Research Article
ISSN:2249-1236
CODEN: IJRRBI (USA)
Safa'a al Qaralleh **et al., *Int*. J. Res. Rev. Pharm. Appl. Sci.,*(2018) 8(1) 139-145***
International Journal of Research and Reviews in Pharmacy and Applied sciences

Staged reconstruction of Hypoplastic left heart syndrome analysis using Ansis

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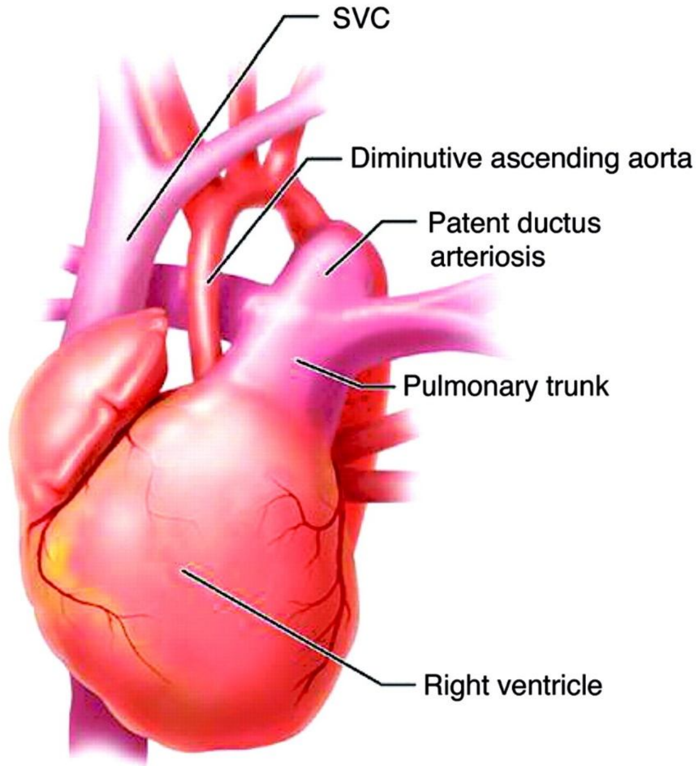


Abstract:
Hypoplastic left heart syndrome (HLHS) is a collection of inherent heart weakness that is characterized by multilevel obstruction of systemic cardiac output from the level of the mitral valve to the proximal descending thoracic aorta and hypoplasia of the left ventricle. A three-staged surgical repair or heart transplantation enough to Treatment of HLHS. It will typically require open-heart surgery to re-direct the oxygen-rich blood and oxygen-poor blood in a series of three reconstructive operations known as "Staged Reconstruction". Stage I, the Norwood procedure, and A few days of birth. Stage II, the Bidirectional Glenn or the HemiFontan, four to six months of birth. Stage III, the Fontan procedure, one-and-a-half to three years of age. Engineering sense go further to find the best design model using in each stage of medical solution, to became finally with battering design can result in long life compared with children have traditional way of surgery. So experiment had described the right ventricle and its function after treatment of HLHS.

Keywords: Engineering simulation software (**ANSYS)**, Hypoplastic left heart syndrome (**HLHS)**, computer-aided engineering **(CAE)** , Computational Fluid Dynamics (**CFD**)

Introduction:

In this paper we use ANSYS program to simulate fluid flows for different shunt models to find which one is the best to use it Blalock-Taussing shunt surgery.Few change in model designed, achieve smaller change in flow or velocity. Their for we need to make new models to achieve our target (enough amount of blood for HLHS patient to survive them). In this part Models was run in steady state case (the same velocity over time) and unsteady state case (different velocity over time) to compare results between them and found which model has high flow and velocity with lees restriction of blood flow, which are the aim of this analysis .

