Observing pneumothoraces: The 35-millimeter rule is safe for both blunt and penetrating chest trauma

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BACKGROUND: As more pneumothoraxes (PTX) are being identified on chest computed tomography (CT), the empiric trigger for tube thoracostomy (TT) versus observation remains unclear. We hypothesized that PTX measuring 35 mm or less on chest CT can be safely observed in both penetrating and blunt trauma mechanisms.

METHODS: A retrospective review was conducted of all patients diagnosed with PTX by chest CT between January 2011 and December 2016. Patients were excluded if they had an associated hemothorax, an immediate TT (TT placed before the initial chest CT), or if they were on mechanical ventilation. Size of PTX was quantified by measuring the radial distance between the parietal and visceral pleura/mediastinum in a line perpendicular to the chest wall on axial imaging of the largest air pocket. Based on previous work, a cutoff of 35 mm on the initial CT was used to dichotomize the groups. Failure of observation was defined as the need for a delayed TT during the first week. A univariate analysis was performed to identify predictors of failure in both groups, and multivariate analysis was constructed to assess the independent impact of PTX measurement on the failure of observation while controlling for demographics and chest injuries.

RESULTS: Of the 1,767 chest trauma patients screened, 832 (47%) had PTX, and of those meeting inclusion criteria, 257 (89.0%) were successfully observed until discharge. Of those successfully observed, 247 (96%) patients had a measurement of 35 mm or less. The positive predictive value for 35 mm as a cutoff was 90.8% to predict successful observation. In the univariant analyses, rib fractures ($p = 0.048$), Glasgow Coma Scale ($p = 0.012$), and size of the PTX (≤35 mm or >35 mm) ($P < 0.0001$) were associated with failed observation. In multivariate analysis, PTX measuring 35 mm or less was an independent predictor of successful observation (odds ratio, 0.142; 95% confidence interval, 0.047–0.428)] for the combined blunt and penetrating trauma patients.

CONCLUSION: A 35-mm cutoff is safe as a general guide with only 9% of stable patients failing initial observation regardless of mechanism. (*J Trauma Acute Care Surg.* 2019;86: 557–564. Copyright © 2019 American Association for the Surgery of Trauma. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic, level III.

KEY WORDS: Observation; pneumothorax; pneumothoraces; tube thoracostomy; chest tube.

The incidence of pneumothoraxes (PTX) among injured patients has long been estimated to be around 5%,[1–4] with numbers of occult PTX, defined as a PTX seen on computed tomography (CT) scans but not on the initial supine chest X-rays (CXR), similar to those of overt PTX in some reports.[5] Major PTX are often detected by CXR. However, standard AP CXR missed nearly half of pneumothoraces.[1,5–11]

Computed tomography scanning is routine in the evaluation of both blunt and penetrating traumas. Although this imaging may have strengthened physicians' decisions and subsequent management, minor abnormalities and incidental findings, including pneumothoraces,[12] are more detected. Findings that would have otherwise remained undetected and untreated, now pose therapeutic dilemmas. On the other hand, the use of CT scan provides the opportunity to better standardize how pathology, like PTX, could be quantified and categorized.

Placing a tube thoracostomy (TT) has been the standard practice for nearly all traumatic PTX as per Advanced Trauma Life Support. However, physicians are now supporting the option of observing hemodynamically patients with PTX.[1,12–19] With few trials in the literature,[1,18,19] routine TT remains a controversial topic. Using the deMoya scoring system,[20] Cropano et al[21] conducted a study in 2015 on 165 patients concluding that the dichotomization of PTX measurement base on a cutoff of 35 mm is able to predict successful observation of hemodynamically stable patients whether or not they are mechanically ventilated. The 35-mm cutoff has been found to have an area under the receiver operating characteristic curve of 0.090 in predicting successful observation with a negative predictive value of 95.7%.

Tube thoracostomy comes with its own morbidities and complications,[22,23] sometimes reaching rates as high as 22% [5,8,24] even when performed by experienced clinicians. They range from pain, wrong placement, exacerbating empyema formation, retained hemothorax/PTX, to longer hospital and intensive care unit (ICU) stays, and, finally, post removal complications.

