Prevalence, causes, and clinical implications of pleural effusion in pulmonary ICU and correlation with patient outcomes

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Introduction Pleural effusion is common in medical ICU (MICU) patients, and it may develop owing to different causes and may affect patients outcomes.

Objective The aim of this work was to study the prevalence and causes of pleural effusion in MICU and its effect on patient outcomes.

Patients and methods A total of 90 patients admitted to MICU in Abbaseia Chest Hospital were included in the present study. The patients initially had pleural effusion or effusion developed during their ICU stay.

Results Overall, 66 patients were males and 24 were females, and their mean age was 51.5±18.6 years. The prevalence rate of pleural effusion in our MICU during 1-year period was 12.7%. Pleural effusion was found to be exudates in 77.7% of cases and transudates in 22.3%. Uncomplicated parapneumonic effusion was the most common cause (36.7%), followed by heart failure (17.8%). The cause of pleural effusion did not significantly affect the patient outcome or duration of ICU stay. No significant reduction in duration of ICU stay or ICU mortality was seen in patients who received therapeutic aspiration or tube drainage compared with patients who received no specific management for effusion.

Conclusion The commonest cause of pleural effusion in MICU is parapneumonic effusion, and chest ultrasonography is the best method of fluid detection. Different methods of management do not significantly affect patient outcomes.

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Introduction

Pleural effusion is common to be detected in critically ill patients. Most pleural effusions found in critical care unit patients are of little clinical significance; however, some are important requiring specific management [1]. Medical ICU (ICU) patients are at risk for developing different types of pleural effusions, as many patients present with hemodynamic instability that requires treatment with aggressive fluid replacement leading to fluid overload, which results in transudative effusions usually bilateral even in the absence of heart failure [2]. Moreover, mechanical ventilation, sedation, and acute lung injury may lead to development of basal atelectasis that can be associated with pleural effusions [3]. Transudative pleural effusions in ICU are usually owing to disturbed oncotic pressure gradient between plasma and pleural space, and also disturbed pleural pressure owing to atelectasis. Exudates are secondary to pulmonary or pleural infections, pulmonary embolism, surgical complications, and malignant processes [1]. Empyema may be detected but is relatively uncommon, but when encountered, it is usually resistant and requires intervention along with antibiotic treatment [4].

Detection of small amount of pleural effusions is challenging in ICU patients, because chest radiography (CXR) performed in supine or semi-recumbent position makes a pleural fluid amount of less than 500 ml produce only increased haziness over the lower lung zone [5]. Chest ultrasonography (US) is a portable, low-cost method that showed consistently high sensitivity, specificity, and accuracy in identifying fluid in the pleural space [6]. Different sonographic patterns of pleural effusions may also provide further valuable information [7].

Objectives

This study aimed to determine the prevalence, causes, and clinical significance of pleural effusion in critically ill patients and to study the different methods of assessment and follow-up of patients till reaching final diagnosis, as well as the different management strategies and to correlate all these data with the final patient's outcomes.

Patients and methods

This prospective study included consecutive patients who were admitted to pulmonary ICU in Abbaseia Chest Hospital either with pleural effusion or developed effusion during ICU stay over a period of 1 year from January 2016 to January 2017. All patients

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were subjected to full history taking, thorough clinical examination, CXR performed anteroposteriorly for the bedridden and posteroanteriorly for ambulant patients, and diagnostic chest US. Computed tomography (CT) chest was performed whenever indicated. In each patient, laboratory or radiological investigations were selected according to the suspected disease etiology reach the final diagnosis. Ethical approval was obtained from ethics committee.

Data collected concerning different management strategies include the following:

