest tube removal	154	NR	75 (49)	56 (75)	19 (25)	NR	40 (26)	33 (82)	7 (8)
Pacanowski et al., 2000[33]	Post–chest tube removal	105	113	12 (11)	NR	NR	5 (4)	1 (1)	1 (100)	0 (0)
Pizano et al., 2002[34]	Post–chest tube removal	75	NR	9 (12)	9 (100)	0 (0)	NR	2 (3)	2 (100)	0 (0)
Tawil et al., 2010[35]	Post–chest tube removal	190	234	31 (13)	31 (100)	0 (0)	NR	9 (4)	9 (100)	0 (0)
Bell et al., 2001[36]	End-inspiration removal	35*	52	4 (8)	4 (100)	0 (0)	NR	2 (4)	2 (100)	0 (0)
	End-expiration removal	34*	50	3 (6)	3 (100)	0 (0)	NR	1 (2)	1 (100)	0 (0)
Deneuville, 2002[37]	Complicated	32	134	26 (19)	16 (46)	19 (54)	NR	22 (16)	8 (36)	14 (64)
	Uncomplicated	96		n/a	n/a	n/a	n/a	n/a	n/a	n/a

*Estimation.
CR, chest radiograph; n/a, not applicable; NR, not reported.

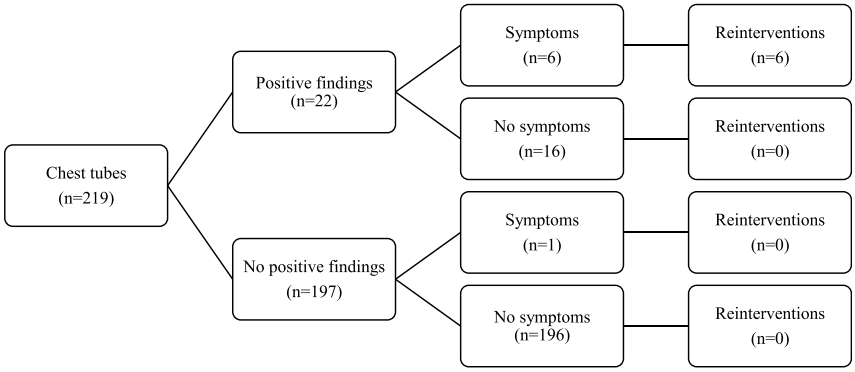

Figure 2. Symptoms after chest tube removal in nonventilated trauma patients.

chest radiograph, there was one patient who had symptoms of recurrent pathology, which was resolved without reintervention.

Ventilated and Nonventilated Patients

There were seven studies on mixed cohorts of ventilated and nonventilated trauma patients with a chest tube included in this review.[9,31,33–37] The MINORS scores of the two comparative studies were 15 and 20, and the five noncomparative studies had a mean score of 12.4 (SD, 1.9; range, 10–15) (Supplemental Digital Content, Appendix 2, http://links.lww.com/TA/B918).

These studies comprised 970 patients, with a total of 1,199 chest tubes. The weighted average age was 39 years (range, 31–43 years), and 77% (range, 69–96%) were male (Table 1, 1.2). The weighted average ISS was 26 (range, 23–28), as reported by six studies.[9,31,33–36] Blunt chest trauma was the mechanism of trauma in 69% (range, 50–100%) of all patients. Five studies (n = 826) reported on hospital length of stay with a weighted average of 11 days (range, 7–21 days) (Table 2, 2.2).[9,31,33,35,36] Five studies (n = 705) reported a weighted average chest tube duration of 6 days (range, 5–7 days).[9,31,33,36,37] In studies reporting on both ventilated and nonventilated patients, an average of 40% (range, 19–100%) were mechanically ventilated.

Outcomes

All seven studies (n = 1,199 chest tubes) reported on abnormalities on postremoval chest radiograph (Table 3, 3.2).[9,31,33–37] In 20% (range, 6–49%) of all removed chest tubes, the postremoval chest radiograph revealed recurrent pathology, of which the majority (70%) were pneumothoraces. Of the removed chest tubes with abnormalities after removal, 45% (range, 8–63%) underwent reintervention, with the majority (66%) being a replacement of the chest tube. The remaining 34% of the reinterventions consisted of thoracotomies and video-assisted thoracoscopic surgeries. All reinterventions were performed in patients who had pathology on the postremoval chest radiograph.

Only one study (n = 105) reported on clinical symptoms (Table 3, 3.2).[33] In this study, five patients demonstrated clinical symptoms. One patient, who showed decreased breath sounds and percussion dullness, had a hemopneumothorax on postremoval chest radiograph and required chest tube replacement. The other four patients with clinical symptoms (coughing, low saturation, dyspnea, burning sensation in the chest) had no abnormalities on chest radiograph and were managed without reintervention.

DISCUSSION

In this systematic review, we found that, in nonventilated patients with chest tubes, there were abnormalities on postremoval chest radiographs in only 10% (range across studies, 0–38%) of all chest tubes and about a quarter of those eventually had a reintervention. Data on symptoms in patients who underwent reintervention were scarce; two studies reported that all reinterventions were on patients with clinical symptoms.[28,38] In the studies including both ventilated and nonventilated patients, there were abnormalities on postremoval chest radiographs in 20% (range, 6–49%) of the cases, and almost half of these had a reintervention.