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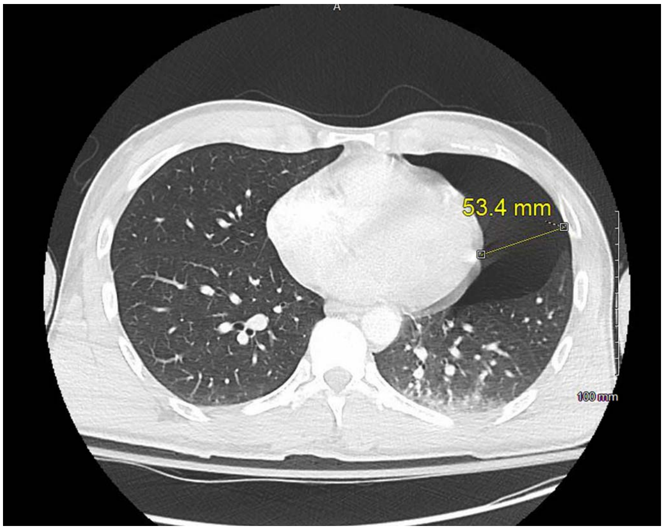

Figure 1. An example on PTX size measurement (performed by taking the radial distance—in millimeters—between the parietal and visceral pleura/mediastinum).

Therefore, there is a need to minimize the use of TT as routine management of all traumatic PTX, limiting it to patients with anticipated deterioration.

Based on our previous work, the purpose of this study is to determine whether the 35-mm rule is valid for observation management in both blunt and penetrating trauma.

MATERIALS AND METHODS

This is a single-center retrospective chart review of trauma patients admitted to a Level I trauma center over the period of 5 years (January 2011 to December 2016). The trauma registry was reviewed to identify patients. We included all patients 18 years and older who had a chest CT at the time of admission. We excluded patients who had no CT performed at the time of admission, had an ipsilateral hemothorax or hemopneumothorax, had a TT inserted before doing a chest CT. Patients who were mechanically ventilated during their index admission were also excluded. Chest CT was reviewed for all included patients to identify and measure the size of the PTX. The measurement was performed by taking the radial distance—in millimeter—between the parietal and visceral pleura/mediastinum in a line perpendicular to the chest wall on axial imaging of the largest air pocket. Measurements were then categorized into those 35 mm or less and those greater than 35 mm (Fig. 1).

The management of each case was categorized into those who were observed and those who underwent immediate TT. Observation was determined to be no intervention within 4 hours of presentation to the emergency department (ED). The primary outcome was the successful observation of PTX. Failure of observation was defined as a need for delayed TT or the need for secondary inventions like video-assisted thoracoscopic surgery, intrapleural tissue plasminogen activator, or thoracotomy. Delayed TT was either due to expansion of the PTX detected on imaging, developing pleural effusion, hemothorax, or tension PTX,

