

# Conservative Management of Residual Pneumothorax Following Tube Thoracostomy Removal in Trauma Patients

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## ABSTRACT

**Introduction:** Residual pneumothorax (rPTX) after tube thoracostomy (TT) is not an uncommon occurrence (10–20%) in any active trauma center. Many different practice patterns exist on how to deal with this clinical conundrum. These differing strategies can include more invasive procedures and increased length of stay (LOS). We hypothesize that the vast majority of these patients can be safely managed with observation and most can be discharged home without complete resolution.

**Materials and methods:** A retrospective study was conducted on trauma patients managed in a level I center over a 2-year period. A “post-pull” chest X-ray was obtained on all TT patients after removal. All patient with rPTX were included for analysis.

**Results:** A total of 412 patients required chest tubes. Since 98 patients were deceased, we excluded them from the study. A total of 314 patients were studied. Forty-two percent of the patients were male, with median age 40. Sixty-one percent of the patients were blunt trauma victims and 39% were penetrating trauma victims. The indications for chest TT were pneumothorax, hemothorax, and hemopneumothorax. A total of 163 had post-pull pneumo and discharged home with residual pathology prior to discharge. Five of these patients were readmitted (3%), and only one required repeat TT, roughly 0.6%.

**Conclusion:** The vast majority of “post-pull” rPTX patients can be managed conservatively and can be safely discharged even without complete resolution.

**Keywords:** Blunt trauma, Chest tube, Chest tube insertion, Penetrating trauma, Pneumothorax, Residual pneumothorax, Tube thoracostomy.

## RESUMEN

**Introducción:** el neumotórax residual (rPTX) después de la toracostomía con sonda (TT) no es una ocurrencia infrecuente (10-20%) en cualquier centro de trauma activo. Existen muchos patrones de práctica diferentes sobre cómo lidiar con este enigma clínico. Estas estrategias diferentes pueden incluir procedimientos más invasivos y mayor LOS. Presumimos que la gran mayoría de estos pacientes pueden manejarse de manera segura con observación y la mayoría pueden ser dados de alta sin resolución completa.

**Materiales y métodos:** se realizó un estudio retrospectivo en pacientes con trauma manejados en un centro de nivel I durante un período de 2 años. Se obtuvo una radiografía de tórax “post-pull” en todos los pacientes TT después de la extracción. Todos los pacientes con rPTX se incluyeron para el análisis.

**Resultados:** Un total de 412 pacientes requirieron tubos torácicos. Dado que 98 pacientes habían fallecido, los excluimos del estudio. Se estudiaron un total de 314 pacientes. Cuarenta y dos por ciento de los pacientes eran hombres, con una mediana de edad de 40 años. Sesenta y uno por ciento de los pacientes eran víctimas de traumatismos cerrados y 39% eran víctimas de traumatismos penetrantes. Las indicaciones para TT de tórax fueron neumotórax, hemotórax y hemoneumotórax. Un total de 163 tenían pneumo post extracción y fueron dados de alta con patología residual antes del alta. Cinco de estos pacientes fueron readmitidos (3%), y solo uno requirió TT repetido, aproximadamente 0.6%.

**Conclusión:** La gran mayoría de los pacientes con rPTX “post-pull” se pueden manejar de forma conservadora y se pueden dar de alta de manera segura incluso sin una resolución completa.

**Palabras clave:** traumatismo cerrado, sonda torácica, inserción de sonda torácica, traumatismo penetrante, neumotórax, neumotórax residual, toracostomía con sonda.

