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Pneumothorax and Pneumomediastinum in Patients with Restrictive Eating Disorders: A Case Series and Literature Review

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Abstract

Background: The purposes of this case series was to identify clinical characteristics of patients with restrictive eating disorders who have experienced pneumothorax or pneumomediastinum and elucidate possible risk factors for the development of pneumothorax or pneumomediastinum in this patient population through literature review. The scope of the case series is limited to patients admitted for medical stabilization from severe restrictive Eating Disorders (EDs).

Methods: We compiled a series of adult patients with severe EDs who were diagnosed with a pneumothorax or pneumomediastinum while admitted to the ACUTE Center for Eating Disorders at Denver Health between April 2016 and January 2021. Additionally, a series of adult patients who reported a history of pneumothorax on admission to the same institution, during the same time period, were identified and characteristics of their pneumothorax were obtained using outside records provided by the patient at time of their admission. A literature review of cases of pneumothorax and pneumomediastinum in patients with EDs was completed.

Results: Twenty-five cases of pneumothorax were identified in patients with anorexia nervosa (AN) or avoidant/restrictive food intake disorder (ARFID), all of whom were below normal body weight, between cases at our institution and literature review. Additionally, 5 patients at our institution, and 21 patients with EDs from the literature with below normal body weight with spontaneous pneumomediastinum were identified.

Conclusions and limitations: The relationship of spontaneous pneumomediastinum in patients with AN and ARFID and low body weights is well established and can be managed conservatively with good outcomes. It is currently unclear if the starved state, and the lung changes it induces in these patients increases patients' risk for spontaneous pneumothorax. Patients with AN and ARFID may be at higher risk for iatrogenic pneumothorax with certain invasive procedures. There is direct connection between patients' eating disorder and occurrence of traumatic pneumothorax. Patients at expected body weights, or in larger bodies with restrictive Eds, were not included in this study and therefore, their risk of pneumothorax and pneumomediastinum in relation to their eating disorder behaviours is unknown.

Keywords: Restrictive eating disorder • Pneumothorax • Anorexia nervosa • Avoidant restrictive food intake disorder • Severe malnutrition • Pneumomediastinum

Abbreviations: AN-BP: Anorexia Nervosa-Binge-Purge Subtype; AN-R: Anorexia Nervosa-Restrictive Subtype; ARFID: Avoidant Restrictive Food Intake Disorder; BMI: Body Mass Index; ACUTE: Center for Eating Disorders and Severe Malnutrition at Denver Health; CVC: Central Venous Catheter; COPD: Chronic Obstructive Pulmonary Disease; CT: Computed Tomography; DLCO: Diffusion Capacity; EDs: Eating Disorders; HC: Healthy Controls; IP: Iatrogenic Pneumothorax; IBW: Ideal Body Weight; MALS: Median Arcuate Ligament Syndrome; NG: Nasogastric; NTM: Non-Tuberculosis Mycobacterium; PICC: Peripherally Inserted Central Catheter; PM: Pneumomediastinum; PTX: Pneumothorax; PSP: Primary Spontaneous Pneumothorax; SSP: Secondary Spontaneous Pneumothorax; SPM: Spontaneous Pneumomediastinum; SP: Spontaneous Pneumothorax; DSM-5: Statistical Manual Of Mental Disorders, Fifth Edition; TP: Traumatic Pneumothorax

Introduction

Medical complications of patients with restrictive Eating Disorders (EDs), which include Anorexia Nervosa-Restrictive Subtype (AN-R), anorexia nervosa -binge-purge subtype (AN-BP), or Avoidant Restrictive Food Intake Disorder (ARFID), have been previously described [1,2]. Compared to other organs systems, however, the lungs appear to be relatively spared from the ravages of EDs with limited descriptions of pulmonary complications in the literature [3,4]. Recently, we described a potential association between Non-Tuberculosis Mycobacterium (NTM) and low body weighted patients whose EDs comprise chronic vomiting [5]. The patient population we care for, at the ACUTE Center for Eating Disorders and Severe Malnutrition at Denver Health (ACUTE), have extreme forms of EDs. Within this patient population, we have observed multiple patients with pulmonary complications including Pneumothorax (PTX) and Pneumomediastinum (PM). PTX is defined as an abnormal gas accumulation within the pleural space. PM describes the pathological presence of air in the interstitial tissues of the mediastinum. Both PTX and PM can be associated

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with significant morbidity and mortality if not effectively diagnosed, both due to complications of the abnormal gas accumulation but also due to underlying diagnoses that can contribute to their development. The development of PTX and PM can occur spontaneously and without injury but also as a complication of iatrogenic or traumatic injury.

