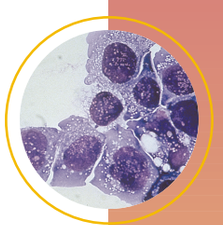
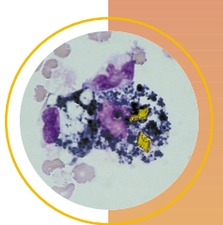
CHAPTER 13





Serous Fluid

LEARNING OBJECTIVES

Upon completion of this chapter, the reader will be able to:

1. Describe the normal formation of serous fluid.
2. Describe four primary causes of serous effusions.
3. Differentiate between a transudate and an exudate, including etiology, appearance, and laboratory tests.
4. Differentiate between a hemothorax and a hemorrhagic exudate.
5. Differentiate between a chylous and a pseudochylous exudate.
6. State the significance of increased neutrophils, lymphocytes, eosinophils, and plasma cells in pleural fluid.
7. Describe the morphologic characteristics of mesothelial cells and malignant cells.
8. List three common chemistry tests performed on pleural fluid, and state their significance.
9. State the common etiologies of pericardial effusions.
10. Discuss the diagnostic significance of peritoneal lavage.
11. Calculate a serum-ascites gradient, and state its significance.
12. Differentiate between ascitic effusions of hepatic and peritoneal origin.
13. State the clinical significance of the carcinoembryonic antigen and CA 125 tests.
14. List four chemical tests performed on ascitic fluid, and state their significance.

KEY TERMS

ascites
effusion
exudate
paracentesis
pericardiocentesis
pericarditis
parietal membrane
peritonitis
serous fluid
thoracentesis
transudate
visceral membrane

The closed cavities of the body—namely, the pleural, pericardial, and peritoneal cavities—are each lined by two membranes referred to as the serous membranes. One membrane lines the cavity wall (***parietal membrane***), and the other covers the organs within the cavity (***visceral membrane***). The fluid between the membranes, which provides lubrication as the surfaces move against each other, is called ***serous fluid***. Normally, only a small amount of serous fluid is present, because production and reabsorption take place at a constant rate.

Formation

Serous fluids are formed as ultrafiltrates of plasma, with no additional material contributed by the membrane cells. Production and reabsorption are subject to hydrostatic and colloidal (oncotic) pressures from the capillaries serving the cavities and the capillary permeability. Under normal conditions, colloidal pressure from serum proteins is the same in the capillaries on both sides of the membrane. Therefore, the greater hydrostatic pressure in the systemic capillaries on the parietal side favors fluid production through the parietal membrane and reabsorption into the lymphatic system through the visceral membrane. In Figure 13–1, the normal formation and absorption of pleural fluid are demonstrated.

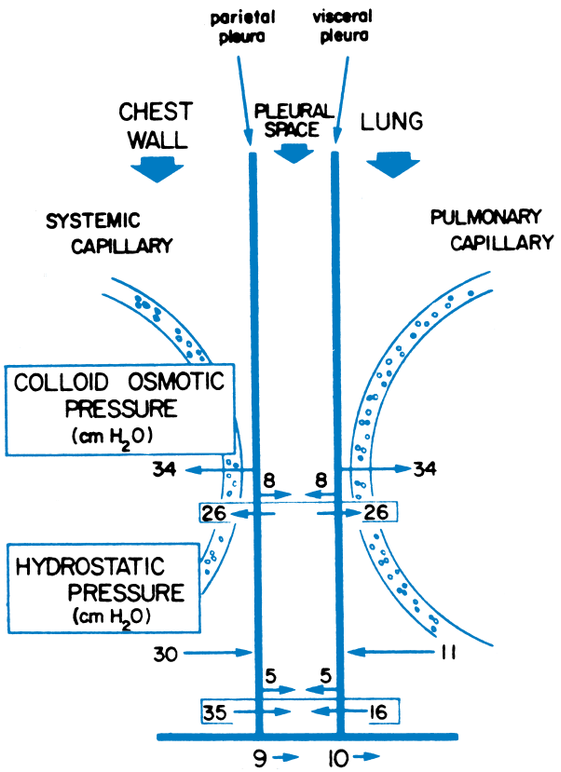


FIGURE 13–1 The normal formation and absorption of pleural fluid. (From Fraser, RG, and Pare, JAP: Diagnosis of Diseases of the Chest, vol. 1. WB Saunders, Philadelphia, 1977, p. 2069, with permission.)

Disruption of the mechanisms of serous fluid formation and reabsorption causes an increase in fluid between the membranes. This is termed an ***effusion***. Primary causes of effusions include increased hydrostatic pressure (congestive heart failure), decreased oncotic pressure (hypoproteinemia), increased capillary permeability (inflammation and infection), and lymphatic obstruction (tumors).

Specimen Collection and Handling

Fluids for laboratory examination are collected by needle aspiration from the respective cavities. These aspiration procedures are referred to as ***thoracentesis*** (pleural), ***pericardiocentesis*** (pericardial), and **paracentesis** (peritoneal). Abundant fluid (greater than 100 mL) is usually collected; therefore, suitable specimens are available for each section of the laboratory.

An ethylenediaminetetraacetic acid (EDTA) tube is used for cell counts and the differential. The remaining fluid can be heparinized (green-top evacuated tubes) for chemical, serologic, microbial, and cytologic analysis. Specimens for pH must be maintained anaerobically in ice. For better recovery of microorganisms and abnormal cells, at least 100 mL of the fluid is concentrated by centrifugation and used for these analyses.

Chemical tests performed on serous fluids are frequently compared with plasma chemical concentrations because the fluids are essentially plasma ultrafiltrates. Therefore, blood specimens should be obtained at the time of collection.

