Research Article

Causes and Management Outcome of Subcutaneous Emphysema in a Busy Thoracic Surgery Unit at Teaching Hospital, Karachi

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Abstract

Background:
Subcutaneous emphysema (SE) is a clinical manifestation of underlying pathology. Identification and addressing those etiologies are therefore important for prevention and management.

Objective: To evaluate the causes and management outcome of SE in Thoracic Surgery unit, JPMC, Karachi

Methods: A prospective, observational study was conducted from 1st February 2019 till 31st January 2020. Patients aged 12 years or more of either gender were included. Patient's demographics, clinical information, causes and treatment provided were recorded. Outcome were noted in terms of days required for resolution of SE along with mortality.

Results: A total of 155 patients with SE were included. Most common cause was iatrogenic in 58 (37.4%) followed by blunt chest trauma in 44 (28.4%). Secondary spontaneous pneumothorax, penetrating chest trauma, blunt neck trauma, primary spontaneous pneumothorax, and penetrating neck trauma were the other causes. Iatrogenic causes included 21 (36.2%) with chest tube malfunction, 14 (24.1%) secondary to barotrauma. All patients had complete resolution with treatment. Extensive SE observed in 28 (18.1%) patients and was significantly associated with iatrogenic causes (P <0.005). Iatrogenic cases took longer days for clinical resolution (P<0.005) and radiological resolution (P< 0.05). There was no mortality primarily due to SE.

Conclusion: Trauma to the lungs and airways secondary to iatrogenic injury is an important preventable cause of SE. Severity of emphysema tend to be extensive among iatrogenic injuries thus taking longer days for resolution. Successful management is possible with high flow oxygen, bronchodilation and meticulous handling of chest tubes.

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Key Words: Subcutaneous emphysema, chest tube, barotrauma, blunt chest trauma, penetrating chest trauma

Introduction

Subcutaneous emphysema (SE) results when air is accumulated beneath the skin or in the soft tissues.[1] Severity of SE can range from mild to extensive, where it can extend from the face to scrotum along with upper limbs. The look of a swollen patient usually tends to overwhelm students, medical practitioners and hospital staff who are not experienced in dealing with such condition and always creates a state of panic among the patient and relatives. SE is uncomfortable, disfiguring, and alarming for the patients but is usually benign. Although rare, extensive SE has been reported to cause progressive cutaneous tension and airway compromise which may be life-threatening.[2-4] There have been reports of systemic air embolism and pacemaker dysfunction.[3] SE signifies underlying occult pneumothorax or aero digestive tract injury.[5] SE may occur before pneumothorax appears on chest X-ray.[1] It can also mask underlying pneumothorax on chest X-ray resulting difficulty in diagnosis and accurate determination of side for pneumothorax.[1] Presence of SE also makes inter-pretation of electrocardiography, echocardiography and ultrasonography difficult. Reported incidence of subcutaneous emphysema is 0.43% to 2.34%.[6]

Predisposing risk factors include smoking tobacco, respiratory system comorbidity, and respiratory infection.[5] Various causes have been reported such as neck and chest trauma, barotrauma, tracheal injury secondary to instrumentation, thoracic surgical complications, respiratory infections, and improper management of chest tubes (CTs).[1,5] In some cases, it may be spontaneous where air from ruptured alveoli travels along pressure gradients between intra-alveolar and perivascular interstitium, spreads to the head, neck, chest, and abdomen by connecting fascial and anatomic planes known as the Macklin effect.[1,4,6]

In patients with SE, crepitus (crackling sound or sensation) can be appreciated clinically. Other signs include swelling, palpebral closure and nasalization of voice.[6] Diagnosis is confirmed radiologically by presence of air which is demonstrated as radiolucency under the skin and soft tissues.[1,6] Some studies have proposed grading system and classification of SE; however, is not routinely used and universally implemented.[1,6]