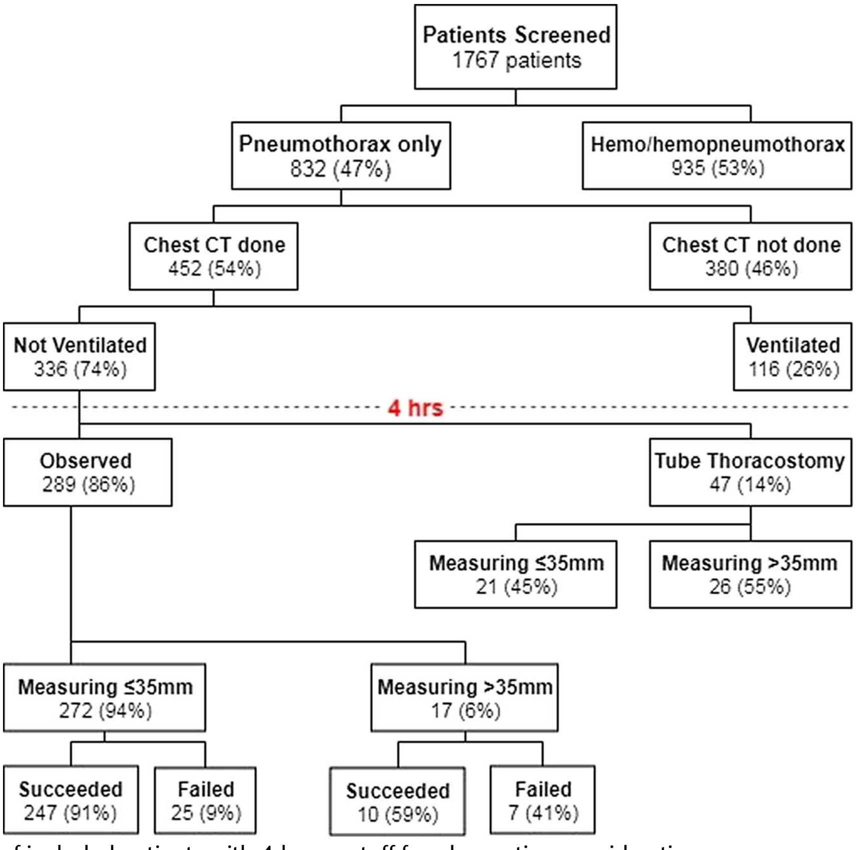

Figure 2. Flow diagram of included patients with 4-hour cutoff for observation consideration.

TABLE 1. Demographics and Trauma Characteristics N = 336

Variables	All Comers (n = 336)	Succeeded (n = 257)	Failed (n = 32)	*p*
Mean age (± SD)	41.5 (±18.9)	40.0 (±19.1)	46.9 (±19.2)	0.053
Race				0.270
White	227 (67.6%)	175 (68.1%)	22 (68.8%)	
Nonwhite	109 (32.4%)	82 (31.9%)	10 (31.2%)	
Male sex	222 (66.1%)	172 (66.9%)	17 (53.1%)	0.122
Mean BMI (± SD)	26.2 (±6.1)	26.0 (±5.5)	28.8 (±11.4)	0.440
COPD:				0.203
No	327 (97.3%)	251 (97.7%)	30 (93.8%)	
Yes	9 (2.7%)	6 (2.3%)	2 (6.3%)	
Mean ED systolic blood pressure (±SD)	129.8 (±22.7)	129.7 (±21.9)	131.7 (±30.7)	0.722
Mean ED dystolic blood pressure (±SD)	76.4 (±13.6)	76.0 (±13.7)	77.7 (±13.2)	0.537
Mean ED heart rate (±SD)	90.1 (±18.4)	90.3 (±17.9)	86.4 (±19.0)	0.248
Mean ED respiratory rate (±SD)	19.5 (±4.1)	19.6 (±4.3)	18.7 (±3.1)	0.278
Supplemental oxygen	79 (23.5%)	56 (21.8%)	6 (18.8%)	
Mechanism of injury:				0.360
Blunt	317 (94.3%)	249 (96.9%)	30 (93.8%)	
Penetrating	19 (5.7%)	8 (3.1%)	2 (6.3%)	
GCS				0.012
13–15	322 (95.8%)	245 (95.3%)	32 (100.0%)	
9–12	10 (3.0%)	9 (3.5%)	0	
<9	4 (1.2%)	3 (1.2%)	0	
Injury Severity Score				0.867
<9	52 (15.5%)	37 (14.4%)	5 (15.6%)	
9–14	137 (40.8%)	104 (40.5%)	10 (31.3%)	
15–24	117 (34.8%)	94 (36.6%)	15 (46.9%)	
≥25	30 (8.9%)	22 (8.6%)	2 (6.3%)	
No. fractured ribs				0.048
0	93 (27.7%)	74 (28.8%)	6 (18.8%)	
1–3	238 (70.8%)	180 (70.0%)	25 (78.1%)	
≥3	5 (1.5%)	3 (1.2%)	1 (3.1%)	
Flail Chest	5 (1.5%)	3 (1.2%)	1 (3.1%)	0.371
Lung contusion	119 (35.4%)	99 (38.5%)	9 (28.1%)	0.252
PTX, median (IQR)	10.4 (5.4–21.1)	8.0 (4.6–13.4)	20.3 (15.1–33.3)	<0.0001
≤35 mm	293 (87.2%)	247 (96.1%)	25 (78.1%)	
>35 mm	43 (12.8%)	10 (3.9%)	7 (21.9%)	
ED disposition:				0.110
Operating room	30 (8.9%)	20 (7.8%)	5 (15.6%)	
ICU	117 (34.8%)	87 (33.9%)	14 (43.8%)	
Floor	189 (56.3%)	150 (58.4%)	13 (40.6%)	
Median ICU length of stay (IQR)	0.0 (0.0–1.0)	0.0 (0.0–1.0)	1.0 (0.0–2.0)	0.056
Median hospital length of stay (IQR)	4.0 (2.0–7.0)	4.0 (2.0–6.5)	7.0 (4.0–9.0)	<0.0001
In-hospital mortality	5 (1.5%)	5 (1.9%)	0	0.426