*Panamerican Journal of Trauma, Critical Care & Emergency Surgery* (2019): 10.5005/jp-journals-10030-1257

## INTRODUCTION

Thoracic injuries are present in more than half of all polytrauma patients and can be a significant cause of mortality in up to 25% of these patients.<sup>1</sup> Tube thoracostomy (TT) is a frequently utilized procedure in trauma centers following blunt and penetrating trauma resulting in pneumothorax, hemothorax, or hemopneumothorax. When the patient is stabilized and there is no further indication for TT, following institution-specific criteria the TT is removed. Residual pneumothorax (rPTX) after TT removal is always a potential risk and not an uncommon occurrence in any trauma center. The reported ranges vary greatly extending from 4% to 50%, with the incidence increasing with severity of thoracic injury and thinner chest walls.<sup>1–5</sup>

There are numerous considerations in addressing rPTX, and the strategies range from conservative observation to repeat TT.

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**How to cite this article:** Sadek HM, Akuamoah-Boateng KA, Borchers CT, et al. Conservative Management of Residual Pneumothorax Following Tube Thoracostomy Removal in Trauma Patients. *Panam J Trauma Crit Care Emerg Surg* 2019;8(3):154–157.

**Source of support:** Nil

**Conflict of interest:** None

Further, rPTX and treatment strategies can lead to invasive procedures, increased morbidity, and increased length of stay. We hypothesized that the vast majority of stable rPTX in clinically stable patients can be safely managed with observation and can be discharged home prior to resolution of their rPTX.

**MATERIALS AND METHODS**

A retrospective study was designed to evaluate the effect of conservative management for traumatic patients with stable rPTX and safe disposition. Data were retrieved from the trauma registry and the health system electronic medical record on all trauma patients from September 2014 to September 2016 who were admitted to the Virginia Commonwealth University (VCU) level I trauma center.

**Procedure**

All trauma patients greater than 14 years old admitted to the VCU level I trauma center with a rPtx post TT removal were included in the study, regardless of the site or timing of TT if it occurred during their primary episode of admission. Trauma patients with a TT who did not have a rPTX after last TT was pulled were excluded from the study. All deceased patients were also excluded. The authors reviewed all the radiographic reports on the day prior to, and post removal of, the last TT, respectively. Our protocols define that any equivocal radiology reads require discussion between the attending physician and the radiologist. Further, if diagnostics are inadequate, then they are repeated. The authors identified the patients with rPtx at the time of discharge. The length of time from TT to the time of removal of the TT was calculated and logged into a secure Excel spreadsheet. The VCU protocol for removal of TT includes patients with clinically stable respiratory dynamics, with no evidence of air leak off suction, with a TT output less than 200 mL in 24 hours, and with resolution of pneumothorax on chest X-ray.

**Settings**

The study took place at a level I regional trauma center that annually admits more than 4,000 patients with penetrating and blunt injuries. The trauma patients are cared for by an integrative provider team of advanced practice providers, surgical residents, fellows in training, and attending trauma surgeons. This study was deemed as a quality improvement and an institutional review board (IRB) review was not required.

**Study Variables**

Study variables included patient’s age, gender, BMI, trauma injury category (penetrating vs blunt), injury severity score (ISS), duration TT was in place, number of TTs placed, and overall hospital length of stay.

**Data Analysis**

Data were recorded on an Excel spreadsheet with all the study variables and inputted to SPSS version 25.0. Demographic data were analyzed using a *t* test. Chi-square was used to measure the difference between the variables. A Pearson correlation test was performed to explore the relationship among the study variables. Statistical significance was set at a *p* value ≤0.05. The confidence interval was estimated at 95%.

**RESULTS**

Over the 2-year period from September 2014 to September 2016, 5,687 trauma activations occurred. A total of 4,145 patients were

admitted to the trauma service. A total of 412 (10%) patients required TT. Of those 98 patients died and were excluded. Out of the remaining 314 patients with TT, 151 patients did not have rPTX post TT removal and were also excluded. The final number of patients included for review was 163 (52%). All of these rPTX were deemed clinically insignificant and not requiring repeat TT prior to discharge. All of these patients were discharged after examining radiography and clinical presentation.

