



ONLINE ARTICLES

Postoperative chest radiograph after open reduction internal fixation of clavicle fractures: a necessary practice?



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Hypothesis/Background: Iatrogenic pneumothorax is a rare but serious complication of open reduction and internal fixation (ORIF) of clavicular fractures. Many institutions use postoperative chest radiographs to evaluate for this complication despite a lack of data to support this routine practice. Due to concerns of radiation exposure and health care costs, this practice may not be necessary. This study determined the rate of iatrogenic pneumothorax after clavicular ORIF with plate fixation at a single institution over 8 years. We hypothesized that postoperative chest radiographs would identify a very low rate of pneumothorax in patients with isolated clavicular fractures with no serious preoperative pulmonary injury.

Methods: A retrospective review was performed identifying all patients undergoing clavicular ORIF with plate fixation at a single Level I trauma center by 3 board-certified orthopedic surgeons from 2009 to 2017. Patients without at least 1 postoperative chest radiograph were excluded. We determined patient demographics and rate of preoperative and postoperative pneumothorax.

Results: We identified 89 patients without preoperative pneumothorax who underwent clavicular ORIF with at least 1 postoperative chest radiograph. Within this group, no patients (0%) had a new postoperative iatrogenic pneumothorax.

Discussion/Conclusion: Within this series of 89 patients with isolated clavicular fractures without preoperative pneumothorax, no iatrogenic pneumothoraces occurred after plate fixation. Therefore, for patients undergoing ORIF of isolated clavicular fractures obtaining a postoperative chest radiograph may be an unnecessary practice, especially given their low sensitivity. Future high-powered studies are needed to validate this finding.

Level of evidence: Level IV; Case Series; Treatment Study

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Keywords: Clavicle; fracture; pneumothorax; internal fixation

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Fractures of the clavicle represent 2.6% to 5% of all fractures, making them one of the most commonly encountered orthopedic injuries.^{16,26,29} Fractures of the middle third account for approximately 80% of all clavicular fractures.^{4,20} The incidence of clavicular fractures has been reported as 71 per 100,000 men and 30 per 100,000 women, with an apparent

increasing incidence of high-energy fractures with displacement, comminution, and shortening.^{15,26,27,29-31} A recent multicenter, randomized clinical trial comparing nonoperative treatment of displaced clavicular fractures with plate fixation revealed improved objective functional scores, time to union, patient satisfaction and less symptomatic malunion in the group treated with operative plate fixation.⁵

Plate fixation is the most common surgical treatment for operative management of displaced midshaft clavicular fractures. This method has been thoroughly studied in the literature, yielding good results and few complications.^{22,28,38} Complications can include deep infection, plate breakage, nonunion, scar-related pain, prominent hardware, and refracture.² Complication rates are difficult to assess with any certitude due to a lack of standard definitions for complications, overlap in the definitions, different means of presenting complications, and a wide variety of fracture patterns and fixation methods. Complication rates in the existing literature are wide ranging, with some as low as 9% and as high as 50%, depending on the study, technique, and definitions in question.^{3,6,7,11,12,14,17,24,25,32,33,35}

Despite a growing body of literature reporting outcomes and complications after operative fixation of clavicular fractures, there does not appear to be any literature evaluating iatrogenic pneumothorax as a result of ORIF. Many institutions used postoperative chest radiographs after clavicle fixation to evaluate for this feared complication. To our knowledge, however, there are no data to support the routine use of postoperative chest radiographs. Due to concerns of radiation and health care costs, this practice may be unnecessary after ORIF of isolated clavicular fractures without serious (defined as more severe than contusion or dependent atelectasis) preoperative pulmonary injury.

The purpose of this study was to determine the rate of iatrogenic pneumothorax and pulmonary complications in the immediate postoperative period after clavicular ORIF with plate fixation. We hypothesized that the rate of iatrogenic pneumothorax would be low in the absence of serious preoperative pulmonary injury or postoperative respiratory symptoms.

