MULTIVARIABLE PLEURAL FLUID TEST

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Abstract

Pleural effusion is excess fluid that accumulates in the fluid-filled space between the lungs and chest cavity. The condition is diagnosed approximately 1 million times each year in the United States; however, the ability to determine if the fluid is transudative or exudative in a quick and concise way still remains a challenge. The methods we determined to differentiate between transudative and exudative fluid quantify the pH, glucose, and total protein as well as identify the presence of catalase and the specific gravity of the fluid.

Fabrication of the design has resulted in a prototype that may successfully differentiates between transudative and exudative effusion with decreased waiting time for the results and increased convenience. Continued work will investigate other test that can be added to the Multivariable Bedside Test to increase the sensitivity and specificity of the test.

Motivation

•1 million pleural effusions diagnosed in the US each year[1]
•The type of fluid depends on the cause of the effusion
- Transudative[2]
Heart failure, pulmonary embolism, cirrhosis
- Exudative[2]
Pneumonia, cancer, kidney disease, inflammatory disease
•Most effusions do not have symptoms until 500mL
- Chest pain, dry coughing, uneasy breathing
•When pleural fluid reaches 500mL it restricts breathing
•Currently fluid is taken to a lab and analyzed, but the process takes at least 24 hrs.[7]
•Could improve health care for those in the military and developing counties

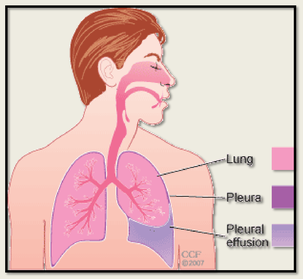

Figure 1: Example of pleural effusion between the lung and chest wall. [1]

Goal: To create a clinical method that is cost efficient, convenient, and quick for the characterization of fluid properties to differentiate between transudative or exudative pleural effusion.

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-Veterinary Clinics in the Madison Area

Final Design

Advantages
- Versatile operating environments
- Cost efficient compared to current methods of characterization

Specifications
- Determines if pleural fluid is transudative or exudative
- 6 tests to improve the diagnostic accuracy for characterizing pleural fluid
- 10.2x12.7x1.9cm to integrate into thoracentesis kit
- High density polyethylene
- 231 grams

Ergonomics
- Compact for ease of handling
- Easily maintained
- Symmetric design
- Consistent layout
- Easy to read
- Contained hydrogen peroxide

Cost Analysis

Item	Cost
Glucose strip (1)	$0.76
pH strip (1)	$0.05
Label (1)	$0.10
Multivariable urine test strip (1)	$0.36
Glucose meter (1)	$29.99
Plastic 10.2x12.7x1.9cm	$5.93
Test tube (1)	$1.15
Hydrogen peroxide (30%) – 100 µL	$0.03
Total	**$38.37**

Table 1. Total cost of materials in single prototype: $38.37. Labor for fabrication not included.

Final Layout

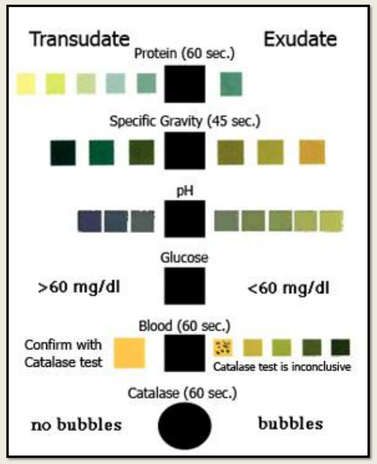


Figure 2. Final design layout. Wells take the place of black shapes in prototype.

Criteria

Test	Transudative	Exudative
Protein	<2.9 g/dL	>2.9 g/dL
Specific Gravity	<1.012	>1.02
pH	> 7.3	< 7.3
Glucose	> 60 mg/dL	< 60 mg/dL
Blood	If present catalase test will bubble (false positive)	Will not affect catalase test
Catalase	No bubbles	Bubbles

Table 2. Criteria used to analyze results of each test

Testing

Creation of Testing Fluid

Exudative
•1/2 of an egg white
•10 drops of lemon juice

Transudative
•1/8 tsp of baking powder
•20 mL of warm H_2O
•1/2 tsp of sugar

Results
- Exudative solution yielded all properties characterized in exudative fluid that we are testing apart from the glucose
- Transudative solution fulfilled all elements being tested
- Tests read the correct ranges of concentrations

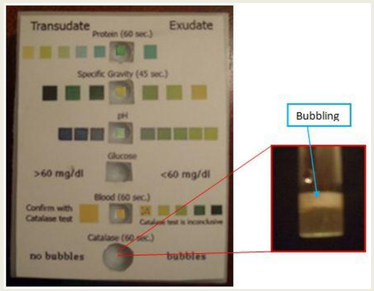
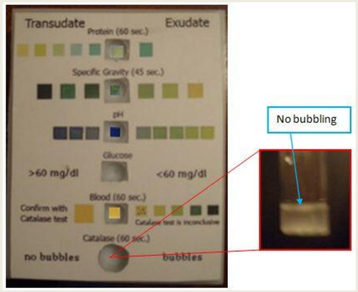


Figure 3. (Left) Result of test with exudative fluid.

Figure 4. (Right) Result of test with transudative fluid.



Final Tests

Protein
- Inflammation is present with exudative effusions causing an increase in capillary permeability [2]
- Allows for protein to cross the viseral pleura
- Sensitivity of 93.1% and specificity of 50% [3]

Glucose
- Low glucose levels are associated with exudative effusions while fluids with high glucose levels are considered transudative
- Mechanisms for these trends are unknown

Specific Gravity
- More dense fluids are considered to be exudative
- Less dense fluids are transudative

pH [4]
- Exudative fluids have an increased level of acid production due to the presence of leukocytes and bacteria
- Exudative fluids also have an inadequate buffering capacity
- Sensitivity of 36% [5]

Catalase
- Increased level of catalase activity is characteristic of exudative fluid
- Catalase is not present in transudative fluid
- Sensitivity of 98% and specificity of 91% [6, 1]

Future Work

Reduce Prototype Size
- Scale down dimensions
- Reduce thickness

Refine Design
- All tests on one test-strip
- Single well
- Reduce plastic and cost
- Seal well to preserve test strip

Change in Tests
- Replace glucose meter with colorimetric test strip
- Additional tests to improve accuracy
- Convenient way to measure pleural fluid to blood serum ratio

Further Testing
- Testing of diagnostic accuracy using previously characterized pleural fluid
- Determine sensitivity and specificity

References

[1] Light, R.W. "Pleural Effusion." *New England Journal of Medicine,* 346.25 (2002): 1971-1977.
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