Patient demographics are illustrated in Table 1. The majority of the patients were male, with blunt trauma and high ISS. Mean age was 41 years, ranging from 15 years to 91 years of age. The duration TT was in place ranged from 1 day to 27 days with a mean of 6 days. Mean length of stay for the patients with rPTX was 13 days with a range of 1–77 days.

Gender distribution of trauma variables showed no statistical significance for ISS, BMI, LOS, and number of TT days (Table 2). Females however were noted to be much older with a statistically significant age difference. We carried out a similar analysis to test the relationship between the type of trauma and the other variables. No statistical significance was noted for ISS, BMI, LOS, and number of days with TT. However, patients with rPTX secondary to penetrating injuries were noted to be significantly younger than patients with rPTX secondary to blunt injuries (Table 3).

To test if there is an association between gender and the type of traumatic injuries, a Chi-square test was used, which yielded an associated statistical significance between gender and type of trauma (Table 4). The proportion of males with blunt injuries was significantly different from the proportion of females with blunt injuries.

To examine the correlation among all the variables used in this study, the authors performed a Pearson correlation test. As noted in Table 5, there was a strong relationship between ISS with the overall length of stay for patients and a moderate relationship

**Table 1:** Demographics of retain pneumothorax patients

	<i>n</i> = 163
<i>Demographics</i>	<i>Mean ± SD or n (%)</i>
Age	40.7 ± 20.2
Gender	
Female	37 (22.7%)
Male	126 (77.3%)
Type of trauma	
Blunt	100 (61.3%)
Penetrating	63 (38.7%)
ISS	23.9 ± 13.4
BMI	26.9 ± 11.7
Number of CT	1.5 ± 1.2
Number of CT days	5.7 ± 3.9
Hospital LOS	13 ± 10.4

**Table 2:** Gender distribution of trauma variables

<i>Patients with rPTX</i>	<i>Mean ± SD</i>		<i>p value</i>
	<i>Female n = 37</i>	<i>Male n = 126</i>	
ISS	24.5 ± 14.1	23.8 ± 13.3	0.771
Age	48.2 ± 22.4	38.6 ± 19.0	0.010
BMI	28 ± 8.9	26.7 ± 12.4	0.551
TT days	5.8 ± 2.9	5.7 ± 4.2	0.879
Hospital LOS	13.5 ± 8.4	12.8 ± 11	0.703

between the number of TTs and the duration of the TT. There was also a strong relationship between the overall length of stay with the number of days patients had a TT and number of TTs. Of these 163 patients, 5 (3%) were readmitted. Only one, or 0.6%, of the readmitted patients required a new TT. The others were readmitted for reasons unrelated to rPTX.

**DISCUSSION**

Residual pneumothorax after TT removal is a very common complication in trauma centers. The primary goal of this study was to demonstrate that patients can be safely discharged prior to resolution of their rPTX when clinically stable. Our findings are similar to Kugler et al.'s 5-year retrospective study that showed 50.3% rPTX or residual pleural effusion, with 4% requiring intervention on discharge.<sup>1</sup> Their team, however, does not perform routine chest X-ray after TT removal. Rather, they obtain radiography only if patients are clinically symptomatic. They recommend follow-up in 1 week, and repeat radiography only if clinically warranted.

Tube thoracostomy is not a benign procedure. Secondary outcomes and complications include incorrect placement and malpositioning of the tube, empyema, and bronchopleural fistula.<sup>2</sup>

**Table 3:** Types of trauma and study variables

Patients with rPTX	Mean ± SD		p value
	Blunt (n = 100)	Penetrating (n = 63)	
ISS	25.1 ± 14.3	22.1 ± 11.8	0.161
Age	48.3 ± 20.6	28.8 ± 12.2	0.000
BMI	27.1 ± 8.1	26.8 ± 15.9	0.861
CT days	5.5 ± 3.2	6.0 ± 4.8	0.411
Hospital LOS	12.8 ± 9.0	13.2 ± 12.4	0.850