The first case of Primary Spontaneous Pneumothorax (PSP) in a patient with Anorexia Nervosa (AN) was described in 1998 [6]. Since its publication, nine other case reports have highlighted cases of PTX, both spontaneous and iatrogenic in patients with EDs with varying complications [7-15]. To our knowledge there are no case series exploring the etiologies of PTX in this patient population. In 2010, Holchlehnert A, et al. [16] presented a case of PM in a patient with AN-R accompanied by an extensive literature review of PM in 53 young patients of the cases reviewed, 13 patients with Spontaneous Pneumomediastinum (SPM) had EDs and 6 were significantly underweight [Body Mass Index (BMI) reported between 9.6 and 12.6 kg/m^2]. Detailed weight information was not available for 35 of the patient cases reviewed.

By reviewing the occurrence of PTX and PM in patients with severe EDs at a single institution, dedicated to the care of these patients with advanced medical complications, and then conducting a literature review, we sought to further the field's knowledge of PTX or PM in this patient population.

Case Series

In this case series, we explore 6 cases of PTX and 5 cases of PM in adult patients admitted to ACUTE. Furthermore, we present 9 patients who reported a history of PTX prior to admission to ACUTE and reviewed the reported circumstances around those events.

ACUTE is an inpatient hospital unit treating adult and adolescent patients with extreme forms EDs and the medical complications that arise because of their severe malnutrition. ACUTE's outcomes and patient population have been previously described [1]. At present, ACUTE treats around 350 individuals annually from all over the world, the majority of whom are diagnosed with AN-R, AN-BP, or ARFID. Cases were identified retrospectively using our institution's electronic health record. Cases were reviewed by ACUTE's internists and a pulmonologist to classify the cause of PTX as Spontaneous (SP), Traumatic (TP) or Iatrogenic (IP). The patients' eating disorder diagnosis was based on psychiatrist and psychologist assessment and documentation at discharge in accordance with Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) [17].

Pneumothorax

Patients who developed PTX during their hospitalization are summarized in Table 1. Of the six patients with PTX, 3 patients carried the diagnosis of AN-BP, 2 were diagnosed with AN-R, and 1 patient was diagnosed with ARFID. All pneumothoraxes identified, while patients were admitted to ACUTE, were classified as iatrogenic. Percentage of Ideal Body Weight (IBW) was low and varied between 47.7% and 82.3%. Prealbumin, a marker of nutrition, also varied widely between <5 mg/dL (our institutions lower assay limit) and 34.9 mg/dL (normal range 20.0-52.0 mg/dL). Three patients required chest tube placement for resolution. In one case, a chest tube was already in place (and was the cause of the PTX). In the remaining two cases, the pneumothoraxes were small and resolved without intervention. Three of the six pneumothoraxes were asymptomatic, whereas two patients reported pleuritic chest pain and one patient was diagnosed by chest x-ray after the development of worsening hypoxia (Table 1).

Two of the cases resulted from diagnostic thoracentesis. One PTX resulted from a pacemaker unnecessarily placed at another institution for bradycardia, likely because of the patient's severe malnutrition. Another PTX was noted incidentally on spinal imaging conducted for unrelated symptoms one day after surgery for Median Arcuate Ligament Syndrome (MALS) release. One PTX resulted from chest tube placement for an empyema. The most unique cause of PTX was Nasogastric (NG) tube placement. In this patient case, the patient started coughing violently during NG tube placement. Due to the patients coughing, the NG was immediately removed, and her coughing resolved. Five hours later, the patient developed worsening hypoxia and chest x-ray revealed a large left sided PTX. While it cannot be confirmed, it is postulated that the NG was placed in the bronchus rather than the esophagus and that the guide wire somehow punctured the lung. This patient's lung parenchyma was known to be abnormal with CT imaging documenting bibasilar opacities. She had also had two MICU admissions each requiring intubation for hypoxic respiratory failure within the 6 weeks prior to her admission to ACUTE. This patient responded well to chest tube placement.