(1) Observation and follow-up of pleural effusion without interference.
(2) Diagnostic thoracocentesis. It was done under sonographic guidance. US scan was performed to confirm the presence of fluid and to select and mark the best puncture site. US guidance improves the success rate of pleural aspiration and minimizes the risk of visceral puncture. Moreover, the risk of pneumothorax following aspirations is reduced, irrespective of the size of the effusion [8].
    Samples were sent for the following:
    (a) Biochemical analysis and following Light's criteria. Exudative effusion was diagnosed when ratio of fluid protein level to the serum protein level is more than 0.5, a ratio of the pleural fluid lactate dehydrogenase (LDH) level to the serum LDH level is more than 0.6, or a pleural fluid LDH level that is more than two-thirds the upper limit of normal for the serum LDH level [9].
    (b) Pleural fluid pH.
    (c) Total and differential cell count.
    (d) Gram-stained culture.
    (e) Ziehl–Neelsen stain.
    (f) Cytological examination of the fluid for detection of malignant cells.
(3) Diagnostic US-guided intervention (in selected cases). It was indicated in the presence of a unilateral pleural effusion associated with pleural thickening whose cause has not been identified by cytological, biochemical, and microbiological analyses of specimens obtained through thoracocentesis [10]. It was also indicated for biopsy from associated mediastinal mass. For associated disease of the lung parenchyma, interventional US was useful for biopsy from peripheral lesions.
(4) Therapeutic drainage of pleural fluid: an US scan was performed to confirm the presence of effusion or empyema and to select the best puncture site. A diagnostic thoracocentesis was then made while visualizing the needle during penetration at the suggested puncture site. If thoracocentesis was successful, drainage was then done at the same puncture site, otherwise the needle size or the puncture site was changed, till obtaining the best puncture site.
(5) Drainage of pleural effusion through chest tube or pig tail. US was used to locate the ideal site for insertion and to determine septations or loculations. The catheter is usually placed in the area of the largest collection.
(6) Collection of data concerning effect of these different management strategies on patient outcome, which may include the following:
    (a) Complications related to manipulation of pleural fluid (empyema, hemothorax, or hydropneumothorax).
    (b) Duration of ICU stay.
    (c) Death from the original cause of pleural effusion (heart failure or pulmonary embolism).
(7) Follow-up of discharged patients till reaching final diagnosis of pleural effusion.

Statistics

Data were collected, tabled, and statistically analyzed using SPSS version 15 (SPSS Inc., Chicago, Illinois, USA).

Parametric data

(1) Data were expressed as minimum, maximum, and mean±SD.
(2) Comparisons between two groups were done using unpaired *t*-test.
(3) Comparisons between more than two groups were done using one-way analysis of variance (*F*-test).

Nonparametric data

(1) Data were expressed as number and percentage.
(2) Comparisons between two groups were done using χ^2.
(3) Comparisons between more than two groups were done using χ^2-test.

Two tailed *P* value greater than 0.05 was considered insignificant, whereas *P* value less than or equal to 0.05 was considered significant.

Results

Baseline characteristics

Of 740 patients admitted to the RICU during 1 year, 90 (12.7%) patients had or developed pleural effusion

and were included in our study. A total of 66 (73.3%) were males and 24 (26.7%) were females. Their ages ranged from 13 to 90 years, with a mean of 51.5±18.61 years. The mean duration of the ICU stay was 8.6±6.5 days. A total of 83 (92.2%) patients had pleural effusion at time of ICU admission, whereas only seven (7.7%) patients developed pleural effusion during ICU stay.

Various causes had led to admission of patients to the ICU (Table 1). The most common cause of admission was severe pneumonia (38/90, 42.2%) followed by exacerbation of chronic obstructive pulmonary disease (18/90, 20%) and sepsis (10/90, 11.1%).

The etiology and characteristics of pleural effusion

A total of 66 (73.3%) patients underwent US-guided thoracocentesis. Thoracentesis was not performed in 24 (26.6%) patients because of severe hemostatic alterations or pleural effusion evaluated to be minimal, and in those cases, the etiology is identified upon clinical basis. Tables 2 and 3 list the final etiology of pleural effusion in all patients.

Uncomplicated parapneumonic effusion was the most common cause of pleural effusion (36.7%), followed by heart failure (17.8%). Infectious exudate including uncomplicated parapneumonic effusion and empyema forming 52.2% of causes of pleural effusion. Malignant pleural effusion was the second most common cause of exudative pleural effusion (16.7%).

Provisional cause of pleural effusion was different from final cause (thoracentesis based) in 17 of 66 patients who underwent thoracentesis.

Among patients included in this study, 42 (46.6%) patients had mild pleural effusion, 23 (25.5%) patients had moderate pleural effusion, and nine (10%) patients had massive pleural effusion. Moreover, 16 (17.7%) patients showed no effusion in CXR and were detected by chest US. US was significantly superior to CXR in detecting pleural effusion as shown in Table 4.

