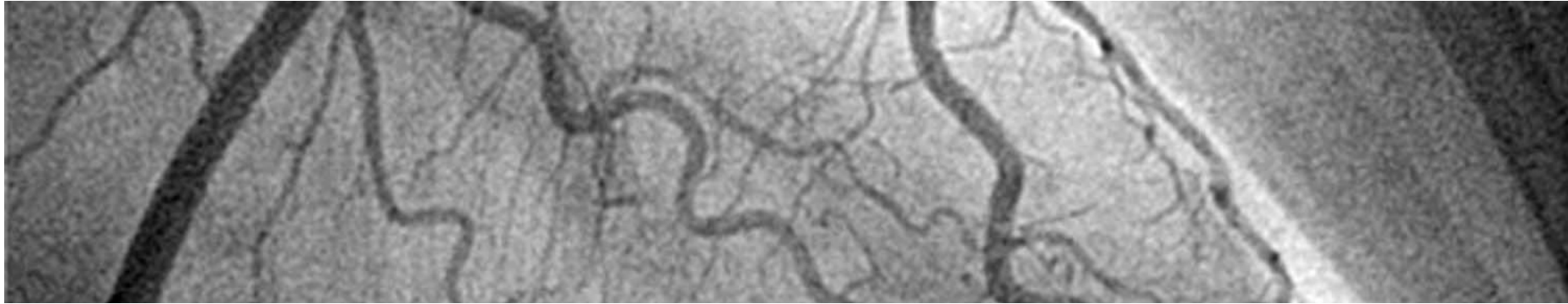


Percutaneous Coronary Intervention

An analysis into the conventional and robot assisted procedures

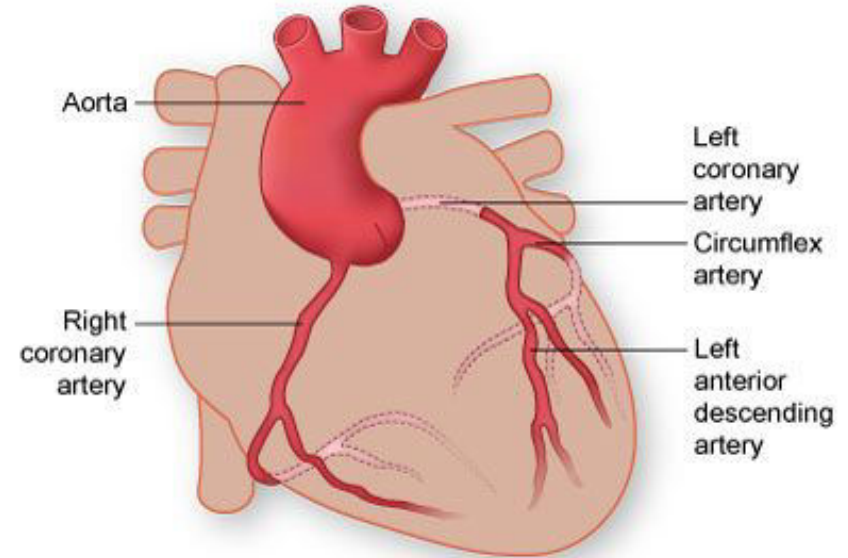


by: Dyava Rama Krishna Reddy

Percutaneous Coronary Intervention (PCI) or Angioplasty:

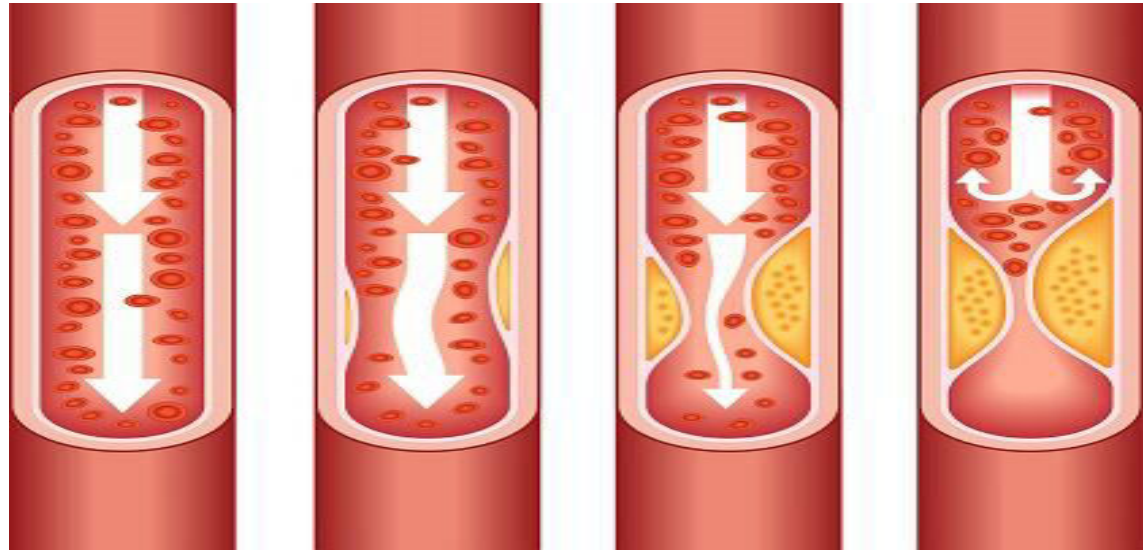
The PCI procedure comes under the study of Angiology. i.e. arteries, veins.

- ✓ Arterial diseases naturally deal with the Coronary Arteries.



Coronary Artery Disease (CAD)

- This happens when the arteries that supply blood to heart muscle become hardened and narrowed.
- This is due to the buildup of cholesterol and other material, called **plaque**.
- This buildup is called **atherosclerosis**.



How Is Coronary Heart Disease Diagnosed?

No single test can diagnose CHD. If your doctor thinks you have CHD, he or she may recommend one or more of the following tests.

- **EKG (Electrocardiogram)**



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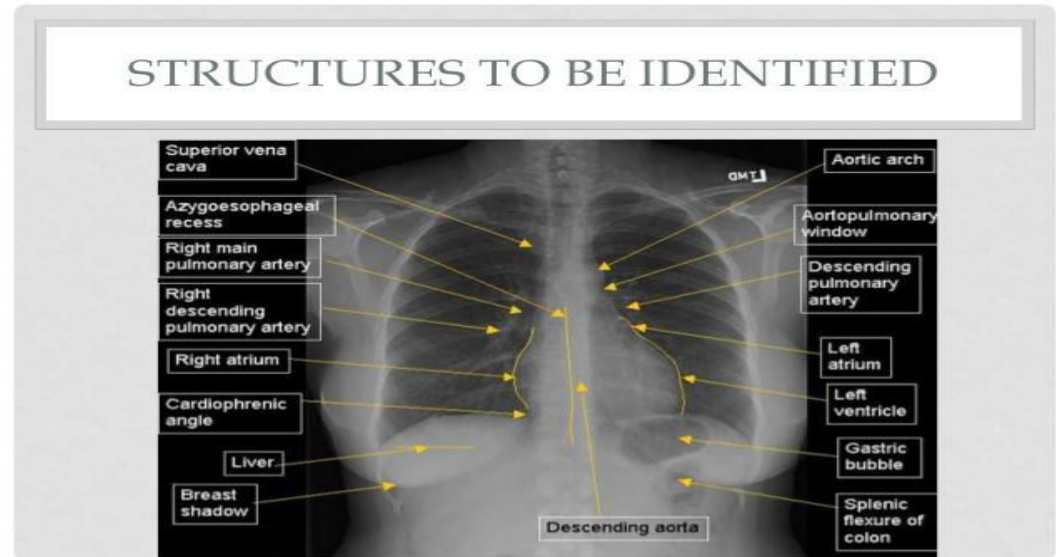
- **EKG (Electrocardiogram)**
- **Stress Testing**
- **Echocardiography**



How Is Coronary Heart Disease Diagnosed?