Transudates and Exudates

A general classification of the cause of an effusion can be accomplished by separating the fluid into the category of ***transudate*** or ***exudate***. Effusions that form because of a systemic disorder that disrupts the balance in the regulation of fluid filtration and reabsorption—such as the changes in hydrostatic pressure created by congestive heart failure or the hypoproteinemia associated with the nephrotic syndrome—are called transudates. Exudates are produced by conditions that directly involve the membranes of the particular cavity, including infections and malignancies. Classification of a serous fluid as a transudate or exudate can provide a valuable initial diagnostic step and aid in the course of further laboratory testing, because testing of transudate fluids is usually not necessary.[4] Traditionally, a variety of laboratory tests have been used to differentiate between transudates and exudates, including appearance, total protein, lactic dehydrogenase, cell counts, and spontaneous clotting. However, the most reliable differentiation is obtained by determining the fluid-to-blood ratios for protein and lactic dehydrogenase.[3] Differential values for these parameters are shown in Table 13–1. Additional tests are available for specific fluids and will be discussed in the following sections.

TABLE 13–1 **Laboratory Differentiation of Transudates and Exudates**[9]

	Transudate	Exudate
Appearance	Clear	Cloudy
Fluid:serum protein ratio	<0.5	>0.5
Fluid:serum LD ratio	<0.6	>0.6
White blood cell count	<1000/µL	>1000/µL
Spontaneous clotting	No	Possible
Pleural fluid cholesterol	<60 mg/dL	>60 mg/dL
Pleural fluid:serum cholesterol ratio	<0.3	>0.3
Pleural fluid:bilirubin ratio	<0.6	>0.6
Serum-ascites albumin gradient	>1.1	<1.1

General Laboratory Procedures

Serous fluid examination—including classification as a transudate or exudate, appearance, cell count and differential, and chemistry, microbiology, and cytology procedures—is performed in the same manner on all serous fluids. However, the significance of the test results and the need for specialized tests vary among fluids. Therefore, the interpretation of routine and special procedures will be discussed individually for each of the three serous fluids.

Tests that are usually performed on all serous fluids include evaluation of the appearance and differentiation between a transudate and an exudate. Effusions of exudative origin are then examined for the presence of microbiologic and cytologic abnormalities. Additional tests are ordered based on specific clinical symptoms.

Red blood cell (RBC) and white blood cell (WBC) counts are not frequently performed on serous fluids because they provide little diagnostic information.[5] In general, WBC counts greater than 1000/µL and RBC counts greater than 100,000/µL are indicative of an exudate. Serous fluid cell counts can be performed manually by using a Neubauer counting chamber and the methods discussed in Chapter 10 or by electronic cell counters. The Model 500 Yellow IRIS workstation contains a cell-counting component for serous and other body fluids (see Appendix A). Inclusion of tissue cells and debris in the count must be considered when electronic counters are used, and care must be taken to prevent the blocking of tubing with debris.

Differential cell counts are routinely performed on serous fluids, preferably on Wright's stained, cytocentrifuged specimens or on slides prepared from the sediment of centrifuged specimens. Smears must be examined not only for WBCs, but also for normal and malignant tissue cells. Any suspicious cells seen on the differential are referred to the cytology laboratory or the pathologist.

Pleural Fluid

Pleural fluid is obtained from the pleural cavity, located between the parietal pleural membrane lining the chest wall and the visceral pleural membrane covering the lungs. Pleural effusions may be of either transudative or exudative origin. In addition to the tests routinely performed to differentiate between transudates and exudates, two additional procedures are helpful when analyzing pleural fluid. These are the pleural fluid cholesterol and fluid–to–serum cholesterol ratio and the pleural fluid–to–serum total bilirubin ratio. A pleural fluid cholesterol greater than 60 mg/dL or a pleural fluid–to–serum cholesterol ratio greater than 0.3 provides reliable information that the fluid is an exudate.[11] A fluid–to–serum total bilirubin ratio of 0.6 or more also indicates the presence of an exudate.

APPEARANCE

Considerable diagnostic information concerning the etiology of a pleural effusion can be learned from the appearance of the specimen (Table 13–2). Normal and transudate pleural fluids are clear and pale yellow. Turbidity is usually related to the presence of WBCs and indicates bacterial infection, tuberculosis, or an immunologic disorder, such as rheumatoid arthritis. The presence of blood in the pleural fluid can signify a **hemothorax** (traumatic injury), membrane damage such as occurs in malignancy, or a traumatic aspiration. As seen with other fluids, blood from a traumatic tap appears streaked and uneven.

To differentiate between a hemothorax and hemorrhagic exudate, a hematocrit can be run on the fluid. If the blood is from a hemothorax, the fluid hematocrit will be similar to the whole blood hematocrit, because the effusion is actually occurring from the inpouring of blood from the injury. A chronic membrane disease effusion will contain both blood and increased pleural fluid, resulting in a much lower hematocrit.

The appearance of a milky pleural fluid may be due to the presence of **chylous material** from thoracic duct leakage or to **pseudochylous material** produced in chronic inflammatory conditions. Chylous material contains a high concentration of triglycerides, whereas pseudochylous material has a higher concentration of cholesterol. Therefore, Sudan III staining will be strongly positive with chylous material. In contrast, pseudochylous effusions will contain cholesterol crystals.[10] Differentiation between chylous and pseudochylous effusions is summarized in Table 13–3.

TABLE 13–2 **Correlation of Pleural Fluid Appearance and Disease**

Appearance	Disease
Clear, pale yellow	Normal
Turbid, white	Microbial infection (tuberculosis)
Bloody	Hemothorax
	Hemorrhagic effusion
Milky	Chylous material from thoracic duct leakage
	Pseudochylous material from chronic inflammation

TABLE 13–3 **Differentiation Between Chylous and Pseudochylous Pleural Effusions[9]**

	Chylous Effusion	Pseudochylous Effusion
Cause	Thoracic duct leakage	Chronic inflammation
Appearance	Milky/white	Milky/green tinge
Leukocytes	Predominantly lymphocytes	Mixed cells
Cholesterol crystals	Absent	Present
Triglycerides	>110 mg/dL	<50 mg/dL
Sudan III staining	Strongly positive	Negative/weakly positive

HEMATOLOGY TESTS

As mentioned previously, the differential cell count is the most diagnostically significant hematology test performed on serous fluids. Primary cells associated with pleural fluid include neutrophils, lymphocytes, eosinophils, mesothelial cells, plasma cells, and malignant cells (Table 13–4). These same cells are also found in pericardial and peritoneal fluids.