History of pneumothorax

Nine patients reported a prior history of PTX at time of admission to

Table 1. Patient diagnosed with pneumothorax during hospitalization on medical stabilization unit for eating disorders.

Patient	Demographics	Prealbumin on Admission (mg/dL) (normal >20 mg/dL)	Symptoms	Cause of Pneumothorax	Size of Pneumothorax Per Radiology Report	Intervention	Days Until Pneumothorax Resolution on Chest Imaging
A	56 yr F, AN-BP 78.5% IBW Non-smoker	34.9	Worsening hypoxia	Iatrogenic- NG tube placement. Patient with abnormal lung parenchyma prior to pneumothorax	Large	Chest tube placement, size 18F	4
B	26 yr F, ARFID r/o AN-R 47.7% IBW Non-smoker	<5	None	Iatrogenic- diagnostic thoracentesis	Moderate	Chest tube placement, size 10F	9
C	32 yr F, AN-BP 70.1% IBW Non-smoker	23.3	Pleuritic chest pain	Iatrogenic- pacemaker placed 5 days prior to admission at our institution	Moderate	Chest tube placement, size 8F	2
D	25 yr F, AN-R 67.3% IBW Non-smoker	17.5	Chest pain and shortness of breath	Iatrogenic- diagnostic thoracentesis day prior to diagnosis	Small	None	0, resolved on repeat chest imaging on day of diagnosis
E	36 yr F, AN-R 73.5% IBW Non-smoker	21.9	None	Iatrogenic- chest tube placed for empyema	Unspecified hydropneumothorax	None	7
F	51 yr F, AN-BP 82.3% IBW Former Smoker, 12 pack years	19.1	None, incidental finding on spine imaging	Iatrogenic- MALS release day prior to diagnosis	Small	None	Unclear, not followed with serial chest imaging

AN-R= Anorexia Nervosa, Restricting subtype; AN-BP= Anorexia Nervosa, Binge-Purge subtype; F= French; IBW= Ideal Body Weight; Pt= Patient; PTX= Pneumothorax

ACUTE. These patients are summarized in Table 2. Four were diagnosed with AN-BP, 3 with ARFID, and 2 with AN-R. In these patients, the cause of the PTX was spread evenly amongst IP, SP, and TP. The percentage IBW that the patient was at the time of the PTX was not available in all cases due to limited record availability from each event. For the five patients for whom this information was available, percentage of IBW ranged from 50.3% to 93.8%. The iatrogenic pneumothoraxes resulted from chest tube placement for empyema, biopsy during bronchoscopy, and central line placement for intravenous fluids. Two of the three traumatic pneumothoraxes were related to the patients eating disorder with one occurring due to resuscitations efforts during a cardiac arrest caused by severe hypokalemia and the other from a syncopal episode also due to hypokalemia that resulted in rib fracture and subsequent PTX. Three patients had histories of SP. Two of these three patients were later diagnosed with NTM. Of note, one of the patients diagnosed with the SP, who was later diagnosed with NTM, had a SP of the contralateral lung one year prior. The SP immediately preceding his care at ACUTE required prolonged chest tube placement and endobronchial valve placement to resolve the PTX (Table 2).

Pneumomediastinum

Five patients were diagnosed with PM during their admission to ACUTE. These patients are summarized in Table 3. Three patients with PM had AN-BP and 2 patients had AN-R. Their percentage of IBW ranged from 53% to 64%. Prealbumin ranged from 10.3 mg/dL to 24.4 mg/dL in these five patients. Three of the 5 patients were asymptomatic with PM being found incidentally on abdominal imaging. The other two patients reported symptoms of severe chest pain and neck pain. Four patients underwent further work up for their PM with esophograms which were normal. One of these patients' PM was attributed to a ruptured bleb seen on Computed Tomography (CT) of the chest. Three patients were determined to have SPM after further work up, of which one SPM was attributed to frequent Valsalva maneuvers while attempting to unplug her ears. The other two had no clear causative preceding event. In all patients, PM resolved without further intervention (Table 3).

Literature Review

A review of the literature in English was conducted using Pubmed over the past 50 years. Search terms included: starvation, malnutrition, anorexia, avoidant restrictive food intake disorder, eating disorder, pulmonary, pneumothorax, pneumomediastinum.