No single test can diagnose CHD. If your doctor thinks you have CHD, he or she may recommend one or more of the following tests.

- **EKG (Electrocardiogram)**
- **Stress Testing**
- **Echocardiography**
- **Coronarography (Heart X-ray)**



How Is Coronary Heart Disease Diagnosed?

No single test can diagnose CHD. If your doctor thinks you have CHD, he or she may recommend one or more of the following tests.

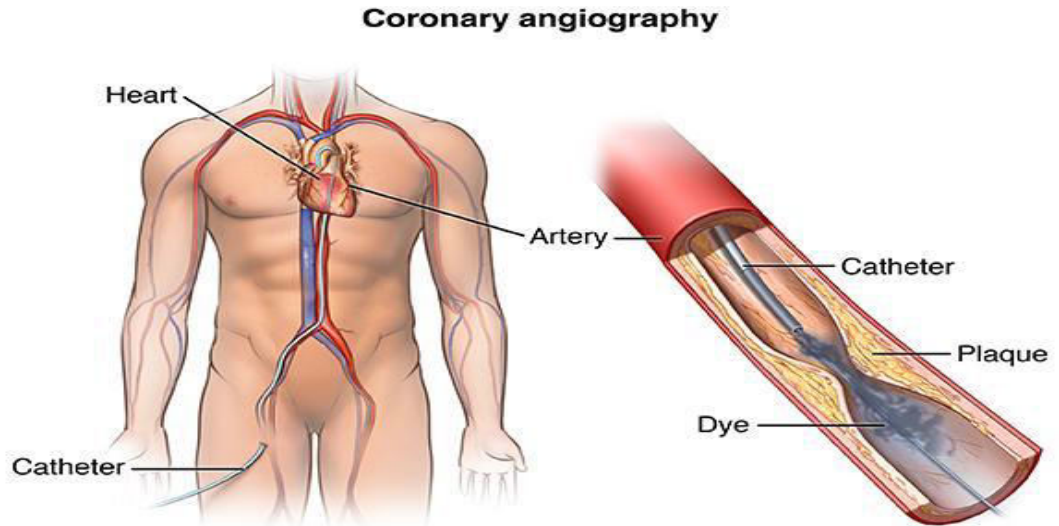
- **EKG (Electrocardiogram)**
- **Stress Testing**
- **Echocardiography**
- **Coronarography (Heart X-ray).**
- **Blood tests**



PCI takes place through:

For this procedure, a thin, flexible tube called a **catheter** is put into a blood vessel in:

- your arm (preferred method)
- groin (upper thigh)
- Sometimes through neck

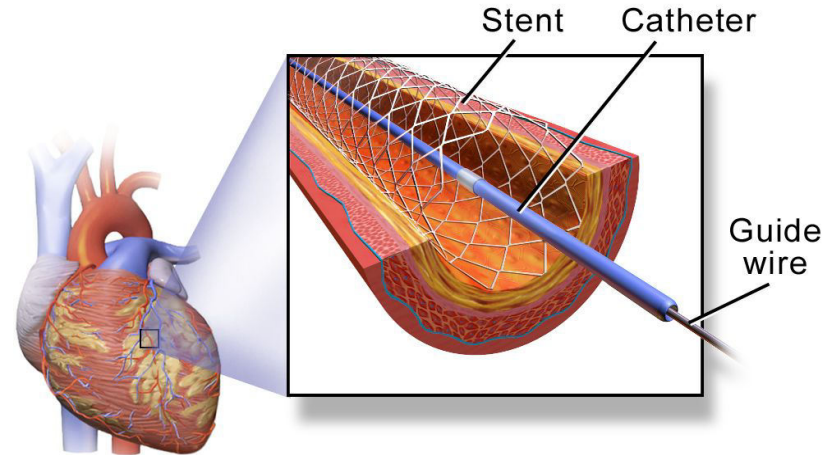


Conventional Procedure

Interventional planning

- PCI, introduced 40 years ago, has remained virtually unchanged
- Patient is informed of risks
- Sedative, aspirin and clopidogrel is given to the patient