Cardiovascular System:

The cardiovascular system divides into two main parts the heart and a vascular system.The heart works as a pump (7.000 L of blood each day), the right side (deoxygenated blood pumps to the lungs)→ Pulmonary Circulation and The left side (oxygenated blood pumps to all parts of the body)→ General Circulation. The vascular system consists of Arteries and veins are main blood vessels through which blood flows Away from Heart and Veins which blood flows to Heart and Capillaries the site of nutrients, gases, electrolytes and waste exchange

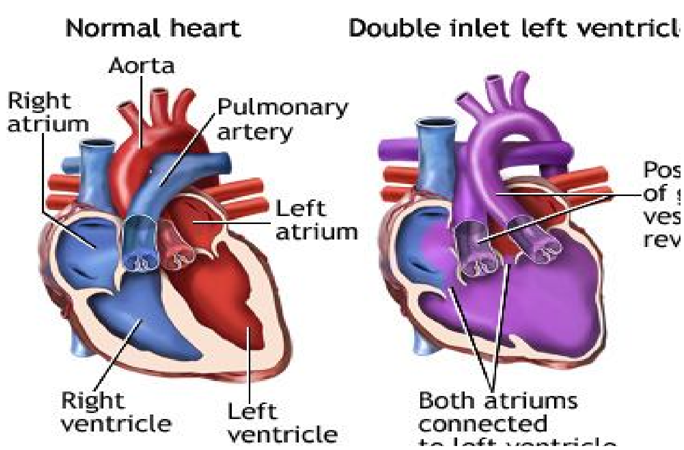


Fig.1: Normal and HLHS human heart

The heart is covered by the pericardium. And has two sides with two chambers, the Blood flows through the heart in one direction the Valves control the blood flow, the cardiac conduction system controls the electrical impulses that cause the heart to contract. the Chambers of the heart is a receiving chamber (upper): atria/atrium (singular: atrium) and a pumping chambers (lower): ventricles, there's a four Heart valves Tricuspid Valve: Right atrioventricular valve that Control blood flow in right heart side and Prevent back flow of blood, also a Mitral Valve: Left atrioventricular valve that Control blood flow in left heart side and Prevent back flow of blood, These valves Open and closed according blood pressure in these chambers.

Hypoplastic left heart syndrome:

Hypoplastic left heart syndrome (HLHS) [Figure.2] is a congenital deformity rarely occurs at birth where the left side of the left heart cannot pump blood effectively to the body and thus the right side pumping blood to the lungs and throughout the body.

It is diagnosed when the fetus is in the mother's womb by conducting an ultrasound examination in the first trimester of pregnancy. The size of the left ventricular ventricle of the affected child is smaller than normal, with abnormalities in the mitral and urethral valves.

surgery: there are three stages of treatment that allow the blood to flow naturally to and from the heart, so the body gets what it needs of blood saturated with oxygen.

Material and methods:
Simulation of three different orientations for blalock-taussing shunt.To design the model of the main vessels with the modification in blalock-taussing shunt, to simulate fluid flows in the shunt and to measure its variables we used several programs that work on mechanical simulation like ANSYS.

ANSYS:
To design the model of the main vessels with the modification in blalock-taussing shunt, simulate fluid flows in it and measure its variables we used Ansys fluent 14.5 programs using the discrete phase model.
Ansys is an engineering simulation software (computer-aided engineering, or CAE), allows engineers to test systems by simulating fluid flows in a virtual environment.
We did our models with cases here and to get this done we had included the designs of the models, meshing them to start the simulation and finally get the results.

Designing the model:
The models was done by different CAD systems in our model of blalock-taussing shunt geometry. Pro/ENGINEER system was used to draw the models because of its properties in engineering drawing such as: accurate CFD results, flexible moving and deforming meshes. In our project we designed three models, the main different between them is the orientation of the shunt from the both side of inlet and out let .The main reason for using three models to study which of them give the best result of velocity and flow for HLHS patient .

