International Journal of Research in Medical Sciences
Kumar A et al. Int J Res Med Sci. 2020 Apr;8(4):1231-1236
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20201099

Original Research Article

A study to know the various causes of pleural effusion and role of pleural fluid adenosine deaminase enzyme in tuberculous pleural effusion

Avdhesh Kumar[1], Brijesh Kumar[2], Sanjay Kumar Verma[3]*, Anand Kumar[1], R. K. Mathur[1], Sudhir Chaudhry[1], Surya Kant[4]

[1]Department of Tuberculosis and Respiratory Diseases, [2]Department of Internal Medicine, G.S.V.M. Medical College, Kanpur, Uttar Pradesh, India
[3]Department of Tuberculosis and Respiratory Diseases, Government Medical College, Kannauj, Uttar Pradesh, India
[4]Department of Pulmonary Medicine, King Georges Medical University, Lucknow, Uttar Pradesh, India

Received: 25 February 2020
Accepted: 13 March 2020

***Correspondence:**
Dr. Sanjay Kumar Verma,
E-mail: drskverma78@rediffmail.com

ABSTRACT

Background: India has the maximum burden of both non MDR tuberculosis (TB) and Multidrug-Resistant (MDR) TB, as per data reported in Global TB Report 2018 and tuberculosis is remains one of the most common cause of pleural effusions.
Methods: This was a cross-sectional study conducted in Department of Respiratory Diseases and a total of 110 patients with pleural effusion were included in the study, which were enrolled for treatment from July 2018 to June 2019.
Results: One hundred and ten patients with pleural effusion were enrolled during the study period. There were 65 males (59%) and 45 (40.9%) females. The overall mean age for males and females were 44.4±18.84 years (35-87 years) and 38.28±17.66 years (35-87 years) respectively. Tuberculous Pleural Effusion group (TPE) seen in 82 patients. Right sided pleural effusion (69.5 %) were more common than left sided (30.4 %). In TPE group the mean pleural fluid ADA level were 86.41±38.08 IU/L (range: 14-195 IU/L). The Malignant Pleural Effusion (MPE) group included 21 patients. In MPE group the mean pleural fluid ADA level were 34.10±32.88 IU/L (range: 8-144 IU/L). The difference in pleural fluid ADA levels between TPE and MPE group was statistically highly significant.
Conclusions: Tuberculous pleural effusion was the most common cause of pleural effusion in present study and observed in 74.5% cases.

Keywords: Malignant, Pleural effusion, Tubercular

INTRODUCTION

According to WHO estimates, in 2017, an estimated 2.7 million people developed tuberculosis (TB) disease in India and over 400000 people died.[1-3] About 80 % cases of tuberculosis are pulmonary and extrapulmonary tuberculosis (EPTB) accounts for about 20-25% of all TB cases. Among extrapulmonary TB cases, Lymph nodes are the most common site of involvement followed by pleural effusion and virtually every site of the body can be affected.[4-5]

The pleura is the serous membrane that covers the lung parenchyma, the mediastinum, the diaphragm and rib cage and pleural space is the coupling system between lung and the chest wall.[6,7] Pleural effusions, the results of collection of fluid in pleural cavity, when the rate of

pleural fluid formation exceeds the rate of pleural fluid absorption.[8]

Mycobacterium tuberculosis enters the pleural space and interacts with previously sensitized T-cells to mycobacteria, resulting in a delayed hypersensitivity reaction and effusion develops.[9,10]

As per Light, 99% of pleural effusion could be classified into two general categories- exudative and transudative.[11] There are several causes of exudative pleural effusion including tuberculosis, neoplasms (primary or secondary), pyogenic bacterial infections, fungal infection, sarcoidosis, collagen vascular disease, transplant patients with graft rejection, trauma, and pulmonary embolism. If the effusion is transudative, systemic causes like congestive heart failure or a hypoalbuminemic state should be searched for.[7]

The aims of this study were to determine the different causes of pleural effusion in a tertiary care hospital and role of pleural fluid adenosine deaminase enzyme in Tuberculous Pleural Effusion (TPE) and Malignant Pleural Effusion (MPE).

METHODS

This prospective study was conducted in 110 cases of pleural effusion attending the Department of Tuberculosis and Respiratory Diseases, G.S.V.M. Medical College, Kanpur and Government medical college, Kannauj from June 2018 to June 2019. Informed consent was obtained from the patients.