or physiologic deterioration, defined as respiratory rate greater than 30 breaths per minute, Spo_2 less than 94% on room air, or heart rate greater than 100 beats per minutes, and systolic blood pressure less than 90 mm Hg attributed to the PTX. Our secondary outcomes were hospital length of stay and ICU length of stay.

We analyzed our data using IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Mann-Whitney *U* test/independent *t* tests or χ^2 tests were applied to evaluate the association for continuous variables or categorical variables with failure of observation as an outcome. The study was approved by the intuitional review board at the Medical College of Wisconsin.

RESULTS

A total of 1,767 patient was identified from the trauma registry (Fig. 2). We excluded 935 (35%) patients who had ipsilateral hemothorax/hemopneumothorax. Of the 832 patients who had only PTX, 452 (54%) patients had a chest CT at the time of presentation. We then excluded 116 (26%) patients who were put on mechanical ventilation during their index admission. The remaining 336 patients were included in this study.

The mean age was 41.5 years (± SD 18.9 years), and 94.3% had a blunt mechanism of injury. Only 1.5% of the patients had a clinical flail chest diagnosis, and 35.4% had a lung contusion. Three hundred twenty-two (95.8%) of the patients had a Glasgow Coma Scale (GCS) score of 13 to 15. The median measurement of the PTX is 10.4 mm (interquartile range [IQR], 5.4–21.1) with 293 (87.2%) PTX measuring 35 mm or less. The median length of stay was 4 days (IQR, 2.0–7.0 days) (Table 1).

A total of 47 patients received immediate TT (within 4 hours of presentation). Two hundred fifty-seven (89%) patients were successfully observed for more than 4 hours. Two hundred seventy-two (94%) patients had a measurement of 35 mm or less, of which 25 (9%) patients failed observation. Of the 17 patients who had a measurement greater than 35 mm, 41% failed observation. Reasons for failing observation in 37.5% of the patients were due to progression detected on radiologic imaging and in 12.5% of the patients due to developing pleural effusion, hemothorax, or tension PTX. Five (15.6%) patients had reported physiological deterioration before TT. The reason for delayed TT was unclear in 11 (34.4%) patients. Of the 336 patients, 8 (2.4%) patients required a secondary intervention (Table 2).

The positive predictive value of predicting successful observation for those 35 mm or less was 90.8%. The negative predictive value was 41.2% (Fig. 2 and Table 1).

On the univariate logistic regression, PTX measurement category (≤35 mm vs. >35 mm) ($P < 0.0001$), GCS ($p = 0.012$), and number of rib fractures ($p = 0.048$) were significant predictors for failing observation (Table 1). However, when controlling for other variables, multivariate logistic regression analysis revealed that only PTX measurement of 35 mm or less was significant (odds ratio, 0.142; 95% confidence interval, 0.047–0.428) in predicting successful observation (Table 3).

DISCUSSION

The optimal management of PTX incidentally found on CT remains debatable. Advanced Trauma Life Support guidelines recommend placing a TT for all traumatic pneumothoraces to avoid the possibility of developing a tension PTX.[25] However, with the absence of unified guidelines, a balance of the benefits and risks of placing a TT should be the key in directing clinicians' management in an attempt of sparing avoidable morbidities and even mortality.