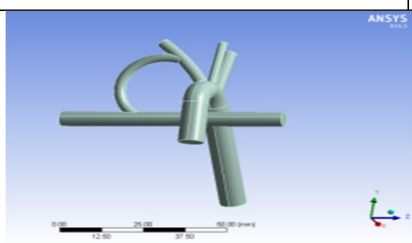
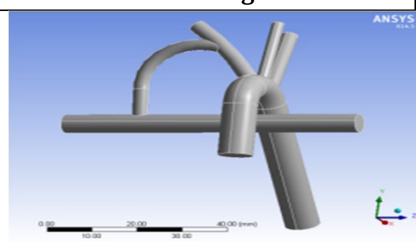
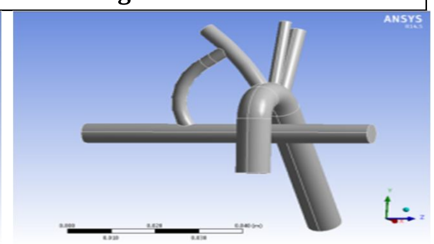
Curve inlet outletshunt	Curve inlet straight outlet	straight inlet curve outlet
		

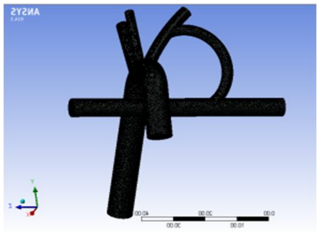
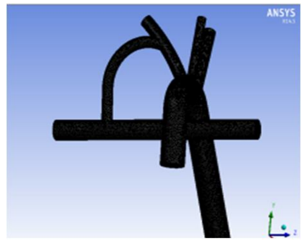
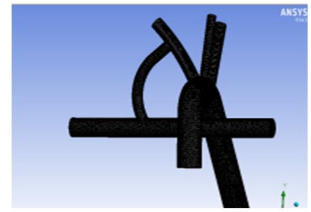
Table 1: The three models

Meshing:
We used fluent software to import the model from exported pro/ENGINEER files, this software use the scan data to define the surface of the domain and then create elements within this defined boundary.

CFD Simulation:
We used Computational Fluid Dynamics (CFD) analysis to enable quick, efficient simulation of fluid flow and calculate fluid forces

Post processing:

Which is how to explain and show the result we have from the fluent software which is done by Ansys plot.

Mesh of 1st model	Mesh of 2nd mode	Mesh of 3rd model
		

Tabel 2: Mesh of the three models

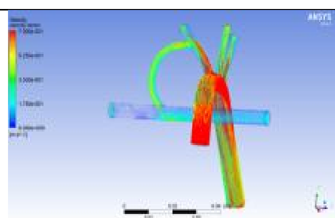
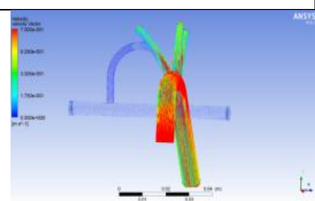
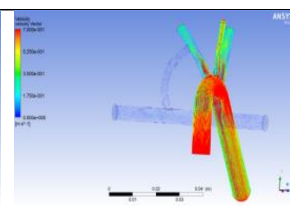
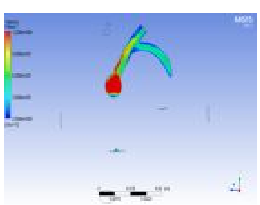
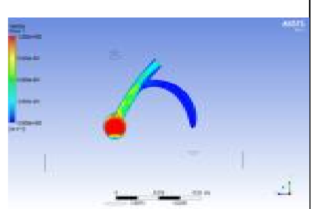
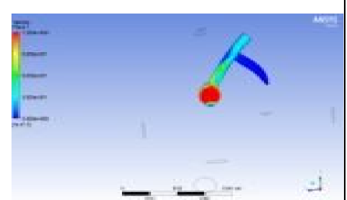
Steady part:

Boundary condition

- The boundary condition set as following:
- The flow is laminar and steady.
- The inlet velocity = 1.2 m/s.
- The outlet of descending aorta is 0.85 of outflow, and the outflow of aorta branches is 0.05.
- The pulmonary set to pressure-outlet = 0.
- Density of blood (1060kg/m3), and viscosity (.0035 kg/m3-s)

CFD Results

This section have a pictures of the result, Showen below; as velocity vector, and planes for the three models.