Stent in Coronary Artery

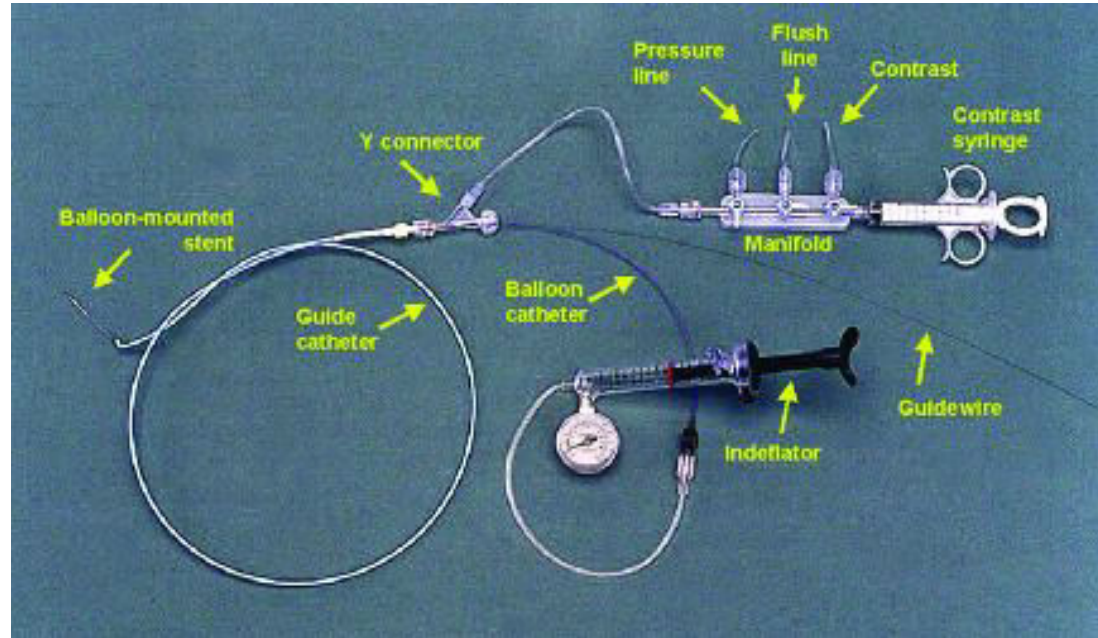


Conventional Procedure

Equipment used and who is involved

- cardiologist
- assistants
- nurses
- radiographers

 **all of whom have extensive and specialized training in these types of procedures**



Conventional Procedure

Intraoperative workflow



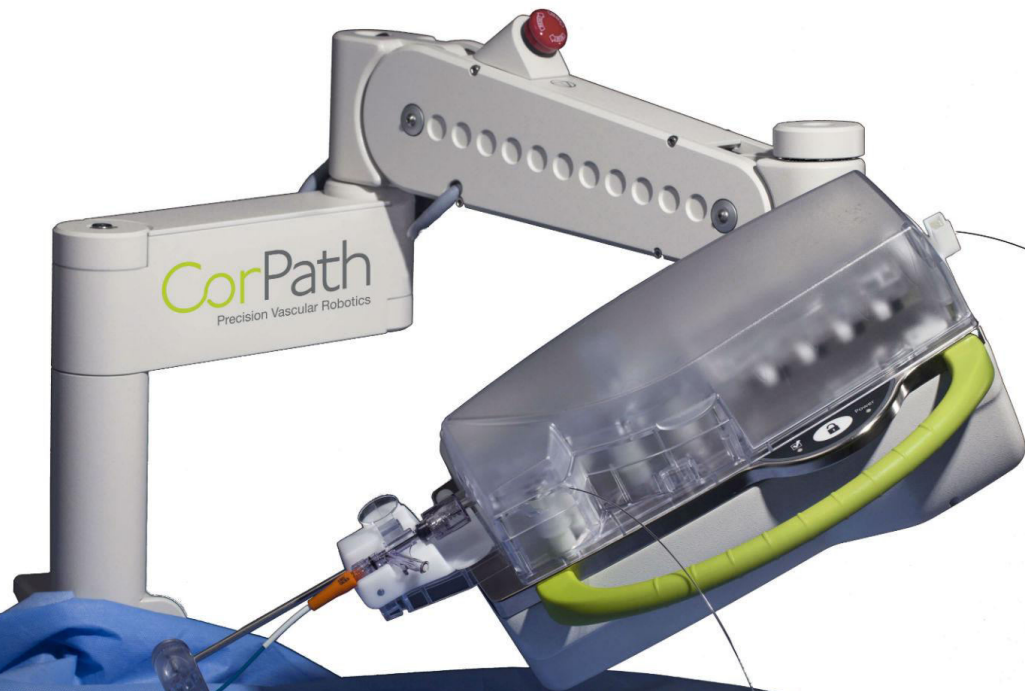
Surgery can vary from ~30 mins up to 3 hours