Pulmonary implications of the starved state

Compared to other organs systems, the effect of EDs on the lungs are less clinically overt [3,4]. The initial clinical descriptions of the impact of malnutrition on lung structure and function came from autopsy studies performed by Jewish physicians in the Warsaw Ghetto during the Holocaust which observed macroscopic findings of pulmonary emphysema in 13.8% of cadavers of patients with severe malnutrition examined (American Jewish Joint Distribution

Table 2. Patients reporting history of pneumothorax on admission to medical stabilization unit for eating disorders.

Patient	Demographics	Prealbumin on Admission to Outside Facility (mg/dL), Normal Range Varied	Symptoms	Cause of pneumothorax	Size of Pneumothorax Per Radiology Report	Intervention	Days until Pneumothorax Resolution on Chest Imaging
A	30 yr F, AN-R 50.3% IBW	3	none	Iatrogenic- Chest tube placed for empyema	Moderate to large	None noted on follow up film after chest tube removal. Patient refused recommended intervention of pleurex catheter	Unknown, did not have serial chest imaging. Resolved between day 10 and day 36 after diagnosis
B	55 yr F, AN-BP *	*	*	Iatrogenic- bronchoscopy with biopsy	*	*	*
C	40 yr F, AN-BP *	*	*	Traumatic- CPR for out of hospital arrest due to ventricular fibrillation with severe hypokalemia	Small	None	*
D	24 yr M, ARFID * MJ user	*	*	Spontaneous - thought to be related to cannabis "dabbing"	*	*	*
	63 yr F, AN-R 65.9% IBW	*	*	Iatrogenic- Internal jugular central line placement for IV fluids during an ED visit	*	*	*
E	42 yr F, AN-BP 93% IBW	19.1	None, incidental finding on spine imaging	Traumatic- related to rib fracture after syncopal episode from hypokalemia	Large	Chest tube placement, size unknown	3
F	30 yr M, ARFID 62% IBW	5.2	Abdominal pain	Spontaneous- pt also had history of contralateral spontaneous PTX 1 year prior. Pt found to have non-tuberculosis mycobacterium	Large	Chest tube placement developed BPF and required EBV placement without full resolution then worsened requiring repeat chest tube placement.	64
G	35 yr F, ARFID *	*	*	Spontaneous- patient diagnosed with non-tuberculosis mycobacterium	*	*	*
H	26 yr F, AN-BP *	*	*	Traumatic- motor vehicle collision	*	*	*

* Data not available; AN-R= Anorexia nervosa, restricting subtype; AN-BP= Anorexia Nervosa, Binge-Purge subtype; BPF=Bronchopleural Fistula; EBV= Endobronchial Valve; ED= Emergency Department; IBW= Ideal Body Weight; Pt= Patient; PTX= Pneumothorax

Table 3. Patients diagnosed with pneumomediastinum during hospitalization on medical stabilization unit for eating disorders.

Patient	Demographics	Prealbumin on Admission (mg/dL) Normal Range >20.0 mg/dL	Symptoms	Further Work Up and Management
A	19 yr F, AN-BP 64% IBW	16.2	None- incidental finding on abdominal x-ray for NG placement.	None
B	38 yr F, AN-BP 53% IBW	10.3	Severe chest pain	CT of the chest demonstrated not only the large pneumomediastinum, but also bronchiectasis and ground glass opacities predominantly in the LUL and RML. Surgery was consulted Surgery requested an esophogram to rule out esophogeal perforation, which was done and negative. Pulmonary was also consulted who thought pneumomediastinum was likely a result of ruptured bleb. She was managed conservatively and her symptoms and pneumomediastinum resolved.
C	27 yr F, AN-R 59.4% IBW	12.9	None- incidental finding on abdominal x-ray for NG placement.	Determined to be sponatenous after work up.
D	25 yr F, AN-R 56% IBW	18.5	Neck Pain	Work up negative. Thought to be related to patient's frequent valsalva pressure to clear plugged ear.
E	21 yr F, AN-BP 61% IBW	24.4	Incidental finding on CT Abdomen for abdominal pain	Determined to be sponatenous after work up.