Materials and methods

A retrospective review of our electronic medical record was performed using Current Procedural Terminology (American Medical Association, Chicago, IL, USA) code 23515 to identify all patients aged older than 18 years undergoing clavicular ORIF with plate

fixation at a single, Level 1 trauma center from July 2009 through January 2017. All procedures were performed by 1 of 3 board-certified orthopedic surgeons. All patients included in this study underwent ORIF with a plate and screw construct. Any patients without at least 1 immediate postoperative chest radiograph were excluded.

A formal open approach to the clavicle was performed. When possible, an interfragmentary lag screw was used for compression of simple fracture patterns. This was followed by a neutralization plate placed on the superior surface of the clavicle, with an appropriate number of screws placed on each side of the fracture. Occasionally, a compression plate or bridge plate technique was used. Plate choice was determined by the operating surgeon, with most of the plates being the clavicle locking plate by DePuy Synthes (Raynham, MA, USA). Locking vs. nonlocking screw choice was determined by the operating surgeon.

We also analyzed several patient demographics, including date of surgery, looking for a statistically significant trend toward fixing more clavicles operatively as the years progressed. Patients were divided into 2 groups based on the presence or absence of preoperative pneumothorax. We compared these groups for statistically significant differences in age, sex, mechanism of injury, fracture pattern (AO Trauma Classification), preoperative pulmonary injury, postoperative pulmonary intervention, and postoperative respiratory symptoms at last follow-up.

These 2 groups were compared using unequal variance *t* test, Pearson χ^2 testing, contingency analysis including Fisher exact test, mosaic plots, and bivariate linear fit as appropriate. Exact probability calculations were used to determine the rate of postoperative iatrogenic pneumothorax. All statistical calculations were performed using JMP 14 software (SAS Institute, Inc., Cary, NC, USA).

Results

We identified 152 patients (114 male, 38 female), with an average age of 39.9 ± 4.9 years (range, 14-89 years), who underwent clavicular ORIF using plate fixation and had at least 1 postoperative chest radiograph, with 23 patients excluded due to lack of postoperative chest radiograph. A pneumothorax was documented in 63 patients (41.4%) before operative clavicular fixation (Table I). The remaining 89 of 152 patients (58.6%) had no evidence of preoperative pneumothorax, and no patients (0%) had a new, postoperative iatrogenic pneumothorax identified on chest x-ray imaging.

Using the unequal variance *t* test, we found a statistically significant difference in age among the preoperative pneumothorax (mean age, 43.1 years) and non-pneumothorax groups (mean age, 37.1 years; $P = .0005$, Table II). By χ^2 testing, the ratio of male to female patients within the 2 groups

Table I Cohort data and rate of preoperative pneumothorax

Sample size (No.)	Male	Female	Average age (yrs)	Procedure	Preoperative PTX	
	(No.)	(No.)			No.	Rate (%)
152	114	38	39.9	ORIF with plate fixation	63	41.4

PTX, pneumothorax; ORIF, open reduction and internal fixation.

Table II Cohort data preoperative pneumothorax group vs. postoperative pneumothorax group

Variable	Preoperative PTX (n = 63)	No preoperative PTX (n = 89)	P value
Average age, yrs	43.8	37.1	.005
Male sex, No. (%)	47 (74.6)	67 (75.3%)	.554

PTX, pneumothorax.

was not statistically significant ($P = .554$). Using exact probability calculations and a 95% confidence interval, we were able to calculate that the upper bound of the proportion of iatrogenic pneumothorax in this study was <3.3% (Table III).

No statistically significant difference in preoperative pneumothorax was found analyzing by the AO Trauma Classification of fracture pattern ($P = .985$; Table IV). The preoperative pneumothorax group had a statistically significant difference in high-energy injury mechanisms ($P = .01$) and in new postoperative pulmonary interventions ($P = .003$, Tables V, VI, and VII). However, there was no statistically significant association between mechanism of injury and pneumothorax ($P = .143$).