Model	1st model	2nd mode	3rd model.
Velocity vector			
YZ Velocity Plane			

Tabel 3: Velocity vector &plane of the three models

Results and discussions:

These models with these different orientations were not discus before, so that in our project we choose these models to study the amount of flow and velocity of it and for comparing with other models. By used ANSYS program the models were running and the most important point for us was flow and velocity in the shunt.The amount of flow is direct proportional to the velocity depend on equation (1) Q=Av.. (1)

Where:

Q: is indicate to the flow, A: is indicate to the Area V: is indicate to the velocity

1st Model:

This model have curve in curve out and that clearly can see in Tabel 3. It appears good velocity in the shunt. The advantage of this model that it is give a good amount of flow in the shunt,the disadvantage of the model is there a huge amounts of blood go to the left side .

2nd Model:

This model have a curve inlet and straight outlet as we can see in Tabel 3 , this model give us a slow movement of blood and thus reflected in the volume of flow in bad way , but we found that the quantity of blood in the both sides of pulmonary are almost equal.

3rd Model:

In this model the inlet of the shunt straight on subclavian artery branch and the outlet is curve as can see in Tabel 3 .For the condition that applied on this model we found that: At the beginning of the shunt the velocity very low and go to disappear at the end of the shunt.

The disadvantages of this model, that the flow is not enough and big amount of flow in right pulmonary unlike the left side of the pulmonary artery.

Unsteady part:

After the last dissection of steady part, now will compute the velocity and flow for the unsteady part, for the three Models.

For purpose of comparing between best and bad result of steady part, and to decide the best orientation of BTS.

Boundary condition

The boundary condition set as following:

- The flow is laminar and unsteady.
- The profile inlet velocity is for pediatric extract from the adult cycle. With maximum velocity = 3 m/s. [Figure 3]
- The pulmonary set to pressure-outlet = 0.
- Density of blood (1060kg/m3), and viscosity (.0035 kg/m3-s)
- Time step= .001, and the number of time step= 900.

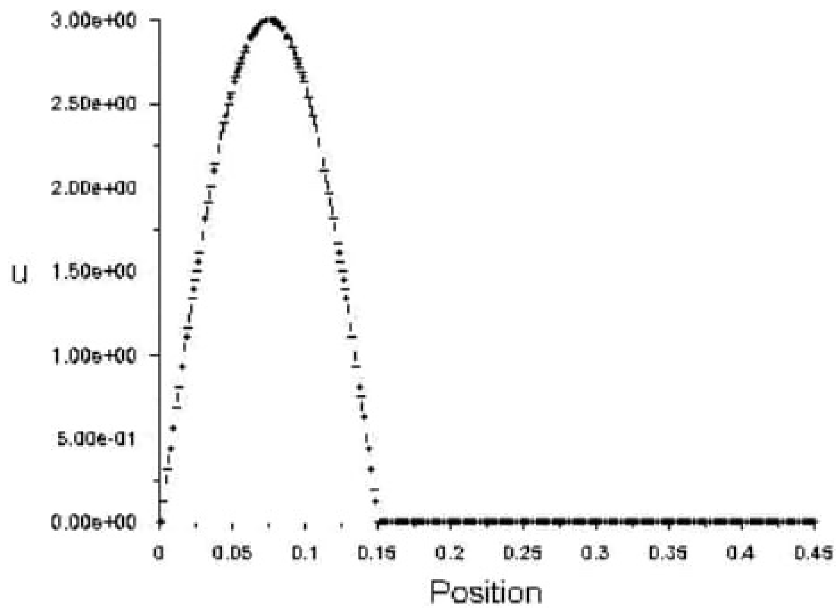


Fig.2: velocity inlet profile.