Although the condition appears overwhelming, its management begins with identification of the offending cause.[1] This study was conducted to analyze different causes of SE among patients admitted in our unit. We believe knowledge of various causes and identification of risk factors would help to take measures for its prevention. Our hospital is a tertiary care referral center in the region and serving patients from different areas of Sindh. Hence, measures taken to avoid SE and adequate treatment could lessen the burden and hospital stay of patients in a busy setup. We have observed practice of infraclavicular skin incisions and subcutaneous intravenous cannula placement in patients with SE referred form other centers. Various invasive technique has been reported for the management of SE. It is not clear whether these invasive options are required for all cases. We conducted this study to analyze management outcome without use of subcutaneous skin incisions, needles or drain placement. Our management was focus-ed on pleural space drainage for pneumothorax, along with supplemental high flow oxygen and bronchodilation.

Methods

A prospective, observational study was conducted in the Department of Thoracic Surgery at Jinnah Postgraduate Medical Center, Karachi from 1st February 2019 till 31stJanuary 2020. Informed consent from patients were obtained and the study was approved by Institutional Review Board (IRB). IRB no. F.2 81/2019-GENL/11632/JPMC dated 15/2/2019.

Patients aged 12 years or more of either gender who developed SE secondary to thoracic pathology were included. Patients with SE secondary to subcutaneous infection or gas gangrene were excluded. Sampling technique was non probability consecutive sampling and sample size was all the patients who fulfilled inclusion criteria over the duration of one year.

Patient data was recorded in the form of a semi-structured questionnaire. It comprised of demographic and clinical information. Clinical information

included cause, symptoms, signs, presence of pneumothorax, need for CT placement/ adjustment along with its functional status and treatment provided.

Extensive emphysema was defined as SE involving face, neck, chest, and extending up to abdomen or upper limbs causing severe deformity and palpebral closure. Primary spontaneous pneumothorax was defined as pneumothorax in a patient who had no known lung pathology. Secondary spontaneous pneumothorax was diagnosed in a patient who developped pneumothorax as a complication of preexisting lung pathology like chronic obstructive pulmonary disease (COPD), emphysematous bulla, tubercular cavities and pneumonia. Emphysema after invasive intervention, positive pressure ventilation and CT complications were labelled as iatrogenic causes.

Outcome was noted in terms of days required for visual, clinical and radiological resolution along with mortality. Visual resolution of deformity was defined as visual disappearance of the gross deformity. Clinical resolution was defined as absence of crepitus on palpation. Radiological resolution was defined as absence of radiolucency in subcutaneous tissues on chest radiographs.

All patients with pneumothorax were managed with a wide bore CT of 32-36Fr placed at triangle of safety under local anesthesia. CTs were removed after complete lung expansion in chest radiographs. We did not give subcutaneous incisions or place subcutaneous catheters. Supplemental, high flow oxygen was given to all patients either via facemask at ≥16l/min in non-intubated patients or ≥70% fraction of inspired oxygen (FiO_2) via T-tube or endotracheal tube for intubated patients until the gross deformity reduced significantly. All patients received bronchodilators orally or aerosolized. Serial chest radiographs were done to assess lung expansion and radiological resolution till follow up after discharge.

For data entry and analysis SPSS version 16.0 was used. Descriptive statistics; age and days for resolution of emphysema were presented as mean and standard deviation (SD). Categorical variables; gender, causes and associated pneumothorax were presented as frequencies and percentages. Independent sample T test was applied for comparison of means. Chi square was applied for comparison of categorical data. P value ≤0.05 was taken as statistically significant.

Results:

Study included 155 patients satisfying inclusion criteria. There were 121 (78.1%) males and 34 (21.9 %) females. Mean age was 44.3 ± 15.2 years (range: 15-85 years).
The most common cause of SE was iatrogenic injuries seen in 58 (37.4%) of cases, followed by blunt chest trauma in 44 (28.4%). Stratification of etiological factors of subcutaneous emphysema according to age, gender, severity of SE, and associated rib fractures and pneumothorax are shown in table 1.