Similar to other body fluids, an increase in pleural fluid neutrophils is indicative of a bacterial infection, such as pneumonia. Neutrophils are also increased in effusions resulting from pancreatitis and pulmonary infarction.

Lymphocytes are normally noticeably present in both transudates and exudates in a variety of forms, including small, large, and reactive. More prominent nucleoli and cleaved nucleii may be present. Elevated lymphocyte counts are seen in effusions resulting from tuberculosis, viral infections, malignancy, and autoimmune disorders such as lupus erythematosus. LE cells also may be seen (Figure 13–2).

TABLE 13–4 **Significance of Cells Seen in Pleural Fluid**

Cell	Significance
Neutrophils	Pneumonia Pancreatitis Pulmonary infarction
Lymphocytes	Tuberculosis Viral infection Autoimmune disorders Malignancy
Mesothelial cells	Normal and reactive forms have no clinical significance Decreased mesothelial cells are associated with tuberculosis
Plasma cells	Tuberculosis
Malignant cells	Primary adenocarcinoma and small-cell carcinoma Metastatic carcinoma

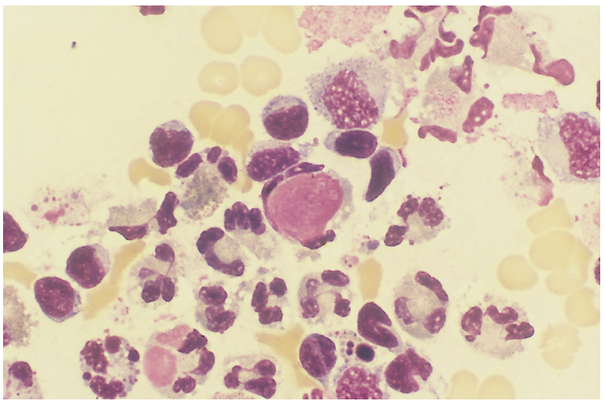


FIGURE 13–2 LE cell in pleural fluid. Notice the ingested "round body" (×1000).

Increased eosinophil levels (greater than 10 percent) may be associated with trauma resulting in the presence of air or blood in the pleural cavity. They are also seen in allergic reactions and parasitic infections.

The membranes lining the serous cavities contain a single layer of mesothelial cells; therefore, it is not unusual to find these cells in the serous fluids. Mesothelial cells are pleomorphic; they resemble lymphocytes, plasma cells, and malignant cells, frequently making identification difficult. They often appear as single, small or large round cells with abundant blue cytoplasm and round nucleii with uniform dark purple cytoplasm and may be referred to as "normal" mesothelial cells (Figures 13–3 and 13–4). In contrast, "reactive" mesothelial cells may appear in clusters, have varying amounts of cytoplasm, eccentric nucleii, and prominent nucleoli, and be multinucleated, therefore, more closely resembling malignant cells (Figures 13–5 and 13–6). An increase in mesothelial cells is not a diagnostically significant finding; however, they may be increased in pneumonia and malignancy. Of more significance is the noticeable lack of mesothelial cells associated with tuberculosis, which results from exudate covering the pleural

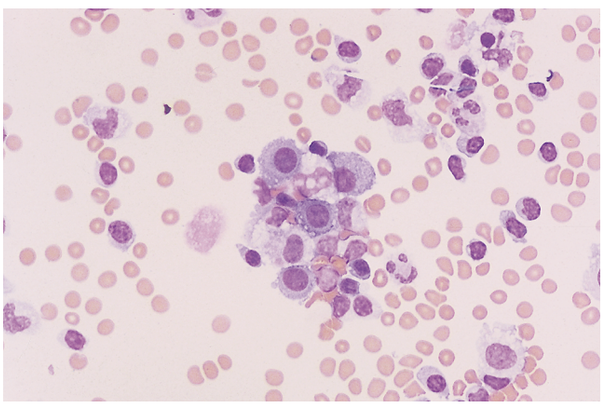


FIGURE 13–3 Normal pleural fluid mesothelial cells, lymphocytes, and monocytes (×250).

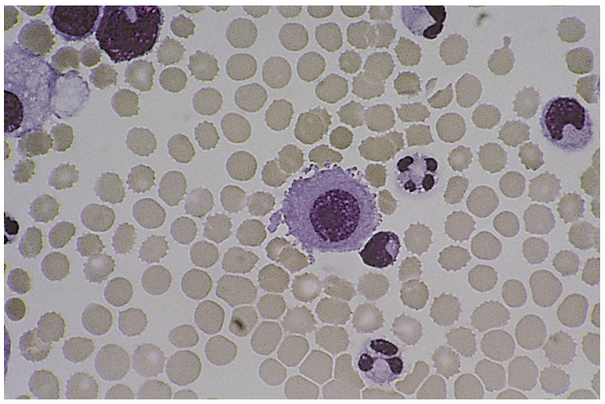


FIGURE 13–4 Normal mesothelial cell (×500).

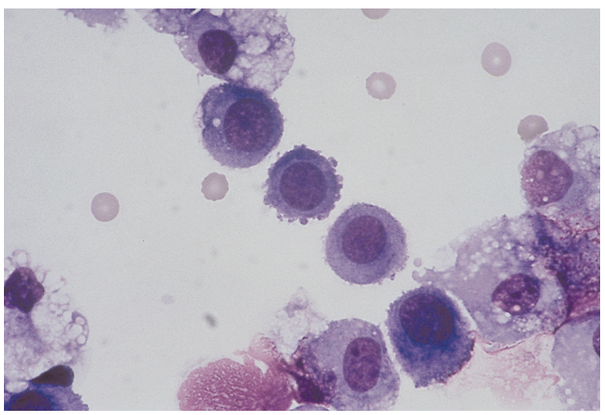


FIGURE 13–5 Reactive mesothelial cells showing eccentric nuclei and vacuolated cytoplasm (×500).