TABLE 2. Management and Hospital Course, N = 336

Variables	All Comers
Tube Thoracostomy (TT)	
No	257 (76.5%)
Yes	79 (23.5%)
Time of TT after trauma median (IQR), h	3.0 (1.0–13.0)
Management	
Initially observed (at most 4 h)	289 (86.0%)
Failed observation (n = 289)	32 (11.1%)
TT within 4 h	47 (14.0%)
Reason for TT after observation failure (n = 32)	
Progression on imaging (CXR or CT scan)	12 (37.5%)
Physiologic deterioration	5 (15.6%)
Developing pleural effusion/hemothorax/tension PTX	4 (12.5%)
Unclear	11 (34.4%)
Need for 2° intervention after TT (n = 336)	
No	328 (97.6%)
Yes	8 (2.4%)

TABLE 3. Multivariant Logistic Regression With Failure of Observation as an Outcome, N = 289

Variable	*p*	OR [95% CI]
PTX measurement (≤35 mm as reference)	0.001	0.142 (0.047–0.428]
GCS	0.065	6.632 (0.889–49.483)
No. rib fractures	0.098	1.300 (0.953–1.774)

Case reports of successful observation of PTX in stable patients are reported in the literature. Ryan et al.[26] reported the spontaneous resolution of a "large" right-sided traumatic PTX treated atypically without placing a TT. Claiming to be the second case report in the literature, Idris and Hefny[27] reported, in 2016, a spontaneous resolution of a PTX estimated to be around 600 mL of air on CT imaging after a conservative management. Both case reports asked whether current traumatic pneumothoraces management guidelines and recommendations for TT should be revisited.

A prospective American Association for the Surgery of Trauma multicenter study was conducted by Moore et al. in 2011[16] to address the factor that might predict failing observation in blunt trauma patients. After analyzing the data of 569 blunt trauma patients recruited from 16 centers, the study concluded that progression and respiratory distress are independent predictors of failing observation and added that most blunt trauma patients with occult PTX can be observed. However, there was no standard approach in the institutions involved in this study and therefore may have weakened the association with size.

Our cumulative work devises an objective clinician-friendly tool help guide management of traumatic PTX. This study adds evidence of validity of the effectiveness of the 35-mm rule in observing hemodynamically stable patients with a low failure rate of 9%. Stratifying patients based on a clear cutoff into those who can be observed and those who are more likely to decompensate implies better utilization of resources and avoidance of unnecessary procedures.

Compared with our previous study,[20] this study includes a bigger cohort with 336 patients compared with 165 patients. Moreover, it validates the 35-mm rule at a different institution with a different practice group. Concerning the study design, the PTX size measurements were validated with two reviewers to enhance internal validity. We included a homogenous patient population with adding mechanical ventilation as an exclusion criterion. Thus, we excluded a potential clinician bias that might increase the tendency of placing a TT at a lower threshold. The hospital length of stay as significantly different ($p < 0.0001$) between the group that was successfully observed and the group that failed observation. This might reflect the morbidities accompanied with TT.

Given that the proposed algorithm in this study for PTX management is not implemented at our institution and given the retrospective nature of the study, there was large variability

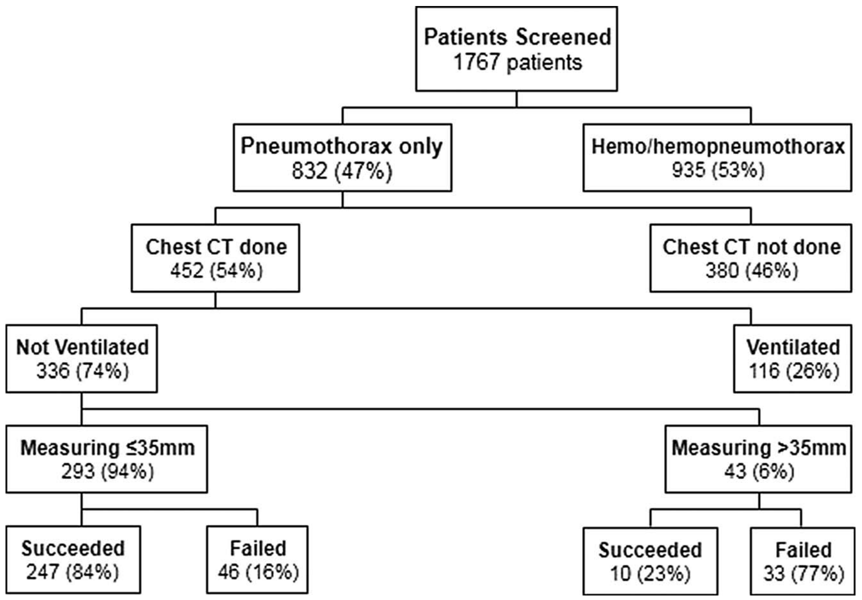

Figure 3. Flow diagram of included patients (all comers).

among physicians in practice decision making for placing a TT. The median time from ED presentation to placing of TT was 3.0 hours (IQR, 1.0–13.0). Therefore, to account for this variability among different practitioners, and after internally surveying our faculty, we were confident with the 4-hour cutoff as a determinant for being observed. However, we are aware that this might have been a limitation in our study by increasing our selection bias in the cohort of patients. In Figure 3, we show the stratification of all patients without any cutoff for being observed.