CT of the chest was done for 50 (55.5%) patients included in this study. Findings were as described in Table 5. CT of the chest with pulmonary angiography was done for only four (4.4%) patients suspected to have pulmonary embolism, and it was positive for pulmonary embolism. Bedside echocardiography was done for 37 (41.1%) patients. Culture and sensitivity of pleural fluid was done showing that 56 (84.8%) samples demonstrated no growth, with only 10 samples with growth of different organisms. The most common isolated organism was methicillin-resistant *Staphylococcus aureus* in four cases (40% of these 10 patients). Cytological examination of pleural fluid was done showing that the most commonly seen predominant cells were polymorphs in 30 (54.5%) patients. Moreover, 13 (14.4%) patients underwent diagnostic biopsy to reach final diagnosis. Procedure was done during ICU stay in eight (61.5%) patients, whereas five (38.5%) patients were diagnosed after discharge from ICU.

Table 1 Admission diagnosis

	n (%)
Severe pneumonia	38 (42.2)
COPD exacerbation	18 (20)
Pulmonary embolism	8 (8.8)
Pulmonary edema	6 (6.6)
TB meningitis	1 (1.1)
Empyema and sepsis	10 (11.1)
OHVS exacerbation	3 (3.3)
Pericardial effusion and mediastinal mass	1 (1.1)
Myasthenia gravis exacerbation	1 (1.1)
Post-TB bronchiectasis	3 (3.3)
Lung collapse	1 (1.1)

COPD, chronic obstructive pulmonary disease; OHVS, obesity hypoventilation syndrome; TB, tuberculosis.

Table 2 Final etiology of effusion

Etiology of pleural effusion	*n* (%)
Exudative	70 (77.7)
Uncomplicated parapneumonic effusion	33 (36.7)
Malignancy	15 (16.7)
Empyema	14 (15.6)
Pulmonary embolism	4 (4.4)
TB	4 (4.4)
Transudative	20 (22.2)
Heart failure	16 (17.8)
Volume overload	2 (2.2)
Hypoalbuminemia	1 (1.1)
Uremia	1 (1.1)

Table 3 Comparison between the provisional etiology and thoracocentesis-based (final) etiology

Diagnosis	Provisional diagnosis [*n* (%)]	Final diagnosis [*n* (%)]	χ^2	*P*
Uncomplicated parapneumonic	19 (28.7)	24 (36.3)	5.99	0.5
Empyema	10 (15.1)	14 (21.2)		
Malignancy	11 (16.6)	13 (19.6)		
HF	13 (19.6)	7 (10.6)		
TB	3 (4.5)	3 (4.5)		
PE	2 (3)	2 (3)		
Volume overload	7 (10.6)	2 (3)		
Uremia	1 (1.5)	1 (1.5)		

HF, heart failure; PE, pulmonary embolism; TB, tuberculosis; $P>0.05$, insignificant; $P\leq0.05$, significant.

Table 4 Comparison between chest radiography and ultrasound in detecting pleural effusion

Detected effusion	CXR [*n* (%)]	US [*n* (%)]	χ^2	*P*
Yes	74 (82.2)	90 (100)	17.5	0.0001*
No	16 (17.8)	0		

CXR, chest radiography; US, ultrasound; $P>0.05$, insignificant; *$P\leq0.05$, significant.

Table 5 Computed tomography chest findings

	n (%)
Pleura	
Site of effusion	
Right	15 (30)
Left	15 (30)
Bilateral	20 (40)
Size of effusion	
Mild	29 (58)
Moderate	10 (20)
Massive	5 (10)
Pleural thickening	1 (2)
Hydropneumothorax	6 (12)
Parenchyma	
Consolidation	17 (34)
Collapse	1 (2)
Cavity lesion and consolidation	8 (16)
Mass	4 (8)
Mediastinum	
Anterior mediastinal mass	2 (4)

There is no significant statistical difference between type of effusion and each of duration of ICU stay and patient final outcome as shown in Tables 6 and 7, respectively.

Management and complications of pleural effusion

A total of 53 (58.9%) patients were followed up: 23 (25.6%) patients underwent US-guided therapeutic aspiration, and US-guided drainage was done for 21 (23.3%) patients through chest tube or pig tail. Of the 66 patients who underwent interventions, only three (4.5%) patients had complications. Complications include surgical emphysema and hydropneumothorax. There is no significant correlation between type of management and duration of ICU stay. There is no significant correlation between method of management chosen and mortality as shown in Table 8.

Overall, 32 (35.5%) patients died. The commonest cause of death was septic shock (34.3%) followed by cardiogenic shock (31.2%).

Discussion

Pleural effusion is common among medical ICU (MICU) patients, and it is usually caused by pulmonary or extrapulmonary disorders, rather than by primary pleural diseases [4].