Inclusion criteria

- All the patients of pleural effusion, both male and female, above the age of 12 years.

Exclusion criteria

- Patients in whom history of typhoid fever, acute viral hepatitis and active cirrhosis were present, were excluded.

Detailed clinical history was taken and thorough clinical examination was done in each and every patient and they were then subjected to a routine laboratory examination like total WBC count, differential WBC Count, fasting Blood Sugar, kidney function test, S. Proteins, serum LDH, Urine Examination, Sputum Examination for AFB and CBNAAT. A plain chest X ray PA view was taken prior to thoracocentesis and another was taken after thoracocentesis to rule out complications.

Pleural fluid collection and processing

For each subject, at least 50 mL of pleural fluid was collected in a syringe during thoracentesis. A portion of the sample was submitted for protein, glucose, TLC, DLC, pleural fluid examination for AFB, Gram's stain, pleural fluid culture for mycobacterium tuberculosis, malignant cells and measurement of protein, ADA and lactate dehydrogenase (LDH) and other relevant investigation as per requirement of cases. ADA was measured in pleural fluid by colorimetric method of Guisti and Galanti.[12] Pleural biopsy was done through Abraham'spunch biopsy needle.[13]

For the diagnosis of Malignant Pleural Effusion (MPE), malignancy in cytology of the pleural fluid and/or on histology of the pleural tissue was considered. ADA activity in the pleural fluid was studied and the results were recorded as IU/L in all the patients. The final diagnosis of pleural effusion was made by history + sputum results + pleural fluid results +pleural fluid ADA levels).

Statistical analysis

Data was compiled using Microsoft excel and analyzed using SPSS, statistics version 20.0. Data were statistically described in terms of Mean±SD and range, or frequencies (number of cases), when appropriate. Categorical variables were analyzed using percentage and student's t test and p value less than 0.05 was considered significant.

RESULTS

In present study, 110 cases of pleural effusions were enrolled for final analysis and of them 65 cases were males and 45 cases were females. The mean age of males and females cases were 44.4±18.84 and 38.28±17.66 years respectively.

Tuberculous Pleural Effusion group (TPE) consisted of 45 male and 37 females. The mean age in this group were 36.93±17.78 (range: 11-79 years). Among this group Right sided pleural effusion (69.5%) were more common than left sided (30.4%). The mean pleural fluid protein was 4.98±3.7. The mean pleural fluid sugar level was 54.16 mg/dl. The mean pleural fluid TLC was 1146/cmm^3. The mean lymphocyte percentage was 79.4±19.7. The mean polymorph percentage was 14.67±19.7. The mean mesothelial percentage was 5% (Other details are given in table 1 and 2).

The Malignant Pleural Effusion (MPE) group included 9 (42.8%) males and 12 (57.1%) females. The mean age in this group were 60.05±10.73 (range: 38-78 years). Among this group Right sided pleural effusion (80.9%) were more common than left sided (19%). The mean pleural fluid protein was 4.19±0.8 mg/dl. The mean pleural fluid sugar level was 55.05±20.7 mg/dl. The mean pleural fluid TLC were 1159/cmm^3. The mean lymphocyte percentage were 78.71±18.15. The mean polymorph percentage were 12.19±13.8. The mean pleural fluid mesothelial percentage were 10 (Other details are given in table 1 and 2).

Table 1: Description of various parameter of study populations (n=110).

Sn	Parameter		TPE (n=82)	Malignant (n=21)	p value (t test)
1	Mean age (in years)		36.93±17.78	60.05±10.73	0.0001
2	Mean weight (kg)		47.55±7.68	48.81±4.57	NS
3	Sex	Male	45	9	
		Female	37	12	
4	Side of effusion	Right	69.5%	80.9%	
		Left	30.4%	19%	
5	Mean ADA levels		86.41±38.08	34.10±32.88	0.0001
6	Mean pleural fluid protein		4.98±3.7	4.19±0.68	NS
7	Mean pleural fluid sugar		54.16±28.22	55.05±20.7	NS
8	Mean pleural fluid TLC		1146±143.02	1159.24±262.54	NS
9	Mean pleural fluid LDH		246.02±28.92	261.81±42.91	0.0001

Table 2: Various etiology of pleural effusion (n=110).