There was a statistically significant upward trend in the number of clavicular fractures fixed via ORIF between 2009 and 2016, with 2017 omitted because only January was included ($P = .01$; Table VIII and Fig. 1). In addition, no respiratory symptoms were noted in any patients at their most recent follow-up, with average follow-up of 20.5 weeks.

Table III Statistical probability of postoperative pneumothorax in a patient population with zero recorded events and a 95% confidence interval

Sample size, No.	Postoperative pneumothorax	Upper bound of 95% CI probability of postoperative pneumothorax
89	0	<3.3%

Table IV Types of fracture pattern by AO trauma classification

Group	15.1A Medial extra-articular	15.2A Midshaft spiral	15.2B Intact spiral wedge	15.2C Midshaft multifragmentary spiral	15.3A(a) Distal nondisplaced extra-articular	15.3A(c) Distal displaced extra-articular	15.3B(c) Distal displaced articular	Total (No.)
	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	(No.)
Pre-op PTX	0 (0.0)	29 (45.3)	6 (9.4)	24 (37.5)	2 (3.1)	1 (1.6)	2 (3.1)	64
No pre-op PTX	3 (3.4)	43 (48.3)	8 (9.0)	31 (34.8)	2 (2.3)	1 (1.1)	1 (1.1)	89

PTX, pneumothorax.
 P value = .985.

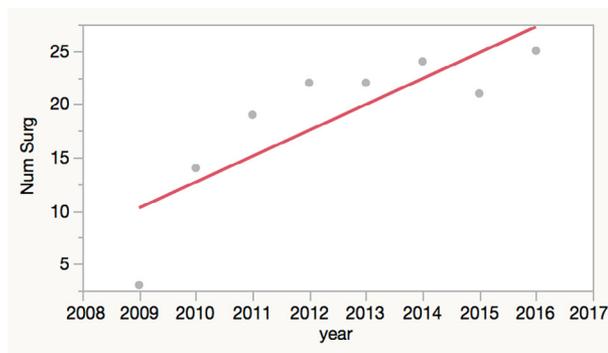


Figure 1 Bivariate fit of number of operations by year.

Discussion

Within our series of 89 patients with isolated clavicular fractures and no identifiable serious preoperative pulmonary injury who were treated with plate ORIF, there were no cases of iatrogenic pneumothorax. Within this group, there were also no respiratory symptoms or new pulmonary injuries at the most recent follow-up at an average of 20.5 weeks.

Pneumothorax in relation to clavicular fracture is a described preoperative complication in the existing literature. In a series of 20 patients with open clavicular fractures, Taitsman et al³⁴ found that 50% had pneumothoraces, 35% of which were bilateral. These data are in line with our preoperative pneumothorax rate of 41.4%. In addition, numerous case reports have cited pneumothorax discovered at the time of injury.^{8,9,21,23,36} Interestingly, there is a single report of delayed pneumothorax after an isolated clavicular fracture discovered at a 5-day follow-up appointment when there had been no radiographic or symptomatic suggestion of pneumothorax at the time of injury.¹³

The statistically significant difference in age among the preoperative pneumothorax and postoperative nonpneumothorax group may reflect that the preoperative pneumothorax group was older, with pulmonary tissue that was less able to withstand the initial injury. Although there is no existing literature specific to clavicular fractures, 1 study did link advancing age to a higher risk for pneumothorax in a trauma setting.¹⁹ The ratio of male-to-female patients was

Table V Mechanism of injury

Group	MVC	MCC	ATV	Sport	Fall from height	Crush	Bicycle accident	Fall from standing	Airplane crash
	50	44	23	11	10	7	5	2	1
Pre-op PTX	23	21	10	1	3	4	0	1	0
No PTX	27	23	13	10	7	3	5	1	1

MVC, motor vehicle crash; MCC, motorcycle crash; ATV, all-terrain vehicle; PTX, pneumothorax.

Table VI High vs. low energy mechanism of injury

Group	High energy	Low energy
	No. (%)	No. (%)
Pre-op PTX	63 (98.4)	1 (1.6)
No PTX	78 (87.6)	11 (12.4)

PTX, pneumothorax.
P = .01.

generally in line with the reported incidence of clavicular fracture in the population at large and did not achieve statistical significance.