LIMITATIONS

Given that the algorithm is still not implemented at our institution, the decision of placing of TT is left to the attending's discretion. In addition, the decision of TT was unclear in 11 (34.4%) cases due to the difficulty of extracting the clinicians' decision retrospectively. Physiologic deterioration was noted in 15.6% of the cases and progression on imaging (CXR or CT scan) was noted in 12 (37.5%) patients. This might reflect the physicians' tendency to place chest tubes even without any physiologic deterioration in groups that might have otherwise been successfully observed. This limitation can be overcome with a prospective observational study. Another limitation is that the determination of the biggest air pocket on the CT was performed visually and then choosing from multiple measurements of probable biggest pockets. Idealistically, a computer-based algorithm used by a radiology specialist should be used to get the appropriate measurement. Another limitation is the imbalance in the mechanism of injury between blunt and penetrating trauma with the majority (94.3%) being blunt mechanisms. Although the mechanism of injury did not appear to affect a significant difference in our analysis, we recognize that the sample size is small. In review of the individual penetrating trauma patients, two of the 10 patients with penetrating traumas failed observation. However, only one failed with progression in the size of PTX detecting on imaging the other patient failed due to a larger hemothorax. Given the retrospective nature of the study, the reason for placing a delayed TT was unclear in some cases despite a stable PTX on follow-up imaging. Our speculation is that the physician felt more comfortable placing a TT due to historical practice patterns. Therefore, the failure rate of patients with penetrating trauma mirrored those with blunt injuries (10.0% vs. 8.7%, respectively). This highlights the need for clear guidelines on when to observe stable patients with pneumothoraces. There is also a need for a future study with balanced mechanism of injuries might to solidify our results.

CONCLUSION

In conclusion, the 35-mm rule remains a simple, clinician-friendly method to safely observe stable patients with pneumothoraces detected on chest CT scan. A push toward less routine utilization of TT is possible with this objective rule. We recommend considering this rule in devising PTX management protocols.

AUTHORSHIP

S.B.Z.E. participated in the conception, study design, data acquisition, analysis, interpretation of analysis, article development and revision. K.A.B. participated in the study design, data acquisition, article development, article development and revision. C.M.D. participated in the patient screening, data acquisition, analysis, interpretation of analysis. C.S.D. participated in the patient screening, data acquisition, analysis, interpretation of analysis. T.P.W. participated in the study design, article development and revision. J.S.J. participated in the study design, article development and revision. D.J.M. participated in the study design, interpretation of analyses, article development and revision. T.W.C. participated in the study design, interpretation of analyses, article development and revision. M.A.B. participated in the study design, article development and revision. P.A.C. participated in the article development and revision. C.T. participated in the article development and revision. M.A.dM. participated in the conception, study design, interpretation of analyses, article development and revision.

DISCLOSURE

The authors do not have any relevant disclosures or conflicts of interest and no funding was utilized for this work.

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DISCUSSION

ANDREW W. KIRKPATRICK, M.D. (Calgary, Alberta, Canada): Well, thank you very much. I want to thank the Association for the privilege of discussing this paper, and to the authors for providing it well in advance.

Dr. de Moya and his group have spent many years thinking about and studying pneumothoraces and their treatment, and their study today was well presented.

The authors retrospectively reviewed whether chest tubes were placed or not after a four-hour time mark in non-ventilated patients suffering traumatic pneumothoraces.

They dichotomized outcomes related to using a 35 MM cutoff value as measured by a simplification of a technique previously described by Dr. de Moya in 2007.

Using this 35 MM rule related to the greatest intrathoracic measurement perpendicular from the chest wall on CT, and this had a 91 percent predictive value for no chest tube being subsequently placed, although only a 41 percent negative predictive value in avoiding chest tube placement, which may actually be the more important number.