AN-R= Anorexia Nervosa, Restricting subtype; AN-BP= Anorexia Nervosa, Binge-Purge subtype; IBW= Ideal body weight; LUL= Left Upper Lobe; NG=Nasogastric Tube; Pt= Patient; PM= Pneumomediastinum; RML=Right Middle Lobe

Committee and Winick 1979) [18]. The authors were limited in their capacity to microscopically and histologically examine specimens. Of the 3 autopsies on which such examinations of the lung occurred, the structure of the alveoli were noted to be preserved however, thinning of the alveolar walls and enlargement of the alveolar spaces were noted. Unfortunately, data to determine exact percentage IBW and BMI on these specimens were not available; however, the authors do note that most patients in their care were 30-50% of their prewar weight at time of death. These observations prompted studies of the lungs of starved rodents by researchers interested in finding additional animal models to facilitate Chronic Obstructive Pulmonary Disease (COPD) research.

Animal Studies

Rats in a fasted state have been shown to have a decrease in lung protein synthesis and an increase in lung proteolysis [19]. Starved rats have been shown to have enlargement of air space and thinning of alveolar walls (similar to the autopsy findings from patients in the Warsaw ghetto), translating to decreased surface area and increased lung compliance [20]. Further rat studies showed decreased lung volumes in young starved rats with a decrease in DNA, protein, elastin, hydroxyproline and crude connective tissue [21]. In this same study, aged, starved rats had similar lung volumes as control rats and only a decrease in DNA and total protein, without the same deficits of connective tissue components observed in their young counterparts. This same group found starvation reduces surfactant production but production returns to normal with refeeding which correlates with the return of tissue elastic forces to normal after refeeding in the rat model [22]. This study also demonstrated that refeeding after starvation is associated with increase in lung cell numbers. A separate study also found reduced elastin and collagen in starved rat lungs and concluded this reduction was due to lack of lung growth rather than connective tissue depletion due to a starved state [23]. These authors also coined the term “nutritional emphysema” as the emphysema induced by starvation do not appear to cause destruction of alveolar septa [22]. Further rat studies demonstrated that starvation cycling slowed lung growth by demonstrating reduced lung volume and alveolar surface area in growing rats [24]. Similar findings have been noted in starved hamsters [25]. The diffusion capacity (DLCO) of starved rats were shown to be reduced compared to fed, age matched controls [26]. Twenty years later a study of rats in a starved state demonstrated 35% loss of alveoli within 72 hours of onset caloric restriction but did not note tissue necrosis [27]. These authors also noted ongoing alveolar loss with continued restriction, however, alveoli returned to their prestarvation levels with refeeding.

Case Series that evaluated pulmonary function testing and cross-sectional pulmonary imaging in Eating Disorders

Pieters T, et al. [28] studied Pulmonary Function Tests (PFTs) in 24 ambulatory and hospitalized females with AN (mean BMI 14.3 kg/m^2). Their research did not find PFTs consistent with pulmonary emphysema, nor did they identify a difference in DLCO in the patients with AN compared to established normal values. They did find a decrease in maximal inspiratory and expiratory pressures, with inspiratory pressure more affected, and increased residual volume compared to established predicted values likely related to respiratory muscle weakness. Pieters T, et al. [28] concluded that the patients with AN in their study did not have PFTs consistent with emphysema because the patients had normal serum protein levels. However, albumin has been shown to be an inaccurate marker of nutritional status in Eds [29,30].

Coxson OH, et al. [31] compared 21 female patients with AN (mean BMI 18 kg/m^2) to healthy, age matched Healthy Controls (HC) and conducted PFTs in addition to CT lung imaging. They noted no difference between the patients with AN and aged matched controls on PFTs, including no difference in maximum inspiratory and expiratory pressures. Notably, the mean BMI of their patients was higher than those in the studies detailed above. The CT of each patient was analyzed for mean density, volume of gas per weight of lung tissue, and surface area to volume ratio. There were significant differences between the patients with AN and the age matched controls in all three categories analyzed with the patients with AN having lower mean CT density, higher volume of gas per weight of lung tissue, and lower surface area to volume ratio. Volume of gas per weight of lung tissue could also be sub classified into normal, small emphysematous and large emphysematous changes. Again, there were significant differences between patients with AN and age matched controls with regards to percentage of lung voxels (a radiological unit of measure) within all three categories. Patients with AN were noted to have less normal and more small and large emphysematous changes on CT compared to age matched controls. This study also noted that while there was not significant difference in DLCO between the two groups there was a correlation between DLCO and BMI, with lower BMI correlating with lower DLCO. The authors specifically noted their findings of DLCO were comparable to those of Harkema JR, et al. [26] in starved rats. The authors concluded there were “emphysema like” changes in patients with AN based-on CT findings and correlation between BMI and DLCO.