The current literature is unclear on safety of omitting postremoval chest radiographs. Only one study, with a mix of ventilated and nonventilated patients, reported on symptoms and demonstrated that symptoms were present in 5% of the patients. In this cohort, there was only one reintervention (1%), which was in a patient who already had symptoms of recurrent pathology.[33] The studies that reported on combined cohorts of ventilated and nonventilated patients showed an average percentage of 40% (range, 19–100%) that were mechanically ventilated. Given the assumption that mechanically ventilated patients suffered more severe injuries but also the fact that clinical symptoms will be masked by sedation of the ventilated patients, routine chest radiographs should be acquired after chest tube removal.

The indications for initial chest tube placement were described by four studies, most commonly a pneumothorax and in fewer cases a hemothorax or a combination of these.[28,30,31,35] The indications for chest tube removal varied between a 4- and 24-hour trial on water seal with an absence of air leak and a fluid output of less than 150 to 250 mL, mostly combined with resolution of the pneumothorax or hemothorax on preremoval chest radiograph. In two of the included studies, the effect of the implementation of a chest tube management protocol was studied. Adrales et al.[10] showed that the utilization of a practice guideline led to a decrease of 3 days in the chest tube duration, with similar complication rates compared with the group of patients who were not treated according to a protocol. Martin et al.[29] found

that the chest tube management protocol led to a complication rate of 4.8%, which was low compared with other studies. The studies by Goodman et al.[31] and Menger et al.[9] reported high reintervention rates in comparison with the other included studies, which may have been caused by the relatively high percentage of included patients who suffered penetrating injuries. However, evidence to support this hypothesis lacks in the concerning studies.

Current literature on the necessity of postremoval chest radiographs in trauma patients is limited, but two studies on more specific other trauma populations than included in this review describe similar findings regarding the role of chest radiographs in trauma patients. A prospective study by Myint et al.[39] studied blunt chest trauma patients in the emergency department and concluded that chest radiographs, in addition to clinical examination, were overused in emergency care. Kugler et al.[8] retrospectively studied trauma patients who were discharged with a pneumothorax or pleural effusion on postremoval chest radiograph. This study found that 11% had a persistent pneumothorax or pleural effusion and only 4% underwent reintervention. These findings recognize the findings in this review that, even in a preselected population of patients with a postremoval pneumothorax or pleural effusion, most patients were safely observed and only few ultimately underwent reintervention.

The current systematic review has some limitations. First, the results of this review may be affected by publication bias. We performed an extensive literature search and are confident that all literature that was available on this subject was included. Second, few studies reported on postremoval symptoms, particularly in ventilated patients. Therefore, it remains difficult to draw definitive conclusions based on this evidence. Third, the studies only reported on in-hospital reinterventions, while data on timing and long-term data on this subject lacked. Patients who were discharged from hospital and developed a recurrent pneumothorax or hemothorax were not investigated. Fourth, subgroup analyses of outcomes in studies describing ventilated patients lacked, and for that reason, the ventilated patients could not be described separately in this review. Fifth, some studies only reported on significant postremoval pneumothoraces or pleural effusion, and in some studies, information on the significance of the pneumothorax or pleural effusion lacked. Also, criteria for the significance of recurrent pathology on the postremoval chest radiograph were not clearly stated. Lastly, we described the outcomes based on the number of chest tubes instead of based on the number of patients because of lack of data in some of the included studies. Because some patients had bilateral chest tubes, a small bias could have been introduced.

CONCLUSION

In nonventilated patients who were treated with a chest tube, 1 in 10 developed recurrent pathology after removal of the chest tube, and a quarter of those underwent reintervention. Two studies (n = 219 chest tubes) that reported on postremoval symptoms in nonventilated trauma patients showed that there were only reinterventions in patients with symptoms.[28,38] In these two studies, omission of routine postremoval chest radiograph seemed safe, provided no symptoms existed. However, current literature remains insufficient to draw definitive conclusions on this matter. More research is needed to assess the necessity of postremoval chest radiographs in nonventilated trauma patients. Also, results of standardized chest tube management protocols appear promising, suggesting a reduction of duration of chest tube use and lower complication rates. Future research should also further investigate their clinical value.

AUTHORSHIP

A.A.R.S. contributed in the study design, data acquisition, risk of bias assessment, data analysis, interpretation of data. R.B.B. contributed in the study design, data acquisition, risk of bias assessment, data analysis, interpretation of data. M.B.d.J. contributed in the study design and interpretation of data. M.C.P.v.B. contributed in the study design and interpretation of data. F.F.A.I. contributed in the study design and interpretation of data. F.H. contributed in the study design, data analysis, and interpretation of data. F.J.P.B. contributed in the study design and interpretation of data. L.P.H.L. contributed in the study design and interpretation of data. R.H.H.G. contributed in the study design, data analysis, and interpretation of data. R.M.H. contributed in the study design, data analysis, and interpretation of data.

DISCLOSURE

The authors declare no conflicts of interest.

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