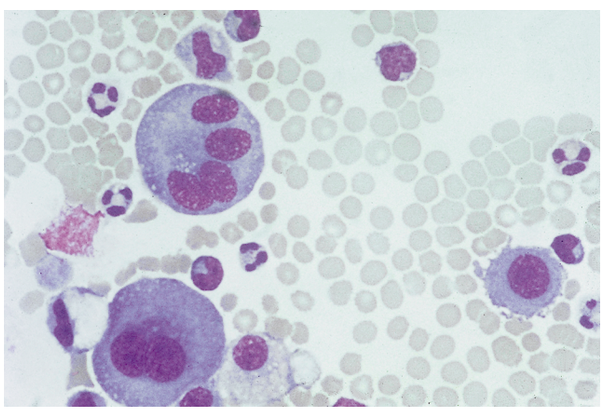


FIGURE 13–6 One normal and two reactive mesothelial cells with a multinucleated form (×500).

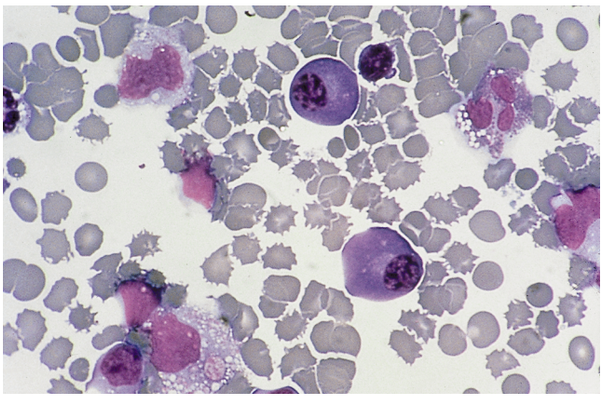


FIGURE 13–7 Pleural fluid plasma cells seen in a case of tuberculosis (×1000).

membranes. Also associated with tuberculosis is an increase in the presence of pleural fluid plasma cells (Figure 13–7).

A primary concern in the examination of all serous effusions is detecting the presence of malignant cells. Differentiation among mesothelial cells and other tissue cells and malignant cells is often difficult. Distinguishing characteristics of malignant cells may include nuclear and cytoplasmic irregularities, hyperchromatic nucleoli, cellular clumps with cytoplasmic molding (community borders), and abnormal nuclear–to–cytoplasmic ratios (Figures 13–8 through 13–10). Malignant effusions most frequently contain large, irregular adenocarcinoma cells, small or oatcell carcinoma cells resembling large lymphocytes, and clumps of metastatic breast carcinoma cells (Figures 13–11 through 13–13). Special staining techniques and flow cytometry may be used for positive identification of tumor cells.

CHEMISTRY TESTS

In addition to the chemical tests performed to differentiate between a pleural transudate and exudate, the most common chemical tests performed on pleural fluid are glucose, pH, and amylase. Triglyceride levels also may be measured to confirm the presence of a chylous effusion (Table 13–5).

Decreased glucose levels are seen with rheumatoid inflammation and purulent infections. As an ultrafiltrate of plasma, pleural fluid glucose levels parallel plasma levels with values less than 60 mg/dL considered decreased. Fluid values should be compared with plasma values. Pleural fluid lactate levels are elevated in bacterial infections and can be considered in addition to the glucose level.

Pleural fluid pH lower than 7.3 may indicate the need for chest-tube drainage, in addition to administration of antibiotics in cases of pneumonia. The finding of a pH as low as 6.0 indicates an esophageal rupture that is allowing the influx of gastric fluid.[2]

As with serum, elevated amylase levels are associated with pancreatitis, and amylase is often elevated first in the

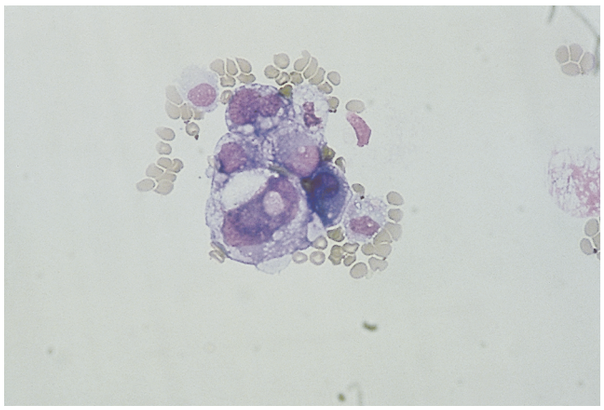


FIGURE 13–8 Pleural fluid adenocarcinoma showing cytoplasmic molding (×250).

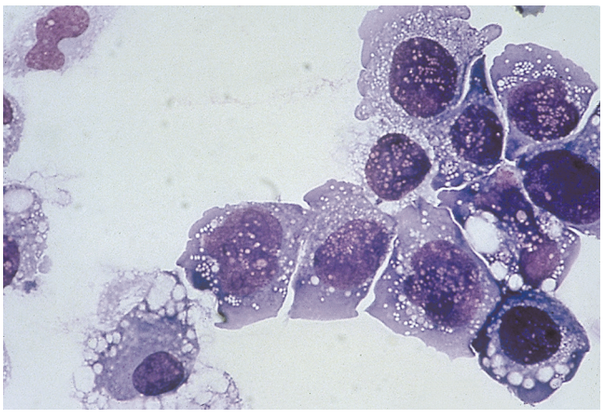


FIGURE 13–11 Poorly differentiated pleural fluid adenocarcinoma showing nuclear irregularities and cytoplasmic vacuoles (×500).