Gardini Gardenghi G, et al. [32] demonstrated that DLCO, in 27 patients with AN (mean BMI 16 kg/m^2), differed significantly from HC. This study further broke down patients with AN by duration of illness, ≤3 years and >3 years. They noted that DLCO progressively worsened with the disease duration. Maximum inspiratory and expiratory pressures were also decreased in patients with AN compared with HC in the study. Inspiratory and expiratory pressures did not worsen with duration of AN. The AN patient with reduced DLCO underwent CT imaging of upper, middle, and lower portions of the lung. These images were evaluated by a thoracic radiologist for air trapping and air density changes suggestive of emphysema. Emphysematous changes were not observed in the patients with AN who underwent CT, suggesting alveolar septa are preserved despite DLCO findings suggesting impairment in gas exchange.

Pneumothorax

In the general population, the incidence of SP has repeatedly been noted to be higher in males than females, with the incidence difference reported to range from a factor of 2.7:1 to 10:1 [33-36]. Most recently, Hallifax JR, et al. [33] identified that about 60% of the SP in their data set could be classified as secondary spontaneous pneumothorax (SSP) due to their association with chronic lung disease. Recurrence rates were similar between sexes, but underlying lung disease was a risk factor for recurrence seemingly independent of age and sex. Unfortunately, these data were not further broken down by weight. In addition to male sex, taller height, tobacco use, and leaner build have also been associated with greater risk of SP in other studies [37-39].

Historically, SP in otherwise healthy patients have been attributed to lung blebs or bullae, so called “emphysema like changes” [40,41]. Blebs have been shown to be more prevalent in individuals with low BMI who smoke [42]. Marijuana has also been implicated in bleb and bullae formation [43]. Evidence of air trapping on CT has also been observed in patients with PSP independent of tobacco use [44]. However, other studies have suggested increased visceral pleural porosity in otherwise normal appearing lung may also contribute to SP formation [45]. Of note, most patients in this study were smokers.

Iatrogenic Pneumothorax (IP) is one that arises due to another medical intervention or procedure such as thoracentesis, Central Venous Catheter (CVC) insertion or lung biopsy, which injures the pleura. Lung biopsy has the highest association with IP occurrence [46]. In the general population, a meta-analysis of IP following thoracentesis, found the incidence of IP to be 6% [47]. In this meta-analysis, use of ultrasound was associated with significant lower risk of IP. The incidence of IP following cardiac device placement has been found to be 1.3% with age >80, female sex, COPD, and dual chamber pacemaker (compared to single chamber pacemaker) being associated with higher incidence of IP [48]. In this same study, obesity was noted to be a negative predictive factor for IP following cardiac device placement. Incidence rate of PTX associated with CVC insertion has been noted to be about 0.7% [49]. This study also noted an association between lower body weight and overall complication (bleeding, vascular injury, PTX, stroke, death) rate from CVC insertion.

Ten case studies of patients with PTX and EDs have previously been described in the English language scientific literature. Six of the 10 reports entailed PSP, two attributed to SSP, and iatrogenic and traumatic each accounted for one case report. These cases are summarized [6-15]. One case reported a prolonged recovery complicated by suspected alveolopleural fistula following IP [7].

Pneumomediastinum

Incidence of SPM in the general population has not been reported in the literature. Koullias JG, et al. [50] reported 24 cases of SPM in a 7 year period at an academic hospital. The average age was 17.5 years old. No weight data was presented. Twenty-five percent of these patients reported use of heroin or cocaine, though the mechanism of use was not specified in the report we assume these substances were inhaled. Two patients reported vomiting prior to diagnosis. All patients were managed conservatively and did not experience recurrence. A systematic review of 600 case reports reported SPM associated with no identifiable cause, athletic activity, inhalation drug abuse, vigorous cough, asthma, vomiting, parturition, and yelling [51]. Most recently SPM has been widely reported in severe COVID-19 pneumonia [52]. The systematic review by Dajer-Fadel WL, et al. [51] reported thoracic chest pain and dyspnea to be the most common symptoms. The average age of the patients in the review was 22.8 years old. Unfortunately, again no data on weight was presented. All patients in the systematic review were managed conservatively with no reported mortality. A single center retrospective analysis by Ebina M, et al. [53] also supports conservative management.