Table 6 Relation between cause of effusion and duration of ICU stay

Cause of pleural effusion	Duration of ICU (minimum–maximum) (mean±SD)	*F*	*P*
Heart failure (*n*=16)	2–35 (9.43±8.88)	0.71	0.6
Malignancy (*n*=15)	3–31 (10.53±7.61)		
Parapneumonic (*n*=33)	2–23 (8.54±5.23)		
Empyema (*n*=14)	1–27 (7.07±7.01)		
TB (*n*=4)	3–23 (13±10.45)		
PE (*n*=4)	3–14 (6.5±5.06)		
Transudative other than HF (*n*=4)	4–11 (6.75±2.98)		

HF, heart failure; PE, pulmonary embolism; TB, tuberculosis; $P>0.05$, insignificant; $P\leq0.05$, significant.

Table 7 Relation between cause of pleural effusion and mortality

Cause of pleural effusion	Mortality group (*n*=32) [*n* (%)]	Survived group (*n*=58) [*n* (%)]	χ^2	*P*
Empyema (*n*=14)	7 (21.8)	7 (12.1)	1.5	0.2
Heart failure (*n*=16)	6 (18.75)	10 (17.2)	0.03	0.8
Malignancy (*n*=15)	3 (9.4)	12 (20.7)	1.9	0.1
Pulmonary embolism (*n*=4)	1 (3.1)	3 (5.2)	0.2	0.6
TB (*n*=4)	1 (3.1)	3 (5.2)	0.2	0.6
Uncomplicated parapneumonic (*n*=33)	12 (37.5)	21 (36.2)	0.01	0.9
Uremia (*n*=1)	1 (3.1)	0	1.8	0.1
Volume overload (*n*=2)	0	2 (3.4)	1.1	0.2
Hypoalbuminemia (*n*=1)	1 (3.1)	0	0.01	0.1

TB, tuberculosis; $P>0.05$ insignificant; $P\leq0.05$ significant.

Table 8 Relation between type of management and mortality

Types of management	Mortality group (*n*=32) [*n* (%)]	Survived group (*n*=58) [*n* (%)]	χ^2	*P*
Conservative management	22 (68.75)	31 (53.4)	1.99	0.1
Therapeutic aspiration	5 (15.6)	18 (31)	2.57	0.1
Drainage	6 (18.8)	15 (71.4)	0.5	0.4

$P>0.05$, insignificant; $P\leq0.05$, significant.

The prevalence of pleural effusion among patients admitted to ICU was 12.7% in our study, which is close to the results of Chinchkar *et al.* [11] who found a prevalence of 14.7% for pleural effusion in ICU patients over an 8-month duration. Fartoukh *et al.* [4] reported a lower prevalence (8.4%) in their study which was conducted on 1351 patients admitted to three teaching hospital MICUs during 1 year. This relatively lower prevalence may be an underestimation, as effusion was diagnosed in that study based on physical examination and CXR with no chest US performed, which suggests the possibility of missing

detection of lower amounts of pleural fluid. Another study conducted by Mattison *et al.* [12] reported a higher prevalence (62%) of pleural effusion in ICU patients, and this may be explained by difference in the type of recruited patients, as that study was conducted at general ICU in Medical University of South Carolina with different causes of admission and multiple comorbidities including decompensated heart failure, which is commonly associated with transudative pleural effusion.

The most common cause of ICU admission in the current study was severe pneumonia (42.2%) followed by acute exacerbation of chronic obstructive pulmonary disease (20%). In the retrospective study of Park *et al.* [13] conducted on 78 patients who underwent diagnostic thoracocentesis, the commonest cause of admission was respiratory disorders (64.1%), followed by cardiovascular disorders (12.8%) and sepsis (11.5%).

In the current study, we found 83 (92.2%) patients had pleural effusion at the time of ICU admission, whereas pleural effusion developed in only seven (7.7%) patients during ICU stay. This is in accordance with Chinchkar *et al.* [11] who found 88% of patients with pleural effusion on the day of admission, whereas 12% had it later on. On the contrary, Mattison *et al.* [12] found a higher percentage of patients who developed pleural effusion during their ICU stay (33.8%).

In the present study, it was found that CXR detected pleural effusion in only 74 (82.2%) patients. Mild pleural effusion was most commonly found in CXR in 46%, followed by moderate effusion in 25.5%, whereas massive effusion represented only 10%. This is in agreement with Mattison *et al.* [12] who reported that mild pleural effusion was most commonly detected in 92% of patients, moderate effusions were detected in 6.4% of patients, and massive effusion in 1.6% of patients. Another study performed by Park *et al.* [13] found that 23% of cases were classified as mild effusion.