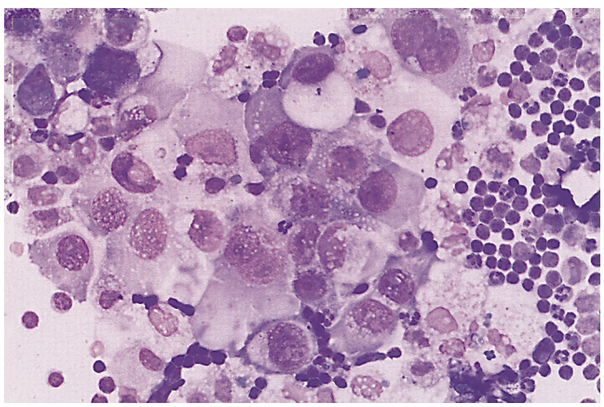


FIGURE 13–9 Pleural fluid adenocarcinoma showing fine nuclear chromatin, nuclear and cytoplasmic molding, and vacuolated cytoplasm (×1000).

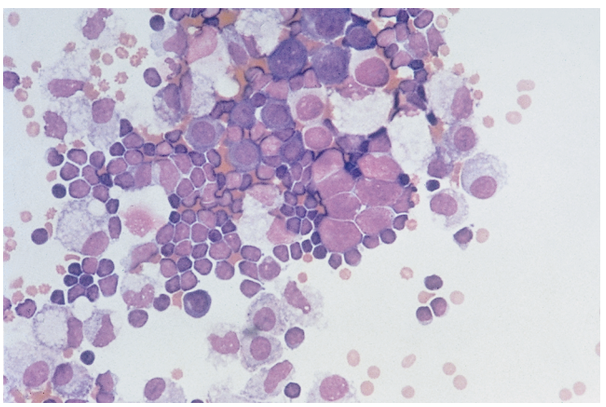


FIGURE 13–12 Pleural fluid small-cell carcinoma showing nuclear molding (×250).

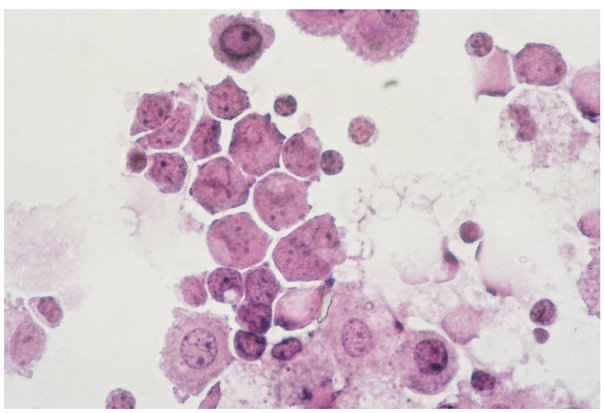


FIGURE 13–10 Enhancement of nuclear irregularities using a toluidine blue stain (×250).

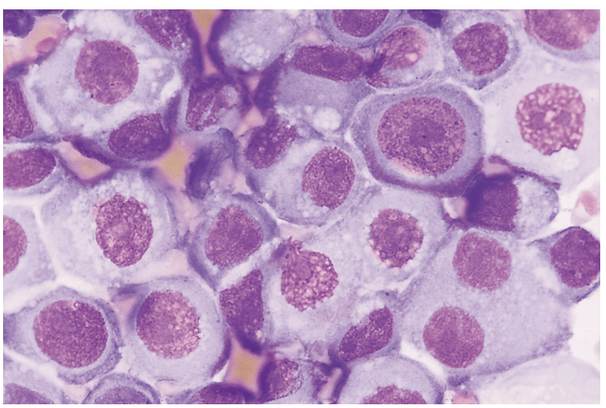


FIGURE 13–13 Metastatic breast carcinoma cells in pleural fluid. Notice the hyperchromatic nucleoli (×1000).

TABLE 13–5 **Significance of Chemical Testing of Pleural Fluid**

Test	Significance
Glucose	Decreased in rheumatoid inflammation Decreased in purulent infection
Lactate	Elevated in bacterial infection
Triglyceride	Elevated in chylous effusions
pH	Decreased in pneumonia not responding to antibiotics Markedly decreased with esophageal rupture
Amylase	Elevated in pancreatitis, esophageal rupture, and malignancy

pleural fluid. Pleural fluid amylase, including salivary amylase, also may be elevated in esophageal rupture and malignancy.

MICROBIOLOGIC AND SEROLOGIC TESTS

Microorganisms primarily associated with pleural effusions include *Staphylococcus aureus*, Enterobacteriaceae, anaerobes, and *Mycobacterium tuberculosis*. Gram stains, cultures (both aerobic and anaerobic), acid-fast stains, and *Mycobacteria* cultures are performed on pleural fluid when clinically indicated. Serologic testing of pleural fluid is used to differentiate effusions of immunologic origin from noninflammatory processes. Tests for antinuclear antibody (**ANA**) and rheumatoid factor (**RF**) are the most frequently performed.

Detection of the tumor marker carcinoembryonic antigen (**CEA**) provides valuable diagnostic information in effusions of malignant origin.

Pericardial Fluid

Normally, only a small amount (10 to 50 mL) of fluid is found between the pericardial serous membranes. Pericardial effusions are primarily the result of changes in the permeability of the membranes due to infection (***pericarditis***), malignancy, trauma, or metabolic disorders, such as uremia (Table 13–6). The presence of an effusion is suspected when cardiac compression is noted during the physician's examination.

APPEARANCE

Normal and transudate pericardial fluid appears clear and pale-yellow. Effusions resulting from infection and malignancy are turbid, and malignant effusions frequently are blood streaked. Grossly bloody effusions are associated with accidental cardiac puncture and misuse of anticoagulant medications. Milky fluids representing chylous and pseudochylous effusions may also be present.