Most common iatrogenic cause was CT malfunction in 21 (36.2%) followed by barotrauma in 14 (24.1%). Sub classification of iatrogenic causes in descending order of frequency is given in table 2.

Pneumothorax was noted in 128 (82.58%) with SE. Total of 40 (25.80%) patients had concomitant COPD. Among the causes of secondary spontaneous pneumothorax, COPD with or without bullous emphysema was observed among 11 (52.38%) patients. Other causes of secondary spontaneous pneumothorax were tuberculosis in seven (33.33%), ruptured hydatid cyst in two (5.92%) and pneumonia in one (4.76%).

Oxygen therapy was given in 144 (92.9%) cases for 4.7 ± 2.3 days (range: 1-10 days) and 23 (14.8%) were kept on invasive ventilation for 5.1 ± 3.3 days (range: 1-14 days). The mean duration of resolution of deformity was 3.1 ± 2.2 days (range: 0-11 days), clinical resolution was 7.8 ± 4.1 days (range: 0-29 days) and radiological resolution was 12.4 ± 5.5 days (range: 3-26 days). Stratification of mean days of resolution according to the etiological factors of SE along with causes of mortality is shown in table 3.

Iatrogenic cases, in general, took significantly longer days for clinical resolution ($P < 0.005$) and radiological resolution ($P < 0.05$); chest tube malfunction cases took longer time in all three domains of resolution ($P < 0.05$), and barotrauma cases took significantly longer days in resolution of deformity ($P < 0.05$) and radiological resolution ($P < 0.005$).

There were 28 (18.1%) patients with extensive SE. There was significant association of extensive SE with iatrogenic cause (P <0.005). In extensive SE mean duration of resolution of deformity was 5.7± 2.1 days, clinical resolution is 13.7±3.7 days and radiological resolution is 19.7±4.7 days (P< 0.05).

During follow up after discharge there was no incidence of recurrence of SE or increase in severity of SE.

Mortality was 5 (3.2%) in our study but none of them were primarily due to SE.

Table 1: *Stratification of etiological factors of subcutaneous emphysema according to demographic and clinical correlates (n=155)*

SE etiology	Gender		Age years (mean ± SD)	Associated injuries		Extensive SE
	Male	Female		Rib fracture	Pneumot-horax	
Iatrogenic (n = 58)	41 (70.7%)	17 (29.3%)	45.6 ± 13.1	14 (24.1%)	44 (75.9%)	17 (29.3%)
Blunt trauma chest (n = 44)	38 (86.4%)	6 (13.6%)	42.5 ± 16.4	40 (90.9%)	41 (93.2%)	7 (15.9%)
Secondary spontaneous pneumothorax (n = 21)	15 (71.4%)	6 (28.6%)	54.1 ± 11.3	0	21 (100.0%)	4 (19.0%)
Penetrating trauma chest (n = 17)	15 (88.2%)	2 (11.8%)	39.3 ± 16.8	0	15 (88.2%)	0
Blunt trauma neck (n = 6)	6 (100.0%)	0	33.3 ± 14.4	1 (16.7%)	1 (16.7%)	0
Primary spontaneous pneumothorax (n=5)	4 (80%)	1 (20%)	27.0 ± 11.0	0	5 (100.0%)	0
Penetrating trauma neck (n = 4)	2 (50%)	2 (50%)	50.2 ± 13.6	0	1 (25.0%)	0

Abbreviations: SE; Subcutaneous Emphysema, SD; Standard Deviation

Table 2: Sub classification of iatrogenic causes of subcutaneous emphysema (n=58)

Sub classification of iatrogenic causes of SE	Frequency (%)
Chest tube malfunction	21 (36.2%)
Barotrauma	14 (24.1%)
Endotracheal intubation	8 (13.8%)
Tracheostomy	8 (13.8%)
Rigid bronchoscopy	2 (3.4%)
Postoperative rupture of bronchial stump	2 (3.4%)
Central line insertion	1 (1.7%)