Sn	Etiology	Total numbers	Percentage
1	Tubercular pleural effusion	82	74.5%
2	Malignant pleural effusion	21	19%
3	Pleural effusion secondary to pneumonia	03	2.7%
4	Cardiac cause	02	1.8%
5	Unknown cause	02	1.8%
Total		110	100%

In TPE group the mean pleural fluid ADA level were 86.41±38.08 IU/L (range: 14-195 IU/L). In MPE group the mean pleural fluid ADA level were 34.10±32.88 IU/L (range: 8-144 IU/L).

In this study, the cutoff value of ADA for diagnosing TPE was 40 U/L and the sensitivity and specificity of ADA were 90.2% and 89.3% respectively. Pleural fluid ADA values were compared between tuberculous and non-tuberculous groups and difference in these values was statistically highly significant. While on comparing the ADA values amongst different non-tubercular groups; the difference was not statistically significant.

DISCUSSION

For pleural effusion to accumulate to form an effusion, it is likely that both the entry rate of fluid must increase, and the exit rate must decrease. Once it has been confirmed that patient has an exudative pleural effusion, next try to determine which of the diseases are responsible for pleural effusion. Always remember that pulmonary infectious diseases, neoplastic causes and pulmonary embolism accounts for majority of all exudative causes. Tuberculosis is very common in India and tuberculous pleural effusion is the most common form of extrapulmonary tuberculosis. Tuberculous Pleural Effusion (TPE) usually occurs as a result of delayed hypersensitivity reaction to the *tubercle bacilli*. In present study, 110 cases of pleural effusion were included between the age group of 11 to 79 years (mean age 41.38±18.65). Of the total cases, 65 (59.1%) patients were males and 45 (40.9%) females, with male to female ratio of 1.4:1.

A study done by Kushwaha R et al, on 100 patients with pleural effusion, aged 4-75 years. They further found that of all the effusions, 82% were exudative in nature and transudates comprised 18% of cases with male preponderance (the ratio of male to female being 1.2:1).[14] Another study had done from India to know the role of adenosine deaminase estimation in differentiation of tuberculous and non-tuberculous exudative pleural effusions among 96 patients between the age group of 12-76 years.[15]

In present study, 74.5% patients were diagnosed as Tuberculous Pleural Effusion (TPE), 19% had malignant pleural effusions (MPE), 2.7% had parapneumonic effusions, 1.8% had cardiac cause and 1.8% had effusions due to unknown cause.

A study from India had been done among 96 cases of pleural effusion and tuberculous group had 56 samples while non-tuberculous group had 40 samples. Non-tuberculous group included different etiologies, namely, malignancy (n=16), infectious diseases (n=18), pulmonary embolism (n=1), Collagen Vascular Diseases (CVD) (n=3) and sarcoidosis (n=2).[15] Tay TR et al, had done retrospective study to analyze the factors affecting pleural fluid adenosine deaminase level, among 160 patients. They further reported that 50% patients were

diagnosed with TPE, 14.4% had malignant effusions, 25% had parapneumonic effusions and 10.6% had effusions which were classified as 'Others'.[16] Another study from Nigeria had done to know the etiology, clinical features and management of 213 patients of pleural effusion. They reported that the most common cause of PE was tuberculosis (TB) (32.9%), followed by malignancy (29.1%) and pneumonia (15.0%) with the male to female ratio of 1.3:1.[17] Khamar et al, had done a clinico-radiological study of 100 patients with pleural effusion. They further reported that Maximum number of cases of pleural effusion were tuberculous (73%) followed by malignant (12%) and parapneumonic effusion (9%).[18] These results are also comparable to above mentioned studies.

In present study, among Tuberculous Pleural Effusion group (TPE), the mean age was 36.93±17.78 (range: 11-79 years). The mean pleural fluid protein and sugar were 4.98±3.7 and 54.16±28.22 mg/dl respectively. The mean pleural fluid TLC and mean lymphocyte percentage and mean mesothelial percentage were 1146/cmm^3, 79.4±19.7 and 5% respectively.