TABLE 13–6 **Significance of Pericardial Fluid Testing**

Test	Significance
Appearance	
Clear, pale yellow	Normal, transudate
Blood-streaked	Infection, malignancy
Grossly bloody	Cardiac puncture, anticoagulant medications
Milky	Chylous and pseudochylous material
Differential	
Increased neutrophils	Bacterial endocarditis
Malignant cells	Metastatic carcinoma
Carcinoembryonic antigen	Metastatic carcinoma
Gram stain and culture	Bacterial endocarditis
Acid-fast stain	Tubercular effusion
Adenosine deaminase	Tubercular effusion

LABORATORY TESTS

Tests performed on pericardial fluid are primarily directed at determining if the fluid is a transudate or an exudate and include the fluid–to–serum protein and lactic dehydrogenase (LD) ratios. Like pleural fluid, WBC counts are of little clinical value, although a count of greater than 1000 WBCs/μL with a high percentage of neutrophils can be indicative of **bacterial endocarditis**.

Cytologic examination of pericardial exudates for the presence of malignant cells is an important part of the fluid analysis. Cells most frequently encountered are the result of metastatic lung or breast carcinoma and resemble those found in pleural fluid (Figure 13–14). Pericardial fluid CEA levels correlate well with cytologic studies.[6]

Bacterial cultures and Gram stains are performed on concentrated fluids when endocarditis is suspected. Effusions of tubercular origin are increasing as the result of acquired immunodeficiency syndrome (AIDS). Therefore, acid-fast stains and chemical tests for adenosine deaminase are often requested on pericardial effusions.

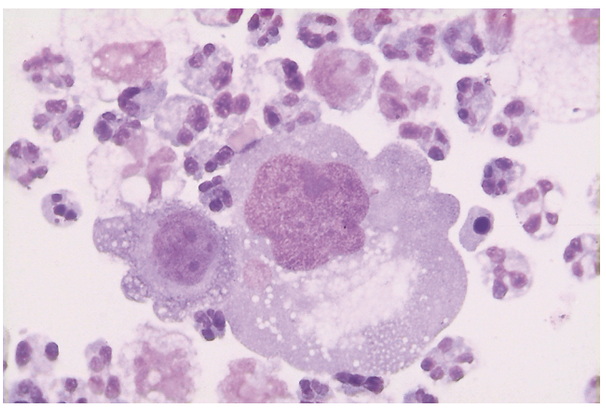


FIGURE 13–14 Malignant pericardial effusion showing cytoplasmic molding and hyperchromatic nucleoli (×1000).

Peritoneal Fluid

Accumulation of fluid in the peritoneal cavity is called ***ascites***, and the fluid is commonly referred to as ascitic fluid rather than peritoneal fluid. In addition to the causes of transudative effusions discussed previously, hepatic disorders, such as cirrhosis, are frequent causes of ascitic transudates. Bacterial infections (***peritonitis***) often as a result of intestinal perforation or a ruptured appendix and malignancy are the most frequent causes of exudative fluids (Table 13–7).

Normal saline is sometimes introduced into the peritoneal cavity to act as a lavage for the detection of abdominal injuries that have not yet resulted in the accumulation of fluid. **Peritoneal lavage** is a particularly sensitive test for the detection of intra-abdominal bleeding in blunt trauma cases, and results of the RBC count are used to aid in determining the need for surgery.[1] RBC counts greater than 100,000/µL are indicative of blunt trauma injuries.

TRANSUDATES VERSUS EXUDATES

Differentiation between ascitic fluid transudates and exudates is more difficult than for pleural and pericardial effusions. The serum-ascites albumin gradient is recommended over the fluid to serum total protein and LD ratios for the detection of transudates of hepatic origin.[8] Fluid and serum albumin levels are measured concurrently, and the fluid albumin level is then subtracted from the serum albumin level. A difference (gradient) of 1.1 or greater suggests a transudate effusion of hepatic origin, and lower gradients are associated with exudative effusions.

EXAMPLE:
Serum albumin = 3.8 mg/dL
Fluid albumin = 1.2 mg/dL
Gradient = 2.6 indicating hepatic effusion

TABLE 13–7 **Significance of Peritoneal Fluid Testing**

Test	Significance
Appearance	
Clear, pale yellow	Normal
Turbid	Microbial infection
Green	Gallbladder, pancreatic disorders
Blood-streaked	Trauma, infection, or malignancy
Milky	Lymphatic trauma and blockage
Peritoneal lavage	>100,000 RBCs/µL indicates blunt trauma injury
WBC count	
<500 cells/µL	Normal
>500 cells/µL	Bacterial peritonitis, cirrhosis
Differential	Bacterial peritonitis Malignancy
Carcinoembryonic antigen	Malignancy of gastrointestinal origin
CA 125	Malignancy of ovarian origin
Glucose	Decreased in tubercular peritonitis, malignancy
Amylase	Increased in pancreatitis, gastrointestinal perforation
Alkaline phosphatase	Increased in gastrointestinal perforation
Blood urea nitrogen/creatinine	Ruptured or punctured bladder
Gram stain and culture	Bacterial peritonitis
Acid-fast stain	Tubercular peritonitis
Adenosine deaminase	Tubercular peritonitis

APPEARANCE

Like pleural and pericardial fluids, normal peritoneal fluid is clear and pale yellow. Exudates are turbid with bacterial or fungal infections and may appear green when bile is present. The presence of bile can be confirmed using standard chemical tests for bilirubin. Blood-streaked fluid is seen following trauma and with intestinal disorders and malignancy. Chylous or pseudochylous material may be present with trauma or blockage of lymphatic vessels.

LABORATORY TESTS

Normal WBC counts are less than 500 cells/µL, and the count increases with bacterial peritonitis and cirrhosis. To distinguish between those two conditions, an absolute neutrophil count should be performed. An absolute neutrophil count greater than 250 to 500 cells/µL or greater than 50 percent of the total WBC count is indicative of infection.[9]

Examination of ascitic exudates for the presence of malignant cells is important for the detection of tumors of primary and metastatic origin. Malignancies are most frequently of gastrointestinal or ovarian origin. Cells present in ascitic fluid include leukocytes, abundant mesothelial cells, macrophages including lipophages (Figure 13–15), and malignant cells (Figures 13–16 and 13–17). Malignant

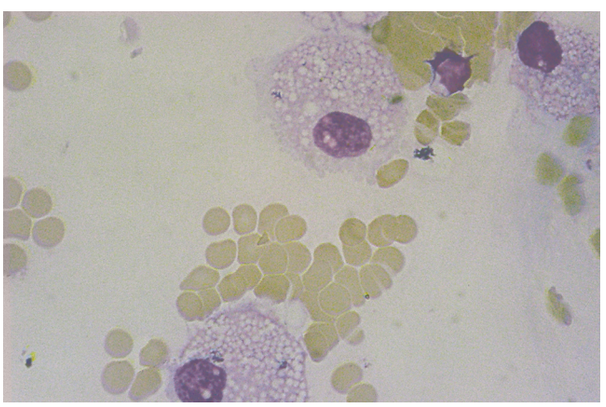


FIGURE 13–15 Lipophages (macrophages containing fat droplets) in peritoneal fluid (×500).