Abbreviations: SE; Subcutaneous Emphysema

Table 3: Stratification of mean days of resolution according to etiology of SE (n=155) and mortality

Etiology of Subcutaneous Emphysema	Duration of resolution in days (Mean ± SD)			
	Resolution of deformity	Clinical resolution	Radiological resolution	Mortality (n=5)
Iatrogenic (n = 58)	3.5 ± 2.2	9.1 ± 5.1**	13.6 ± 6.5*	MODS (n = 1)
Chest tube malfunction (n = 21)	4.2 ± 1.9*	12.7 ± 4.6**	17.4 ± 5.5**	ARDS (n = 1)
Barotrauma (n = 14)	4.4 ± 2.2*	10.1 ± 4.0	16.5 ± 6.1*	Postoperative rupture of bronchial stump (n = 1)
Blunt trauma chest (n = 44)	3.0 ± 2.5	7.6 ± 3.6	12.8 ± 4.9	Severe cardiopulmonary contusion (n = 1)
Penetrating trauma chest (n = 17)	2.1 ± 1.2	5.5 ± 1.8*	9.1 ± 2.3**	-
Blunt trauma neck (n = 6)	1.6 ± 1.0	3.8 ± 0.9*	7.3 ± 1.0*	-
Penetrating trauma neck (n = 4)	1.5 ± 1.3	4.5 ± 1.3	7.7 ± 1.5	-
Secondary spontaneous pneumo-thorax (n = 21)	3.8 ± 1.8	8.7 ± 3.7	13.7 ± 4.8	MODS (n=1)
Primary spontaneous pneumoth-orax (n = 5)	2.8 ± 0.8	7.2 ± 0.8	11.4 ± 1.9	-

Abbreviations: SD; Standard Deviation * p<0.05; ** p<0.005

Discussion:

SE in thoracic surgery is a well-known sequel after trauma to the chest and airway. It can manifest in patients requiring assisted ventilation or may after Spontaneous Pneumomediastinum (SPM).[7]

In our study we observed most common cause was iatrogenic followed by blunt chest trauma. CT malfunction was most frequent iatrogenic cause observed in 21 (36.2%) patients followed by barotrauma in 14 (24.1%) patients. Agajanzadeh et al., reported in their 10 years of experience that pneumothorax with concomitant COPD was most common cause of SE. Other significant causes reported were chest trauma and iatrogenic.[1] They reported greater severity of SE among iatrogenic causes including barotrauma which is consistent with our observation. About 1/5th (18%) of our cases were diagnosed with extensive SE and statistical significance observed when cause was iatrogenic ($P < 0.005$). In our study 40 patients had concomitant COPD, out of which COPD with or without bullous emphysema was the cause of pneumothorax and SE among 11 patients.

Our department is a tertiary care referral center and among the referred patients with CTs we observed use of small caliber trocar tubes, blocked or kinked tubes, accidental removal of CTs, side port migration and CT site wound dehiscence as the factors responsible for SE. Ahmad et al., they observed higher rates of SE when tube thoracostomies were performed in emergencies by trainee physicians and outside a level I trauma center. Whereas, less complications were noted when procedure was done by ATLS® certified trained thoracic surgeons.[8]

Barotrauma was the second most common iatrogenic cause. Risk factors observed for barotrauma were rib fractures after trauma including CPR in five patients, pneumonia in four, COPD in three and ARDS in one patient. Failure to identify occult pneumothorax before positive pressure ventilation in trauma patients and critical patients who had received CPR, high positive pressure ventilator settings (PEEP or auto PEEP) in patients with underlying diseased lungs can lead to extensive SE.[8]

Aero digestive tract injuries can occur during blunt, penetrating and iatrogenic trauma.[9] We observed SE in eight patients after endotracheal intubation, eight after tracheostomy and two after rigid bronchoscopy.