Kushwaha R et al, showed that showed that the majority of tuberculous effusions had more than 50% lymphocytes, 81.25% had greater than 5 gm/dl of protein and 90.63% had glucose greater than 50 gm/dl.[14] Aggarwal et al, showed that tuberculous effusions rarely contain more than 5% mesothelial cells which is in agreement with this study 19. Gupta BK et al, had shown mean pleural fluid protein 4.3±0.9 and mean pleural fluid sugar 46.2±17.6, among 56 cases of tuberculous effusions.[15] Basu A et al, had done prospective clinicopathological study of tuberculous pleural effusion, among 44 patients. They further reported pleural fluid protein 4.64 gm/dl and pleural fluid sugar 57.89 mg/dl.[20] Another study had been reported from India and which included 100 patients of pleural effusion. This study stated that the incidence of exudative effusion was 98% and 91% of the patients with exudative effusion had protein content more than 3 gm%, while all the transudates had protein content less than 3 gm%. Authors further highlighted that 91.78% of the patients of tuberculous pleural effusion had lymphocytic predominance in pleural fluid.[18]

In present study, among Malignant Pleural Effusion (MPE) group, the mean age was 60.05±10.73 (range: 38-78 years). The mean pleural fluid protein and sugar were 4.19±.68 mg/dl and 55.05±20.7 mg/dl respectively. The mean pleural fluid TLC and mean lymphocyte percentage and mean mesothelial percentage were 1159/cmm^3, 78.71±18.15 and 10% respectively. In MPE group the mean pleural fluid ADA level were 34.10±32.88 IU/L (range: 8-144 IU/L).

A study from India reported that malignant cells were present in pleural fluid of 28 patients. This study further reported that 89.29% samples were exudative and 10.71% were transudative and 71.43% of malignant effusions were hemorrhagic.[14] Soe Z et al, had done a study, among 73 patients (43 males and 30 females) with malignant pleural effusions and their age lies between 61 to 70 years.[21] In their study, the mean ADA levels, pleural fluid protein and pleural fluid sugar were 23.83 U/L, 4.1 mg/dl and 88.12 mg/dl respectively. Authors further concluded that Pleural fluid cytology for malignant cells was positive in 47 patients (64.4%) and rest was negative. Another study from India, reported malignant pleural effusion in 16.6% cases and among malignant pleural effusion mean pleural fluid protein and mean pleural fluid sugar and ADA were 4.2±1.1 and 42.2±19.6 and 26.6respectively.[15] Saha K et al, conducted a cross-sectional study among 166 patients of malignant pleural effusion.[22] Off the total cases, 121 (72.89%) were male and 45 27.11%) were female and most of them were between 50 and 70 years of age groups. In their study, Mean Adenosine Deaminase (ADA) activity in the pleural fluid was 24.05 U/L with a SD of 9.57 with highest and lowest value being 39 and 3 U/L. They further found that a total of 141 (84.94%) cases was diagnosed by pleural fluid cytology; among them 91 (64.54%) cases had a positive report on the first occasions, 35 (24.82%) cases were positive on second occasion and 15 (10.64%) were positive in third occasion. Khamar et al, reported that among malignant pleural effusion patients, 91.67% had lymphocytic predominance.[18]

Adenosine deaminase estimation in pleural fluid has long been taken as a marker for tuberculous pleurisy.[23,24] The ADA is an enzyme involved in the purine catabolism and it catalyzes the deamination of adenosine to inosine and of deoxyadenosine to deoxyinosine.[25] Adenosine deaminase is involved in the proliferation and differentiation of lymphocytes, specifically the T-lymphocytes.[26,27] Levels above 40 U/L indicate pleural tuberculosis with sensitivity 81 to 100% and specificity 83 to 100%, while some other workers have observed that this cut-off indicates a still higher sensitivity of 90-100% and specificity of 89-100%.[28-30]

In present study, among Tuberculous Pleural Effusion group (TPE), the mean pleural fluid ADA level were 86.41±38.08 IU/L (range: 14-195 IU/L).

Verma SK et al, had done a study to evaluate the value of adenosine deaminase level in 50 consecutive patients of tubercular pleural effusion.[31] They further concluded that among tubercular pleural effusion, fluid ADA level was more than 36 IU/L (ranged 36 to 229.7 IU/L) and in case of malignancy it was more than 18.5 IU/L (range : 18.5 to 87.6 IU/L). Gupta BK et al, reported mean ADA of 67.34±22.85 IU/L among 56 cases of tuberculous pleural effusion.[15] Another study from Singapore concluded that mean pleural fluid ADA was significantly higher in the TPE group compared to non TPE group (100±35 IU/L vs 30±37 IU/L, $p<0.001$) 16. Another study done in india, among 44 cases of tuberculous pleural effusion

