BEDSIDE DEVICE TO MEASURE JUGULAR VENOUS PRESSURE

Anthony Schmitz (Team Leader), Taylor Moehling (Communicator), Danielle Horn (BSAC), Kelsie Harris (BWIG)
Clients: Dr. Steven H. Yale MD of Marshfield Clinic
Advisor: Professor Chris Brace

1. Abstract

This poster outlines the non-invasive device that has been developed to measure the jugular venous pressure of a patient with heart failure. The final design incorporates a sensor to measure the absolute distance between the internal jugular vein and sternal angle and an iPhone app to measure the angle of elevation. The circumference of the patient's chest will be measured with a tape measure to determine the depth of the right atrium. The sensor method was tested for precision using two team members at various angles of Inclination. The data set was erroneous because at some angles, the ruler method proved to be more precise.

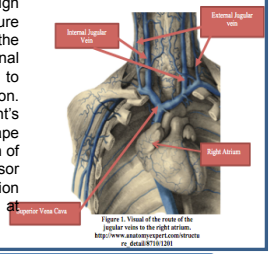


Figure 1. Visual of the route of the jugular veins to the right atrium. http://www.anatomyexpert.com/structure_detail/8710/1201

2. Problem Statement

Background

Heart failure is the leading cause of death in both men and women in the United States and evaluating the jugular venous pressure is one of the best ways to assess and diagnose heart failure. [1] In the internal jugular vein, the blood is emptying from the head and into the heart. When the pulsation is visible on the neck, the veins in head are pushing more blood into the heart than the heart can pump out. What is seen, is the filling of the jugular vein with blood, which is the indicator of the pressure. The height of the pulsation in the jugular vein corresponds to the pressure in the right atrium because it measures the pressure building on the heart. [2]

Motivation

Proper analysis of jugular venous pressure is a critical factor in diagnosing and monitoring heart failure patients in a clinical setting. Currently, the procedures taking place today are lacking in feasibility, accuracy, and straightforwardness to impact the vast number of people that could benefit from them.

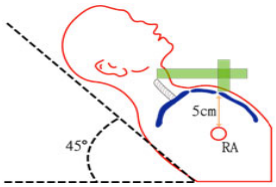


Figure 2: How to find jugular venous pressure using distances. http://renalfellow.blogspot.com/2011/01/jugular-venous-pressuredistention.html

3. Design Criteria

A beside device to measure the jugular venous pressure must meet the following requirements:

- Non-invasive
- Precise and accurate
- Daily use in clinics
- Small, lightweight and easily stored
- Electronic readout
- Less than $500

4. Final Design

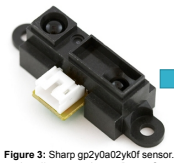


Figure 3: Sharp gp2y0a02yk0f sensor. http://www.google.com/imgres?start=0&num=10&hl=en&safe=off&tbo=d&biw


Figure 4: Leonardo Arduino http://www.google.com/imgres?hl=en&safe=off&sa=X&tbo=d&biw=1454&bih


Figure 5: Computer http://www.google.com/imgres?num=10&hl=en&safe=off&tbo=d&biw=1454&bih

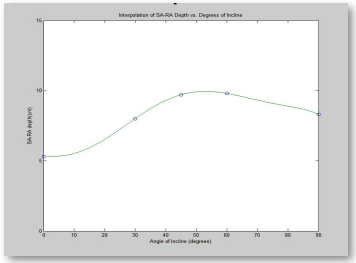


Figure 6: Graph of relationship between angle of elevation and depth of right atrium. Initial depth of right atrium below sternal angle depends on angle of elevation of the bed.

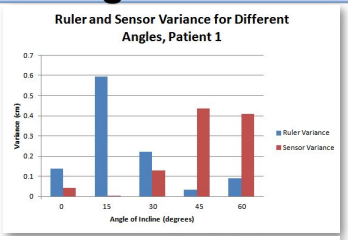
Figure 7: AccelMeter application on iPhone http://www.google.com/imgres?q=accelmeter+application+iphone&um=1&hl=en&newwindow

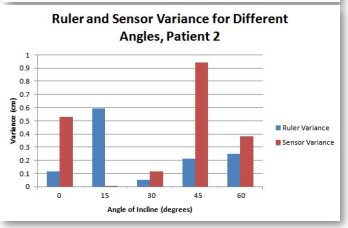
- AccelMeter iPhone application to measure angle of elevation of bed
- Depth of right atrium from sternal angle depends on angle of elevation of patient on bed
- Sensor placed directly on sternal angle using medical tape
- Reflective object held at point of pulsation as reflective material for the sensor
- Sensor measures absolute distance between sternal angle and pulsation of internal jugular vein
- Easy to locate sternal angle but need trained eyes to locate pulsation of internal jugular vein
- Geometry used to find vertical distance from internal jugular vein to sternal angle
- MATLAB program requires chest circumference, angle of elevation and absolute distance to output jugular venous pressure


Figure 8: Displaying use of rulers to obtain vertical distance. http://www.mespere.com/venus-1000


Figure 9: Using the sensor to measure the absolute distance between the pulsation of the internal jugular vein and the sternal angle.

5.Testing of Precision





The graphs above show precision through the comparison of the variance of the ruler method and the sensor method. Since the overall variance of the ruler method is closer to zero than the sensor method, this does not support the original hypothesis that the sensor method is more precise than the ruler method. This suggests that, in general, the ruler method has less of an error than the sensor method.

6. Future Work

- Test for accuracy using heart failure patients that have jugular venous pressure data by using the invasive procedure and comparing that to the sensor data
- Convert the computer program to Java/ C++
- Create smart phone application that computes the jugular venous pressure

7. Acknowledgements

- Dr. Steven Yale
- Chris Brace
- Dr. Walter Kao
- Professor Amit Nimunkar
- Matthew Bollom
- Deb Deppler
- Gustav-Karlsson Robotics
- Jeroen Doggen-Arduino
- Devin Harris
- Bret Lotzer
- Caroline Price

8.References

[1] "AnatomyEXPERT - Structure Detail." *AnatomyEXPERT - Structure Detail*. N.p., n.d. Web. 15 Oct. 2012. <http://www.anatomyexpert.com/structure_detail/8710/1201/>.

[2] "What it Looks Like: Jugular Vein Distention." EMS Basics- Fundamentals of Care for the Working EMT. Paramedicine 101, 17 2011. Web. 9 Dec 2012. <http://emsbasics.com/2011/10/17/what-it-looks-like-jugular-vein-distention/>.