Chest radiographs, when taken individually, have relatively low financial cost and radiation exposure. A single chest radiograph is equivalent to approximately 10 days' worth of normal background radiation exposure.¹⁸ Although costs vary widely based on the health care system, insurance status, geographic region, and other factors, there is no existing literature to our knowledge on the financial cost associated with obtaining chest radiographs in patients with clavicular fractures. Given the prevalence of clavicular fractures and the routine use of chest radiographs in a trauma setting, the overall financial burden is not negligible. In 2013, Ziegler et al³⁷ examined the financial utility of chest radiographs in trauma patients at a Level II trauma center who also underwent a thoracic computed tomography (CT) scan. They discovered that eschewing the chest radiograph entirely would produce savings between \$30,592 and \$142,186 per year, depending on the pricing method used.³⁷

One of the important highlights of their study was the sensitivity of chest radiographs in detecting injury. Two recent meta-analyses examined the sensitivity of chest radiographs in detecting pneumothoraces against a backdrop of CT-confirmed pneumothorax. A 2013 meta-analysis of 13 studies found chest radiographs had a pooled sensitivity of 39.8%, whereas a 2014 meta-analysis of 28 studies found a pooled sensitivity of 46%.^{1,10} These same studies found ultrasound was significantly more sensitive in detecting a pneumothorax, with a pooled sensitivity of 87%.¹⁰

Although pneumothorax remains a potential complication of plate fixation of clavicular fractures, with careful technique, it is a rare phenomenon. Our series of 89 patients with 0 confirmed postoperative pneumothoraces supports this notion. In 2018, approximately 165,000 clavicular fractures can be expected to occur in the United States. Some percentage of these will be treated operatively with plate fixation, and chest radiographs reflexively obtained. The financial burden on the health care system will be significant. When combined with the poor sensitivity of chest radiographs in detecting pneumothoraces, regular postoperative chest radiographs may not be indicated after ORIF of clavicular fractures with plate fixation. We believe that more high-powered and prospective studies would aid in supporting this finding.

Although our study reveals some compelling data, it is not without drawbacks. As the literature notes, pneumothoraces can arise in delayed fashion and can also resolve spontaneously, which could theoretically have occurred with any one of our patients between their operation and follow-up. Given the poor sensitivity of chest radiographs in detecting

Table VII Number of patients requiring new postoperative pulmonary interventions

Group	Patients	Fractures	Pneumothoraces	Operations	Preoperative pulmonary injury	New postoperative pulmonary intervention
	(No.)	(No.)	(No.)	(No.)	No. (%)	No. (%)
Pre-op pneumothorax	63	64	74	64	64 (100.0)	32 (50.8)
No post-op pneumothorax	89	89	0	89	21 (23.6)	24 (27.0)

P = .003.

Table VIII Number of operations by year

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Operations, No.	3	14	19	22	22	24	21	25	3

P = .008.

pneumothoraces, it is also possible patients did indeed sustain iatrogenic pneumothoraces that were missed radiographically and were not symptomatic enough to warrant detection through other means. If the surgeon's goal is to identify all pneumothoraces after ORIF, ultrasound is nearly twice as sensitive and less costly in doing so.

Finally, our study is subject to the well-known drawbacks of retrospective studies. Any future studies on iatrogenic postoperative pneumothoraces after plate fixation of clavicular fractures could include postoperative CT of the chest or ultrasonography given their substantiated higher sensitivities to determine true presence or absence of pneumothorax. However, these findings may not be clinically relevant from a respiratory function standpoint.

Conclusion

Given our cohort of 89 patients with no iatrogenic pneumothorax after clavicular ORIF reduction and the low sensitivity of a plain radiograph to identify small pneumothoraces, obtaining a postoperative chest radiograph without postoperative respiratory symptoms may be unnecessary. Future high-powered studies are needed to validate this finding.

Disclaimer

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