highlighted that the mean pleural fluid ADA was 100.05 IU/L in pleural fluid.[20] Another study had done in Egypt, to estimate the cutoff value of ADA in MPE and TPE group, among 30 patients (TPE = 19, MPE = 11). They further reported that the mean level of ADA was 83.5± 50.3 U/L in TPE and 28.7 ±23.6 U/L in malignant pleural effusion ($p<0.001$). This study further highlighted that the cutoff value of ADA for diagnosing TPE was 30 U/L (sensitivity =80%, specificity =85%, diagnostic accuracy =83.3%, Positive predictive value =84.2%, negative predictive value = 81%).[32] Another study done from India, reported that 93.15% patients with tuberculous pleural effusion group had ADA > 40 IU.[18]

Nanvani P et al, had done a prospective study to evaluate the diagnostic value of ADA in 122 cases of pleural effusion. They further reported the mean ADA level in tubercular pleural effusion is 85.97 U/L versus 39.33 U/L in non-tubercular cases. They further concluded that after using cutoff value of ADA of 55 IU/L, the sensitivity and specificity were 93.51 and 86.6 respectively.[33]

CONCLUSION

The present study highlighted that tuberculosis is still the most common cause of exudative pleural effusion in India. In India, there is about 40% prevalence of tuberculosis, so sensitivity and specificity of pleural fluid ADA test for the diagnosis of tuberculous origin is high. Pleural fluid ADA test is noninvasive, inexpensive and repeatable test and may be very useful in differentiating tuberculous etiology from other causes in exudative pleural effusion.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Mazumdar S, Satyanarayana S, Pai M. Self-reported tuberculosis in India: evidence from NFHS-4. BMJ Global Health. 2019 May 1;4(3):e001371.
2. World Health Organization. Global tuberculosis report, 2018. Geneva. WHO, 2017.
3. Pai M, Correa N, Mistry N, Jha P. Reducing global tuberculosis deaths time for India to step up. Lancet. 2017 Mar 25;389(10075):1174-6.
4. Patel A, Choudhury S. Pleural tuberculosis presented as multiple pleural masses: An atypical presentation. Lung Ind: Offic Organ Ind Chest Soci. 2013 Jan;30(1):54.
5. McAdams HP, Erasmus J, Winter JA. Radiologic manifestations of pulmonary tuberculosis. Radiol Clin North Am. 1995 Jul;33(4):655-78.
6. Light RW, Broaddus VC. Pleural Effusion. In: Murry JF, Nadel JA, Masson RJ, Boushey HA eds. Textbook of respiratory medicine 3rd ed Philadelphia: WB saunders; 2000:2013-2041.
7. Light RW. Pleural diseases. In: Baltimore MD eds. 5th Ed. Lippincot Williams and Wilkins 2007.
8. Fridlender ZG, Gotsman I. Pleural effusion. New Eng J Med. 2002 Oct 17;347(16):1286.
9. Vorster MJ, Allwood BW, Diacon AH, Koegelenberg CFN. Tuberculous pleural effusions: advances and controversies. J Thorac Dis. 2015;7(6):981-91.
10. Sharma SK, Mitra DK, Balamurugan A, Pandey RM, Mehra NK. Cytokine polarization in miliary and pleural tuberculosis. J Clin Immunol. 2002 Nov 1;22(6):345-52.
11. Light RW, Macgregor MI, Luchsinger PC, Ball WC. Pleural effusions: the diagnostic separation of transudates and exudates. Annal Inter Med. 1972 Oct 1;77(4):507-13.
12. Guisti G, Galanti B. Colorimetric method in: Bergmeyer HU, ed. Method of Enzymatic analysis 3rd Ed. Berlin, Germany Verlag Chemie, Weinheim; 1984:315-323.
13. Abrams LD. A pleural biopsy punch. Lancet. 1958;30-1.
14. Kushwaha R, Shashikala P, Hiremath S, Basavaraj HG. Cells in pleural fluid and their value in differential diagnosis. J Cytol. 2008 Oct 1;25(4):138.
15. Gupta BK, Bharat V, Bandyopadhyay D. Role of adenosine deaminase estimation in differentiation of tuberculous and non-tuberculous exudative pleural effusions. J Clin Med Res. 2010 Apr;2(2):79.
16. Tay TR, Tee A. Factors affecting pleural fluid adenosine deaminase level and the implication on the diagnosis of tuberculous pleural effusion: a retrospective cohort study. BMC Infec Dis. 2013 Dec;13(1):546.
17. Adeoye PO, Johnson WR, Desalu OO, Ofoegbu CP, Fawibe AE, Salami AK, et al. Etiology, clinical characteristics, and management of pleural effusion in Ilorin, Nigeria. Nigerian Med J: J Nigeria Med Assoc. 2017 Mar;58(2):76.
18. Khamar ND, Gohil PR, Thacker RN, Gediya US. A clinical study of pleural effusion and its radiological, biochemical, bacteriological and cytological correlation. J Integ Health Sci. 2017 Jan 1;5(1):8.
19. Aggarwal AN, Gupta D, Jindal SK. Diagnosis of tuberculous pleural effusion. Ind J Chest Dis allied sciences. 1999;41(2):89-100.
20. Basu A, Chakrabarti I, Ghosh N, Chakraborty S. A clinicopathological study of tuberculous pleural effusion in a tertiary care hospital. Annal Trop Med Pub Health. 2012 May 1;5(3):168.
21. Soe Z, Aung Z, Tun KD. A Clinical Study on Malignant Pleural Effusion. Inter J Collaborative Res Inter Med Pub Health,2012;5:761-79.
22. Saha K, Maikap MK, Maji A, Moitra M, Jash D. Demographic, clinical, biochemical, radiological and etiological characteristics of malignant pleural effusions from Eastern India. Ind J Cancer. 2017 Jan 1;54(1):257.