SE is diagnosed clinically. Depending upon the severity swelling can be observed on face, neck, chest, abdomen and sometimes up to scrotum and upper limbs (Fig 1). Extensive SE can cause palpebral closure causing visual disturbance. Swelling of neck might lead to voice changes due to compression of vocal cord. Nasalized voice is a clinical sign in patients who have mediastinal emphysema.[6,10] Patients may also complain of dysphonia, dysphagia, and dyspnea.[11] Extensive SE leading to tension phenolmenon and acute airway compromise have been reported.[12] However, we did not observe any life threatening complications. In some cases, imaging is essential for confirmation of diagnosis where streaks of air are seen within tissue planes.[13] Chest radio-graph of a patient with extensive emphysema after blunt chest trauma is shown in Fig 2.

SE is generally self-limiting.[7] Foremost, is identification of the underlying pathology and addressing it to avoid progression of emphysema.[1] Management starts from reassurance of patient and family as the gross appearance due to swelling creates a state of panic among them. Management was done with oxygen therapy along with bronchodilation and pleural drainage for pneumothorax. Oxygen therapy increases the gradient for reabsorption of nitrogen from tissues by reducing partial pressure of nitrogen.[7,14] In 1954, Kircher *et al.* suggested that the resolution rate of pneumothorax was 1.25%/day in room air.[15] In patients with pneumothorax, high flow oxygen results in fourfold increase in the rate of resorption.[16] It is believed same principle applies to reabsorption of subcutaneous air.[17] Bronchodilators reduce alveolar pressure reducing trans alveolar gradient and leak. Antibiotics for infection, steroids for inflammation and mist along with hydration to loosen secretions and cough suppressants are helpful.[1,7]

SE can be progressive or persistent if the air leak exceeds the capacity of CT to evacuate air from pleural space. Use of larger caliber CT (28-36 Fr) along

with negative pleural suction facilities pleural drainage.[1,8] Trocar CT which are still in practice in some centers must be discouraged, rather blunt finger dissecttion is preferred. Therefore, adequate knowledge and training for CT placement and handling is crucial. It is further advised that while managing high risk patients on a ventilator, extra care must be taken to avoid high PEEP.[8,18,19]

A number of techniques have been reported to treat SE. Those are infraclavicular skin incisions or blow hole incision extending down to pectoralis fascia, placement of subcutaneous drains and catheters with or without suction, negative pressure wound therapy all having their own limitations.[1-5] Although various case reports suggests effectives of these techniques for rapid resolution of massive emphysema within 24 hours to complete resolution over days but no comparative large studies have been conducted to determine relative effectiveness of each procedures.[5] These techniques are invasive, are potential sources of infection, can be uncomfortable to the patients, and some are ineffective due to blockage from clots, and result in scarring.[3,5] These methods also do not address the underlying cause of SE.[5] The above mentioned technique were reported for extensive SE and gave no clear concept if they have role in management of SE of lesser severity. We did not use these techniques in any of our patients.

In our observation treatment resulted in complete clinical and radiological resolution with no recurence. Iatrogenic cases took significantly longer for clinical ($P < 0.005$) and radiological resolution ($P < 0.05$) as they were frequently associated with extensive emphysema ($P < 0.005$). No morality was observed primarily due to SE.

To date there has been no large comparative study between invasive techniques and management with high flow oxygen, bronchodilation and pleural drainage.[5] It is suggested that a comparative study be designed to observe the effectiveness of two management options. Our study is single center study with limited sample size. We have included SE of all severity. Oxygen therapy was discontinued after resolution of deformity or when emphysema was of lesser severity which could have resulted in prolonged days for clinical and radiological resolution in some of the patients.

Fig 1: *Extensive SE secondary to blunt trauma chest with multiple ribs fracture and bilateral pneumothorax*

Fig 2: *Chest X-ray demonstrating air in the subcutaneous tissue of a case with extensive SE*

Conclusion:

Trauma to the lungs and airways secondary to iatrogenic injury is an important preventable cause of SE. Severity of emphysema tend to be extensive among iatrogenic injuries thus taking longer days for resolution. Successful management is possible with high flow oxygen, bronchodilation and meticulous handling of chest tubes.

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