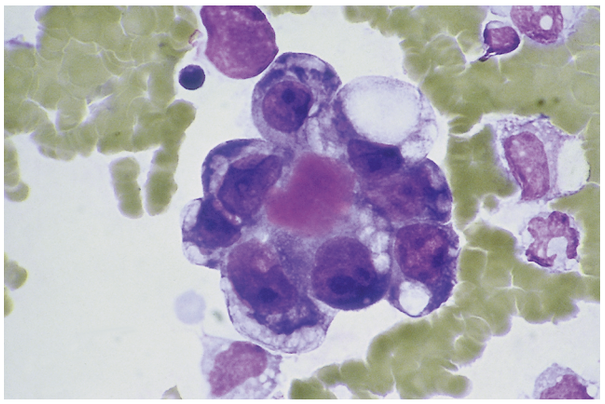


FIGURE 13–16 Ovarian carcinoma showing community borders, nuclear irregularity, and hyperchromatic nucleoli (×500).

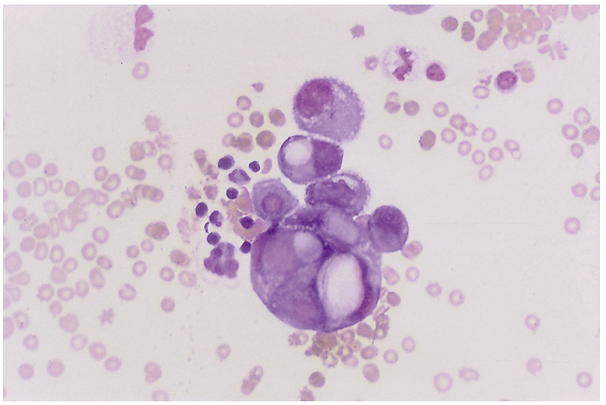


FIGURE 13–19 Colon carcinoma cells containing mucin vacuoles and nuclear irregularities (×500).

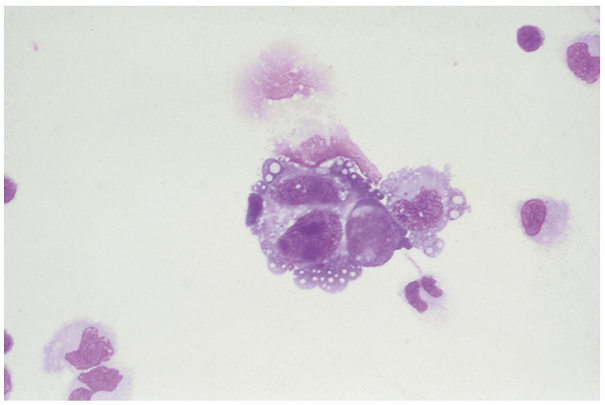


FIGURE 13–17 Adenocarcinoma of the prostate showing cytoplasmic vacuoles, community borders, and hyperchromatic nucleoli (×500).

cells often contain mucin-filled vacuoles (Figures 13–18 and 13–19). Psammoma bodies containing concentric striations of collagen-like material can be seen in benign conditions and are also associated with ovarian and thyroid malignancies (Figure 13–20). Measurement of the tumor markers CEA and CA 125 is a valuable procedure for identifying the primary source of tumors producing ascitic exudates. The presence of CA 125 antigen with a negative CEA suggests the source is from the ovaries, fallopian tubes, or endometrium.[7]

Chemical examination of ascitic fluid consists primarily of glucose, amylase, and alkaline phosphatase determinations. Glucose is decreased below serum levels in tubercular peritonitis and malignancy. Amylase is determined on ascitic fluid to ascertain cases of pancreatitis, and it may be elevated in patients with gastrointestinal perforations. An elevated alkaline phosphatase level is also highly diagnostic of intestinal perforation.

Measurements of blood urea nitrogen and creatinine in the fluid are requested when a ruptured bladder or acciden-

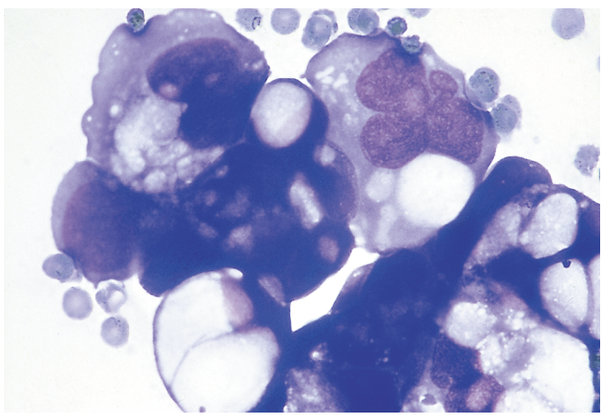


FIGURE 13–18 Ovarian carcinoma cells with large mucin-containing vacuoles (×500).