23. Ribera E, Martinez-Vazquez JM, Ocana I, Ruiz I, Segura RM, Encabo G, et al. Gamma interferon and adenosine deaminase in pleuritis. Med Clin. 1990 Mar;94(10):364-7.
24. Valdés L, San José E, Alvarez D, Sarandeses A, Pose A, Chomón B, et al. Diagnosis of tuberculous pleurisy using the biologic parameters adenosine deaminase, lysozyme, and interferon gamma. Chest. 1993 Feb 1;103(2):458-65.
25. Muranishi H, Nakashima M, Hirano H, Saitoh T, Takahashi H, Tanaka K, et al. Simultaneous measurements of adenosine deaminase activity and tuberculostearic acid in pleural effusions for the diagnosis of tuberculous pleuritis. Inter Med. 1992;31(6):752-5.
26. Roth LB. Searching for tuberculosis in the pleural space. Chest. 1999 Jul 1;116(1):3-5.
27. Gilhotra R, Sehgal S, Jindal SK. Pleural biopsy and adenosine deaminase enzyme activity in effusions of different aetiologies. Lung Ind. 1989 Aug 1;7(3):122.
28. Valdés L, Alvarez D, San José E, Penela P, Valle JM, García-Pazos JM, et al. Tuberculous pleurisy: a study of 254 patients. Archiv Inter Med. 1998 Oct 12;158(18):2017-21.
29. Ungerer JP, Oosthuizen HM, Retief JH, Bissbort SH. Significance of adenosine deaminase activity and its isoenzymes in tuberculous effusions. Chest. 1994 Jul 1;106(1):33-7.
30. Burgess LJ, Maritz FJ, Le Roux I, Taljaard JJ. Use of adenosine deaminase as a diagnostic tool for tuberculous pleurisy. Thorax. 1995 Jun 1;50(6):672-4.
31. Verma SK, Dubey AL, Singh PA, Tewerson SL, Sharma D. Adenosine deaminase (ADA) level in tubercular pleural effusion. Lung Ind: Offici Organ Ind Chest Soci. 2008 Jul;25(3):109.
32. Helmy NA, Eissa SA, Masoud HH, Elessawy AF, Ahmed RI. Diagnostic value of adenosine deaminase in tuberculous and malignant pleural effusion. Egyp J Chest Dis Tubercul. 2012 Oct 1;61(4):413-7.
33. Nanwani P, Kapoor A, Khatri S. Diagnostic Value of Adenosine Deaminase Activity In Tuberculosis and Non Tuberculous Lymphocytic Body Fluids. J Evid Based Health. 2016;3:554-61.

Cite this article as: Kumar A, Kumar B, Verma SK, Kumar A, Mathur RK, Chaudhry S, et al. A study to know the various causes of pleural effusion and role of pleural fluid adenosine deaminase enzyme in tuberculous pleural effusion. Int J Res Med Sci 2020;8:1231-6.