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Clinical observations and cardiovascular fluid mechanics in stents

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Abstract: Clinical data of 11 patients who had stent implanted were collected. The name of artery blocks, length of lesion, length of stent, diameter of stent and pressure, were recorded. The following observations were made and correlated the data with fluid dynamics of cardiac flow.

Introduction:

Stents are small expandable tubes put into arteries .It restores blood flow. There are two types of stents bare metal stents and drug eluting stents. Third generation stents are also developed which after giving drug become bare metal or gets absorbed by body or uses a coating inside artery. The Kalam Raju stent was the first indigenous stent to be developed in India. The introduction of indigenous stents led to a significant drop in prices of all stents in India.

The available clinical data[1] with indigenous stents cobalt chromium stents showed good results with low major adverse events and low thrombosis. The indigenous drug eluting stents with biodegradable polymer bio re absorbable scaffold are also emerging..

In the following table the clinical details of 11 patients are enlisted .The quantity of blood flow through the stent portion is calculated using Murrays law for mass conservative networks. Quantity of blood flow Q is proportional to R^3 where R is the radius.

The quantity of blood flow given in table below is in close agreement with that mentioned by Haran Zafoor etal[3] .They have assessed the blood flow rate and velocity in coronary artery stenosis using optical coherence tomography (FD-OCT).

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In the table below

DES - DRUG ELUTING STENT ,ATM =101325 Pascal is the stent inflation pressure used when a stent is deployed, K constant depending on the channel parameters ;RCA-right coronary artery LAD- Left anterior descending: LCX –left circumflex artery;

Vessel name of artery	stenosis	Length of lesion mm	Stent dimensions mm x mm	Quantity of blood flow through stent portion ml
Proximal LCX	90%	15	2.7x18 DES	K 2.460 12ATM
Mid LCX	90%	30	3x30DES	K 3.375 10ATM
. .Mid LCX	90%	12	2.5x14 DES	K 1.953 9ATM
Mid LCX	70%	10	3x28 DES	K 3.375 12ATM
Mid RCA	100%	20	3x30	K 3.375 12ATM
Mid RCA	100%	15	3x18 DES	K 3.375 12ATM
Mid LAD	80%	25	2.75x28	K 2.599 9ATM
Mid LAD	99%	10	2.75x15	K 2.599 9ATM
Mid LAD	70%	20	2.75x28	K 2.599 12ATM
Proxy LAD	80%	10	3X15	K 3.575 12ATM
Proxy LAD	99%	15	2.5x18	K 1.953 12ATM

Using LCX diameter 2.13± 0.44mm, LAD diameter 2.30±0.42mm,RCA diameter 2.96±0.60mm and using the formula Stenosis =(1-(diameter of most stenotic part/estimated original diameter))100 the quantity of blood flow before stent is calculated [2]

Name of artery	stenosis	Quantity of blood flow before inserting stent ml
LCX	60%	K 0.13579
LCX	70%	K 0.05728
LCX	90%	K 0.002097
LAD	70%	K 0.05278

In cardiac flow the tube is rigid, elastic, deformable slender and flow is steady laminar flow. When blood flows through a channel and if size changes there will be other factors for consideration. In Poiseuille flow, volume flow Q is proportional to R^4 . In Murrays flow, Q is proportional to radius R^3 but other fluid properties are constant. Hagen poiseulle law is based on the assumption channel size is same. Pressure per length $\partial P/L$ is same in both cases. If channel size is changing other factors will come into play but $\partial P/L$ will be same in both cases. So both laws are not contradictory.

Conclusions: An attempt to correlate limited clinical data with basics of cardiovascular fluid mechanics is done . There is scope for more work with an access to more clinical data.

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2.Wikipedia

3 .Measurement of the blood flow rate and velocity in corona artery stenosis using intracoronary frequency domain optical coherence tomography. Validation against fractional reserve IJC Heart &Vasculature Volume 5,Dec 2014,pages 68- 71