CFD Results:

This section have a pictures of the result, Showen below; as velocity vector, and planes for the three models.

Velocity vector of three models:

Velocity vector of the three models at differants time step:

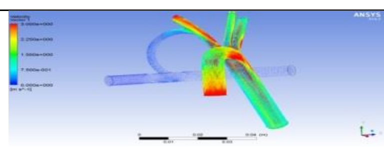
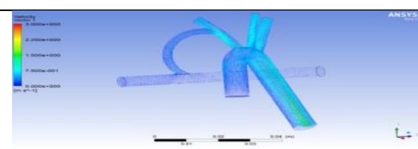
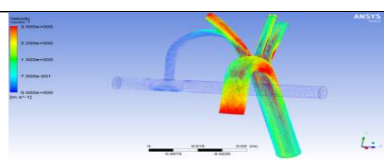
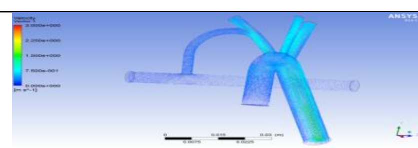
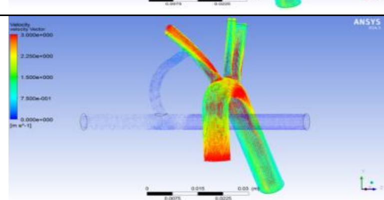
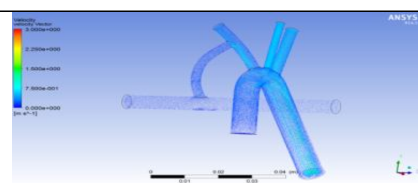
Model	velocity vector at 0.07 s	velocity vector at 0.15 s.
1st model		
2nd model		
3rd model		

Table 4: velocity vector at differants time step

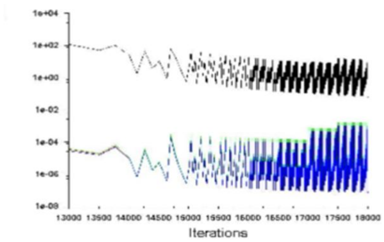
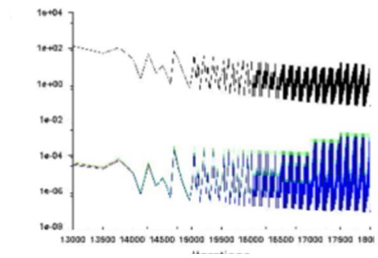
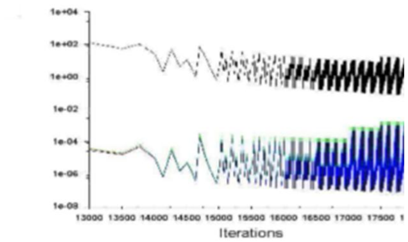
Curve model	Straight Out model	Straight In model
		

Table 5: Scaled residual of three models

Conclusion:

From our analysis from Ansys program for both steady and unsteady way, we can now decide that the 1st Model – with curve shunt in inlet and outlet –give us a good result in velocity and flow in shunt and pulmonary, then the Straight outlet, then the straight inlet shunt. Despite the disadvantages of most flow run to left side more than right side. So we can say it achieved our target, and it's the best orientation of the BTS until now.

References:

1. Marcdante, Karen, Robert M. Kliegman, Hal B. Jenson. Nelson's Essentials of Pediatrics. 6e.USA. 2010
2. P. Syamasundar Rao University of Texas at Houston Medical School, Houston, Texas, USA.
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