Corindus

Vascular Robotics



CorPath 200

- 1 mm precision linear control and 360 degrees rotational movement
- Sub-millimeter stent measurement
- 95% reduction in radiation exposure
- 24 minute average procedure time
- 3 patient learning curve
- Priced at < \$500,000

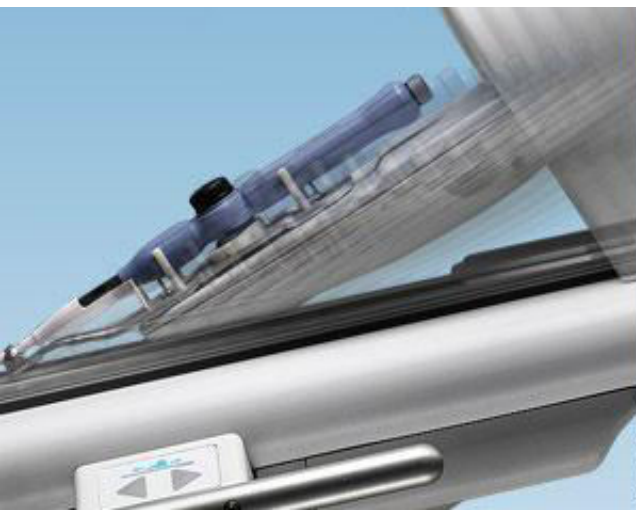

Corindus
Vascular Robotics





 Catheter
Robotics Inc.

 Catheter
Precision



Amigo Catheter Robotics

- Linear, rotational and an additional bendable tip (3 degrees of freedom)
- Imitates the conventional catheter tools
- No remote workstation or radiation protection



Magellan 2012



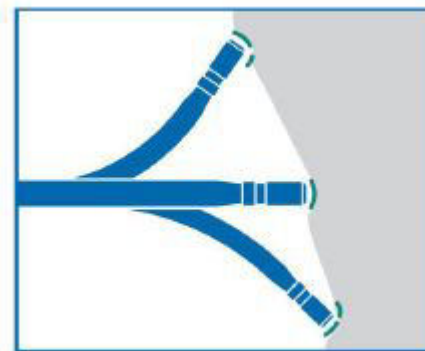
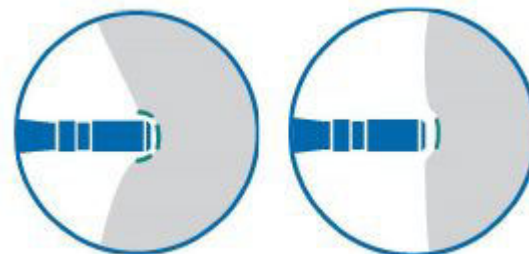
MagellanTM
Transport System

Sensei X 2014





1mm Tip Precision





Over 26 Studies





Over 26 Studies

Over 2.700 Patients





Over 26 Studies

Over 2.700 Patients

Over 14.000 Procedures



Comparison conventional vs robotics



- Need for an experienced surgeon
- Can be long in complex intervention
- Already non-intrusive surgery
- Can be less stressful for the patient