I have a number of brief comments and questions.

And first and foremost, I do want to applaud the authors in not mixing apples and oranges by analyzing patients with pneumothoraces who are subjected to positive-pressure ventilation with those are not, as positive-pressure ventilation is the single most important risk factor.

In other studies for pneumothorax progression and in inducing hemodynamically unstable tension pneumothorax, an entity that's actually quite rare in spontaneously breathing patients, mixing ventilated and non-ventilatted patients has been done too often in the past, including the authors' previous work, in which they derived the 35 MM rule, and in the previous AAST retrospective series.

Thus, I think the current study is a valid contribution, but we must be clear we are speaking about stable spontaneously breathing patients, and this information should not be expanded to apply to patients who are or will be subjected to positive-pressure ventilation – apples and oranges.

And I think it's important to note, as there was no actual protocol for when a patient required a chest tube, who was being observed, and that the reason for chest tube placement was unavailable in nearly one-half of the cases, that this data may largely reflect physician behavior and opinion regarding chest tube management, more than informing on the path of physiological requirement for chest tubes. And I think randomized trials need to be continued to be encouraged.

I think it's also important to recognize that the current data looks very reasonable in terms of predicting avoidance of a chest tube, but this may be due to the low prevalence of the condition, sort of a pre-test probability.

The chest tube placement in this population was actually 50/50 in terms of a negative predictive value. And the retrospective nature of the data precludes any real power calculation on this.

So really, my brief question relates to the authors as, could they look at other size markers, such as 30 MM, 40 MM, or 50 MM; essentially building a sort of receiver operator's curve to look at the relative positive and negative predictive values for another measurement other than 35 MM?

Or maybe even simply put, as only 12 percent of the group actually had a pneumothorax greater than 35 MM and there was no report of any real adverse patient-centered outcomes, such as a tension pneumothorax, is it possible that ANY pneumothorax in a stable non-ventilated patient could be observed, regardless of size?

Thank you very much.

KIMBERLY A. DAVIS, M.D., M.B.A. (New Haven, Connecticut): I enjoyed your presentation, and I applaud your efforts in this area.

How many of these pneumothoraces were occult and how many of these were visualized on chest x-ray? The reason that I ask is that most occult pneumothoraces can be observed, and the only reason that we know about them is because we're putting everybody through the scanner.

MATTHEW MARTIN, M.D. (Olympia, Washington): Congratulations to the authors, and I think this is important work. I think that in general, anything that makes us put less chest tubes into these small pneumothoraces is better.

My take on your data was that it really showed that 35 MM is just as arbitrary as any other size measurement we're using. From looking at the data that you presented, it looked like only about three of the patients who got a chest tube actually got one for a clinical indication.

So I think it's really important that we don't equate "got a chest tube" to "needed a chest tube". I have two questions: First, how many of those patients were symptomatic versus asymptomatic? And second, why are we putting chest tubes into somebody who may have a size greater than 35mm, be it 40 or 50 MM, but they're asymptomatic? Are we actually treating a patient, or just trying to make an x-ray look better? Thank you.

MATTHEW J. WALL JR., M.D. (Houston, Texas): Enjoyed your presentation. As I looked at your slides, you were measuring from the chest wall to the mediastinum, so are you perhaps measuring mediastinal shift or perhaps where in the chest the pneumothorax is occurring, with the upper chest having a greater distance between the chest wall and the mediastinum?

SHANNON M. FOSTER, M.D. (West Reading, Pennsylvania): A few questions. As we are all dealing with the aging population, were there some specific considerations for your geriatric patients, particularly in reference to those who already have lung volume loss based on kyphosis, based on previous surgery, based on severe COPD, emphysema, etc., because it seemed that your two age groups were relatively young, and so for a lot of us at geriatric centers, that really won't address the choice to put a tube or not in some of those patients. Thank you.

DAVID J. SKARUPA, M.D. (Jacksonville, Florida): What was the serial progression imaging? You mentioned these were picked up on CT scan, but then, what serial imaging did they get – chest x-rays, ultrasound, CTs? Thank you.

THOMAS K. DUNCAN, D.O. (Ventura, California): Great presentation. My question is, what mechanism do you have/what algorithm do you have, in regards to working up these patients with eFast scans?