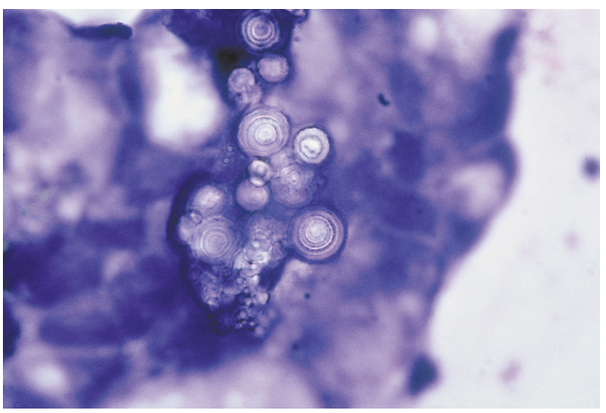


FIGURE 13–20 Psammoma bodies exhibiting concentric striations (×500).

tal puncture of the bladder during the paracentesis is of concern.

Gram stains and bacterial cultures for both aerobes and anaerobes are performed when bacterial peritonitis is suspected. Inoculation of fluid into blood culture bottles at the bedside increases the recovery of anaerobic organisms. Acid-fast stains, adenosine deaminase, and cultures for tuberculosis may also be requested.

REFERENCES

1. Feied, CF: Diagnostic peritoneal lavage. Postgrad Med 85(4):40–49, 1989.
2. Houston, MC: Pleural fluid pH: Diagnostic, therapeutic and prognostic value. Am J Surg 154(3):333–337, 1987.
3. Jain, AP, Gupta, OP, and Khan, N: Comparative diagnostic efficiency of criteria used for differentiating transudate and exudate pleural effusions. J Assoc Physicians India 30(11):823–825, 1982.
4. Jay, SJ: Pleural effusions: Definitive evaluation of the exudate. Postgrad Med 80(5):180–188, 1986.
5. Kjeldsberg, CR, and Knight, JA: Body Fluids: Laboratory Examination of Amniotic, Cerebrospinal, Seminal, Serous and Synovial Fluids. A Textbook Atlas. ASCP, Chicago, 1993.
6. Pinto,MM: Carcinoembryonic antigen in pericardial effusion. Lab Med 18(10): 671–672, 1987.
7. Pinto, MM, et al: Immunoradiometric assay of CA 125 in effusions. Cancer 59(2):218–222, 1987.
8. Runyan, BA, et al. The serum-ascites albumin gradient is superior to the exudate transudate concept in the differential diagnosis of ascites. Ann Intern Med 117:215–218, 1992.
9. Smith, GP, and Kjeldsberg, CR: Cerebrospinal, synovial and serous body fluids. In Henry, JB (ed): Clinical Diagnosis and Management by Laboratory Methods. WB Saunders, Philadelphia, 1996.
10. Stogner, SW, and Campbell, GD: Pleural effusions: What you can learn from the results of a "tap." Postgrad Med 91(5):439–454, 1992.
11. Valdez, L, et al: Cholesterol: A useful parameter for distinguishing between pleural exudates and transudates. Chest 99(5):1097–1102, 1991.

STUDY QUESTIONS

1. What is the purpose of serous fluid?
2. Explain why each of the following conditions will cause a serous effusion: congestive heart failure, hypoproteinemia, inflammation, and lymphatic tumor.
3. What type of serous fluid is obtained by thoracentesis? Paracentesis?
4. Why is differentiation of a serous fluid as a transudate or an exudate of diagnostic significance?
5. State a pathologic condition that causes production of a transudate. An exudate.
6. Describe the characteristic appearance, fluid–to–serum protein and LD ratios, and cell count of a transudate. Which result(s) are most reliable?
7. How can performing a hematocrit aid in determining the cause of a bloody pleural fluid?
8. How can the laboratory determine if a milky pleural fluid is caused by thoracic duct leakage?
9. State a pathologic cause of increased pleural fluid neutrophils. Lymphocytes. Eosinophils. Plasma cells.
10. Why are mesothelial cells routinely seen in pleural fluid differentials?
11. Is it more clinically significant to observe increased or decreased mesothelial cells? Why?
12. State four characteristics of malignant cells.
13. Should pleural fluid glucose levels be compared with plasma levels? Why or why not?
14. Why is the pH of pleural fluid decreased following esophageal rupture?
15. Describe two clinically significant cellular observations in pericardial fluid.
16. Define ascites.
17. Under what circumstance might a peritoneal lavage be performed?
18. The ascitic fluid albumin is 2.8 mg/dL and the patient's serum albumin is 3.5 mg/dL. Is this fluid a transudate or an exudate? Why?
19. What is the significance of an ascitic fluid that is positive for CA 125 antigen?
20. How should cultures of ascitic fluid be incubated?

CASE STUDIES AND CLINICAL SITUATIONS

1. Fluid from a patient with congestive heart failure is collected by thoracentesis and sent to the laboratory for testing. It appears clear and pale yellow and has a WBC count of 450/μL, fluid to serum protein ratio of 0.35, and fluid to serum LD ratio of 0.46.
   a. What type of fluid was collected?
   b. Based on the laboratory results, would this fluid be considered a transudate or an exudate? Why?
   c. List two other tests that could be performed to aid in classifying this fluid.
2. A cloudy pleural fluid has a glucose level of 30 mg/dL (serum glucose level is 100 mg/dL) and a pH of 6.8.
   a. What condition do these results indicate?
   b. What additional treatment might the patient receive based on these results?
3. A cloudy pericardial fluid from a patient with AIDS is received in the laboratory. Gram stain and routine cultures are negative. What additional tests should be performed on this fluid?
4. Paracentesis is performed on a patient with ascites. The fluid appears turbid and has an elevated WBC count. Additional tests ordered include an absolute

granulocyte count, amylase, creatinine, CEA, and CA 125.

a. What is the purpose for the absolute granulocyte count? If it is less than 250 cells/μL, what condition is indicated?
b. If the amylase level is elevated, what is its significance? State an additional test that might be ordered.
c. Explain the significance of an elevated creatinine level.

5. Describe a situation in which paracentesis might be performed on a patient who does not have ascites. If the RBC count is 300,000/μL, what does this indicate?

6. Microscopic examination of an ascitic fluid shows many cells with nuclear and cytoplasmic irregularities containing Psammoma bodies. The CEA test result is normal. What additional test would be helpful?