Secondary PM can occur due to esophageal rupture, PTX, and trauma. Secondary PM has also been reported as a complication of mechanical ventilation as well. Patients presenting with PM should be evaluated for a secondary cause. If found, the secondary cause should be treated.

Hochlehnert A, et al. [16] have previously presented a case report of a patient with AN-R accompanied by a review of SPM in the literature that included 30 young patients (age 11 to 28 years old) in addition to Koullias JG, et al.’s [50] data. Excluding Koullias et al.’s [50] data, 20 of the 30 patients were female. In all cases where weight and height data were available (16 cases), BMI was <18 kg/m^2. Fourteen of the 16 cases had BMI <13.8 kg/m^2. The remaining cases did not provide a weight, height, or BMI. Thirteen of the cases had a diagnosis of AN or suspected diagnosis of AN. Four patients reported significant weight loss in the months prior to their presentation with SPM. Four patients reported self-induced vomiting. Two patients reported unintentional vomiting. All the patients were managed conservatively, and no deaths were reported. The authors postulated that severe malnutrition because of AN may allow for an air leak into the interstitium of the lung giving way to PM.

Discussion

Pneumomediastinum in restrictive eating disorders

PM can be further classified as spontaneous (SPM) or secondary. Secondary PM can be attributed to a specific occurrence or injury, such as esophageal rupture, PTX or penetrating trauma [54]. PM is thought to occur when air escapes ruptured alveoli and a pressure gradient allows that air to travel into the interstitial tissues. The air will continue to leak from the ruptured alveoli and then follow the path of least resistance, driven by the respiratory cycle further into the interstitial tissues. This is termed the Macklin Effect [55]. Macklin & Macklin determined these air leaks could be facilitated by regional alveolar abnormalities, such as atelectasis or pneumonia, or general over inflation of the lung or reduced blood vessel caliber combined with increased intrapulmonary pressure, such as with violent cough or straining, or with hyperinflation, such as with intense or sudden exertion. Considering the physiological processes which can contribute to SPM, patients with EDs may be at increased risk for SPM for several reasons. As detailed above, animal studies and human studies have indicated that patients in a starved state may have general over-inflation of the lung and reduced elasticity of the lung tissue which may increase ease of alveolar injury. Furthermore, many patients with EDs engage in compulsory exercise which could result in hyperinflation. Considering the 54 cases of SPM reported and reviewed by Hochlehnert A, et al. [16] and our own cases 5 cases of PM, in sum, 12 cases (20.3%) were associated with vomiting regardless of weight or suspected/confirmed eating disorder diagnosis. Thus, the behavior of self-induced vomiting may place patients at risk for SPM. Surprisingly, based on review of cases of SPM under our care, an ED which involves self-induced vomiting does not appear to be associated with secondary PM.

Pneumothorax in restrictive eating disorders

Pneumothoraxes are classified by their etiology: PSP, SSP which occur in the setting of underlying structural lung disease, IP, and TP. Our case series and the literature review support Hochlehnert A, et al.’s [16] conclusion that SPM is more common than SP in patients with EDs. SP, however, does occur in patients with EDs based on literature review and review of the patients we have treated at our institution. Of note, while the population incidence of PSP is widely reported as higher in male patients in the general population, patients with restrictive EDs and PTX in our case series and literature review were majority female (7 females and 4 males).

Our case series also identifies the first occurrences of SP in patients with ARFID. In fact, they account for all three of the SP in our case series from patients at our institution. Of note, two of these patients were both ultimately diagnosed with NTM, which likely contributed to their development of SP. The remaining patient's PTX was attributed to marijuana use.

Between the cases presented in this series and those discovered in our literature review of PTX, 5 were TP and 4 of these can be directly attributed to the patient's eating disorder independent of how the lungs are affected by severe malnutrition. One occurred as a result of a patient fall due to the patients starved and deconditioned state causing non penetrating chest trauma, another due to rib fractures sustained from and ED-related syncopal episode, one resulted from severe, purging-induced hypokalemia leading to cardiac arrest and chest compressions sufficient to result in rib fracture and lastly one PTX occurred due to stomach rupture during a binge episode.