For example, when patients come into your shop, do they have an eFast performed before they go to the CT scanner? As you know, an eFast scan will pick up an anterior pneumothorax more so than a chest x-ray, and you certainly don't want to have a patient leave your trauma bay to proceed to the CT scanner with a large pneumothorax and you end up in the 'tunnel of doom,' causing you to put in an emergent chest tube; so, I'd like to know what your mechanism is in regards to that.

THOMAS J. SCHROEPPEL, M.D. (Colorado Springs, Colorado): A couple of questions. What are you actually using for chest tubes? We've switched over to pigtails recently and noted excellent results.

The last question is, how did you define failure? I mean, just the simple sake of putting a tube in doesn't necessarily mean the patient needed a tube. Was it symptoms, was it a change in size of the pneumothorax? How did you define the failure? Thank you.

ANDREW W. KIRKPATRICK, M.D. (Calvary, Alberta, Canada): Just a real quick comment about the comment from Dr Davis concerning the need for an RCT in ventilated patients with occult pneumothoraces. There is already an ongoing RCT on occult pneumothoraces in critical care, which focuses on ventilated patients, called OPTICC. You just Google OPTICC; it should be the first hit (www.opticc.com). It's an RCT that everybody is welcome to participate in.

SAVO BOU ZEIN EDDINE, M.D. (Milwaukee, Wisconsin): Thank you all for your thoughtful comments. I'll start by addressing Dr. Kirkpatrick's questions.

As you mentioned, this study is a cumulative work that has been done since 2007 and through the years different cutoffs have been tested, and the areas under ROC curve were determined.

In the study done in 2015 by Cropano et al, the 35 mm cutoff was found to have an area under the receiver operating characteristic (ROC) curve of 0.90 and a negative predictive value of 95.7% in predicting successful observation.

We are recommending the 35 mm rule as a guide for clinicians' decisions. We acknowledge that it is hard to set an objective cutoff for placing a chest tubes for pneumothoraces. The impact of a pneumothorax of the same size varies with the physiology and the habitus of the patient. A big guy with a pneumothorax might respond physiologically in a different way compared to an old lady with a pneumothorax of the same size.

Therefore, this rule is not intended to replace physiology, but to help physicians in making their decision with confidence and based on supported data. This will help identify patients who are at a higher risk of further physiological deterioration and spare the morbidities of un-needed tube thoracostomies.

We did separate the ventilated versus non-ventilated patients, as you mentioned, to get a more homogenous group, and the group analysis was presented at 31st Panamerican

Congress Of Trauma, Critical Care And Emergency Surgery in Cartagena, Colombia. Ventilated patients had compatible failure rates to the same 35 mm rule.

In response to Matthew Martin, M.D.: We collected vital signs, pre- and post-placement of chest tubes to determine if the chest tube placement was necessary, and this is further explored in our manuscript.

In response to Kimberly A. Davis, M.D., M.B.A.: The study included both overt and occult pneumothoraces. Given the exclusion criteria, we believe that the majority of our patients had an occult pneumothorax. We are in the process of initiating a AAST multicenter study to address your question. Thank you for your comments.

In response to Shannon M. Foster, M.D.: We didn't specifically address the geriatric population in our study, as the mean age of our population was for young, mean age 41.5 years (±18.9), but this can further be explored in a separate study.

In response to David J. Skarupa, M.D.: Serial imaging was either a chest x-ray or a CT scan that documented an increase in size on the follow-up. We didn't include ultrasound results.

In response to Thomas K. Duncan, D.O.: The use of eFAST to detect pneumothorax is being studied at our institution by Dr. Thomas Carver. However, its use to quantify the size of the pneumothorax is not routinely performed.

In response to Thomas J. Schroeppel, M.D.: That's right. The use of pigtails for pneumothoraces' drainage has been well studied. However, this is not part of our protocol at MCW. At our institution, we are studying it for draining for hemothoraces as a part of multicenter trial lead by University of Arizona – Tucson. Failure of observation was defined either as a need for a delayed tube thoracostomy or secondary intervention, like Video-assisted thoracoscopic surgery (VATS) or intrapleural tissue plasminogen activator and thoracotomy.

I believe I answered all the questions. Thank you all for your thoughtful comments.