Positioning of the tube can cause multiple system complications depending on the placement of the tube. These include, but are not limited to, lung injury, esophageal perforation, liver injury, aortic impingement, vasculature laceration, injury to organs above and below the diaphragm, diaphragmatic perforation, and cardiogenic shock from compression of the right ventricle.<sup>2</sup>

In our study, all patients with rPTX were treated conservatively. No rPTX was large enough to require a new TT insertion immediately post removal. This is in contrast to other studies where a minimum of 5% required new TT post removal irrespective of whether Valsalva was used prior to removal.<sup>6</sup> In our retrospective study, we did not compare the technique of TT removal. In a similar 4-year retrospective study by Kong et al., 382 patients required TT secondary to pneumothorax. Thirty-two (8%) patients developed rPTX post TT removal and all were treated conservatively without further intervention and discharged after 24 hours.<sup>7</sup> As noted in the results, only one patient was readmitted and required an intervention for the rPTX.

There are several areas of limitation in this study. First, this was a retrospective study and not randomized, which limits the basis for inference about treatment effects. Second, the design of the study did not have a control group, which likewise limits the generalization of the results. In addition, we did not include variables such as the time the TTs were on suction and water seal to validate other researchers who have found the length of time TTs are placed on water seal are more at risk of rPTX. As noted by Bridges et al., using a short interval of water seal can reduce the time of TT by almost a day as well as reduce costs and decrease hospital LOS.<sup>8</sup> Mao et al. points out that increased duration of water seal can show increased hospital length of stay and increase number of chest radiographs.<sup>5</sup> Also, some institutions utilize high-flow oxygen

**Table 4:** Gender and type of trauma

Gender		n	Trauma type		p value
			Blunt trauma	Penetrating trauma	
Male	n	70	56	0.009	
	% within trauma type	70.0	88.9		
	Female	n	30		7
		% within trauma type	30.0		11.1

**Table 5:** Correlation of various trauma variables

Spearman's ρ	BMI	Correlation coefficient	p value	Number of days with TT	ISS	#CT	Total hospital length of stay
			0.090		-0.109	-0.125	0.054
		Sig. (two-tailed)	0.258		0.169	0.114	0.492
	Number of days with TT	Correlation coefficient	0.090		0.267	0.072	0.492
		Sig. (two-tailed)	0.258		0.001	0.364	0.000
	ISS	Correlation coefficient	-0.109	0.267		0.170	0.527
		Sig. (two-tailed)	0.169	0.001		0.030	<0.001
	#CT	Correlation coefficient	-0.125	0.072	0.170		0.439
		Sig. (two-tailed)	0.114	0.364	0.030		0.000
	Total hospital length of stay	Correlation coefficient	0.054	0.492	0.527	0.439	
		Sig. (two-tailed)	0.492	0.000	0.000	0.000	



for the “nitrogen washout” effect to facilitate complete resolution of the pneumothorax.<sup>5</sup> We currently do not use this practice consistently but it is a valid conversation for future planning. Finally, standardizing our patient education regarding their rPTX and resources for follow-up would support safe discharge of our clinically stable patients with rPTX.

Consideration for future investigation includes a prospective study evaluating correlation on the timing of placing the TT to water seal with rate of rPTX, evaluation of TT removal strategies, evaluation of patients with rPTX in a longitudinal study, evaluation of surgical patients, detailed analysis of the patient demographics requiring repeat TT on readmission, evaluation of patient characteristics that led to pneumothorax, and identification of a quantifying range of rPTX that is deemed safe for discharge.

## CONCLUSION

Over a 2-year period, 163 patients had rPTX, which were deemed clinically insignificant following TT removal prior to discharge. Only one of our patients or 0.6% required TT on readmission. Based on these findings, we conclude that the vast majority of patients with clinically insignificant rPTX can be managed conservatively and safely discharged home with adequate education and follow-up.

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