All the patients we directly cared for, at the time of PTX diagnosis, occurred in setting of iatrogenic injury. Of the 11 cases of SP in this series and in the literature review, only three spontaneous pneumothoraxes were diagnosed on admission to eating disorder treatment. The patients we care for almost exclusively present to our institution in a planned admission from home, other eating disorder treatment facilities or from other hospitals. Because of this, patients are unlikely to present to our unit with new or uninvestigated symptoms making the diagnosis of a new SP on admission to our facility seemingly less likely.

In sum, between the cases we describe, and the cases outlined from the literature, this manuscript details 10 cases of IP. Two of these are a result of CVC (Hohn and intrajugular) placement for the purpose of fluid/electrolyte resuscitation and lab draws. Additionally, two IP resulted from diagnostic thoracentesis and two from chest tube placement for empyema. Unnecessary pacemaker placement for symptomatic bradycardia as a result of patient's low body weight, NG placement, bronchoscopy with biopsy, and surgical release for MALS, each accounted for one case of IP. Studies in the literature outlined above did identify low BMI as a risk factor for CVC associated IP, and obesity as protective factor against development of IP with cardiac device placement. It is unknown how low BMI and/or severe malnutrition effects patient risk for IP with thoracentesis, lung biopsy or surgery. However, one could posit that abnormal lung parenchyma and function described in the starved state may place patients at higher risk for IP when the procedures undertaken involve the lung or structures overlying the thoracic region. Given the nature of IP arising from a medical procedure, its true occurrence in patients with EDs may be underreported.

Of all the 25 cases of PTX identified in patients with EDs, only four required surgical management for resolution. These four patients all had IBW <72%. The initial management of PTX of all cause varied with some managed conservatively while others received pigtail catheter or chest tube drainage. No patients had needle aspiration as initial management, with exception of the patient presenting with tension PTX who promptly had a chest tube placed following needle decompression. Surgical thoracotomy with pleurodesis for prevention of recurrence was not reported in any of the case reports.

Conclusion and Limitations

Our patient population, in this case series is limited to patients at low body weights due to a restrictive ED presenting for medical stabilization. This case series does not include patients with restrictive ED who are at expected body weight or in a larger body. Therefore, conclusions regarding pneumothorax and pneumomediastinum occurrence in patients with restrictive Eds that are not at low body weights cannot be drawn. Furthermore, because this article is a case series, and the cases incorporated via literature review are primarily case studies or case series, there is no "comparison group" to allow the authors to determine if pneumothorax and/or pneumomediastinum occur more frequently or have different outcomes in patients at low body weights who have severe restrictive EDs.

Based on the case series presented and literature review it is unclear at this time if the changes that occur in the lung with severe malnutrition predispose patients with EDs for SP compared to the general population. However, the authors do recommend that patients admitting to eating disorder treatment with pulmonary complaints, such as pleuritic chest pain, dyspnea, or cough, undergo evaluation for PTX or PM with a chest x-ray. Presence of an ED may place patient at increased risk for TP because of fall, syncope or cardiac arrest requiring cardiopulmonary resuscitation, independent of lung changes possibly induced by the starved state.

Some procedures have shown an increase incidence of IP in patients with low body weight. Care should be taken to avoid invasive thoracic procedures in patients with AN and ARFID at low body weight whenever possible. CVC insertion should be avoided, especially for use solely for fluid resuscitation or frequent lab draws. For fluid resuscitation and lab draws, Peripherally Inserted Central Catheter (PICC) should be used instead. Pacemaker placement for bradycardia should be avoided in patients with AN and ARFID at low body weights, as their bradycardia will resolve with weight restoration. Thoracentesis should be performed only by an experienced operator with radiological guidance in this patient population. We also recommend abdominal x-ray be performed to confirm NG placement prior to its use in all clinical settings.

In patients with Eds, who do experience PTX, of any cause, conservative management should be pursued along with weight restoration, if clinically appropriate. If patients are symptomatic, the authors favor insertion of smaller "pigtail" catheters. After the diagnosis of PM in patients with AN or ARFID, secondary causes, such as esophageal perforation, should be ruled out. These patients who experience SPM, should also be managed conservatively.

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N/A as this was an unfunded study

Conflict of Interest

None

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