In the present study, US was significantly superior to CXR in detecting pleural effusion, as it was able to detect all cases, but CXR detected pleural effusion in 74 (82.2%) patients. Motogna *et al.* [14] reported same superiority of US over CXR in pleural effusion detection. Similar significance was reported by Zanobetti *et al.* [15] while studying the possibility of replacing standard CXR by chest US in evaluation of critically ill patients in emergency department in Italy.

In the current study, CT chest was done for 50 (55.5%) patients. The most common concomitant finding was consolidation in 17 (34%) patients. Chinchkar *et al.* [11] also found that lung consolidation was the most commonly seen concomitant finding in CT of the chest in cases of pleural effusion. Bedside echocardiography was done in this study for 37 (41.1%) patients; 32% of them had heart failure and 13.5% of them had tricuspid valve vegetations. In the study of Chinchkar *et al.* [11], echocardiography was done for all patients. Left ventricular function was impaired in eight (16%) cases. In this study, four (4.4%) patients were provisionally diagnosed as uncomplicated parapneumonic effusion, whereas after thoracocentesis, final diagnosis was found to be empyema.

In the current study, it was found that exudative effusion constitutes 77.7% of causes of pleural effusion in MICU, whereas transudative effusion constitutes 22.2%. Other studies have stated similar results [4,13,16]. Heidecker *et al.* [17] reported a lower percentage for exudative pleural effusion (48.6%) in their retrospectively reviewed 397 patients who underwent thoracentesis in general critical care service.

In the present study, pleural infection was the commonest cause of pleural fluid accumulation; uncomplicated parapneumonic effusion and empyema constituted 52.2% of all causes of pleural effusion, followed by heart failure (17.8%). Malignant pleural effusion was the second most common cause of exudative pleural effusion (16.7%). This agrees with Fartoukh *et al.* [4] who demonstrated that the most frequently detected cause (43%) of pleural effusion in ICU patients was infectious exudate (parapneumonic 26% and empyema 17%), followed by noninfectious exudate (33%) and transudate (24%). Similar results were reported by Tu *et al.* [16], who found that 62% of MICU patients who underwent thoracentesis had infectious exudate including parapneumonic effusion, empyema, urosepsis, liver abscess, deep neck infection, and wound infection. The prevalence of empyema in febrile patients admitted to MICU was 16%. Moreover, Park *et al.* [13] found that infectious exudate, especially parapneumonic effusion, was the most common cause of pleural effusion in ICU (41%), followed by malignant pleural effusion (19.2%), and heart failure-related effusion (17.7%), whereas Chinchkar *et al.* [11] reported that the most common cause of pleural effusion in ICU was malignancy (24%), followed by parapneumonic effusion (22%) and then heart failure (18%). In contrast to these results, Mattison *et al.* [12] found that the most common causes of pleural effusion in ICU were heart failure (35%) and atelectasis-related effusion (23%). Infectious causes of pleural effusion were seen in only eight (12%) cases.

In the current study it was found that, duration of stay and mortality among ICU patients with pleural effusion were not significantly affected by the cause of pleural effusion. This may be explained by presence of many other factors affecting mortality in these patients, regardless the cause of effusion, such as the primary cause that necessitates admission to ICU which was not related to pleural effusion in many cases. Moreover, mortality in these patients was affected by hemodynamic status of the patients, need for mechanical ventilation, associated comorbidities, and complications developed during ICU stay. So we can conclude that pleural effusion with its different causes had nonsignificant effect on mortality and duration of ICU stay.

In the present study, US-guided therapeutic aspiration was done for 23 (25.6%) patients. It was mainly indicated in malignant effusion in 11 (47.8%) patients to improve dyspnea. Moreover, it was done for four (17.3%) patients with uncomplicated moderate parapneumonic effusion. US-guided drainage either through large-bore or small-bore catheter was done for empyema and malignant effusion. In the study of Park *et al.* [13], tube drainage was done in a similar percentage (19.2%), and the commonest reason for drainage was parapneumonic effusion or empyema followed by malignancy.

Hydropneumothorax and surgical emphysema occurred in three (4%) patients after chest tube drainage, whereas no complications reported with US-guided interventions.

Conclusion

The commonest cause of pleural effusion in MICU is parapneumonic effusion, and chest US is the best method of fluid detection. Different methods of management do not significantly affect patient outcomes.

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Conflicts of interest

There are no conflicts of interest.

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