- Can reduce the time needed for operation
- Allows for more precise surgery
- Less exposure to x-rays
- Expensive investment \$\$\$

Improvements



- Develop **allergies free** dye
- Better **protect** personnel from **x-ray**
- Improve **ergonomie** for the surgeon



- Better **integration** of the whole operation in the **robotic system**
- **Self loading** wires and stents
- Increase **tactile sense** of guidewire tips
- More **versatile robot** for other **heart operation**

Sources:

Kaplan, A. Three-Year Experience with the Robotic Catheter System. EP Lab Digest. May 2013

Kaiser, CP. Texas Health Arlington Memorial Hospital Becoming a Center of Excellence. Cardiovascular Business, May 2011.

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<https://www.nhlbi.nih.gov/health/health-topics/topics/angioplasty>

<http://www.hansenmedical.com/us/en>

Sources:

<http://www.hansenmedical.com/us/en/cardiac-arrhythmia/sensei-robotic-system/clinical-value>

<http://www.hansenmedical.com/us/en/vascular/magellan-robotic-system/magellan-transport-system>

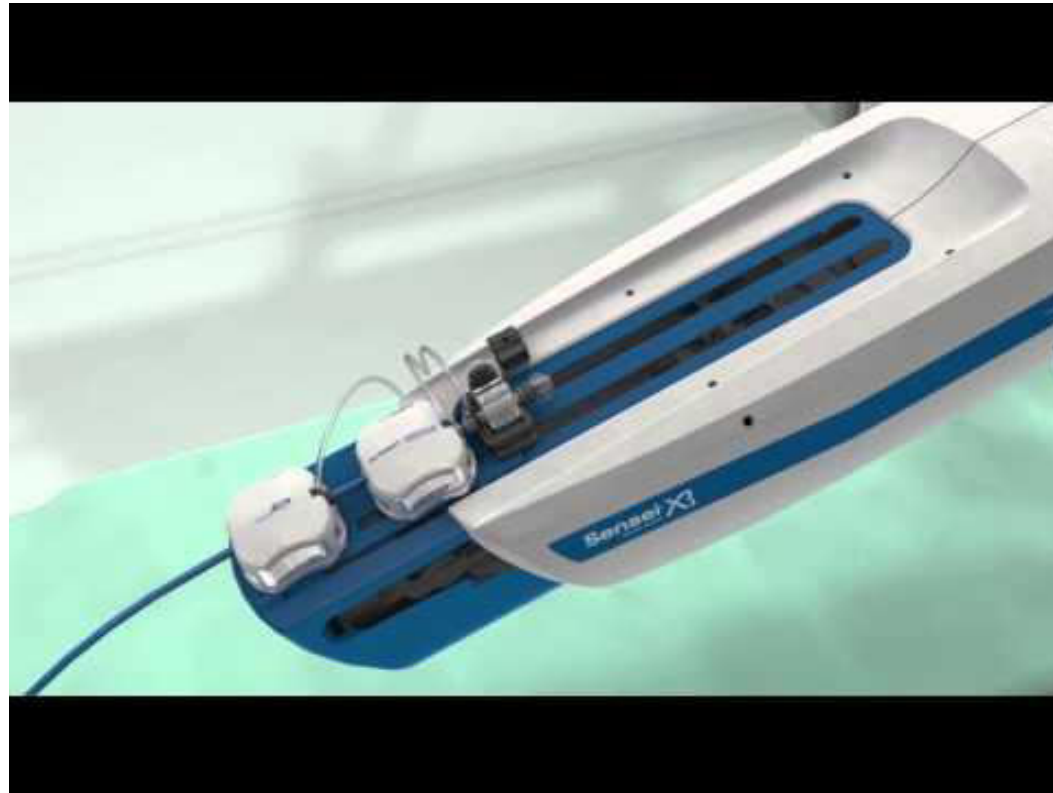
<http://www.corindus.com/about-corphath/what-is-robotic-assisted-pci>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC514052/>

<http://med.fsu.edu/>

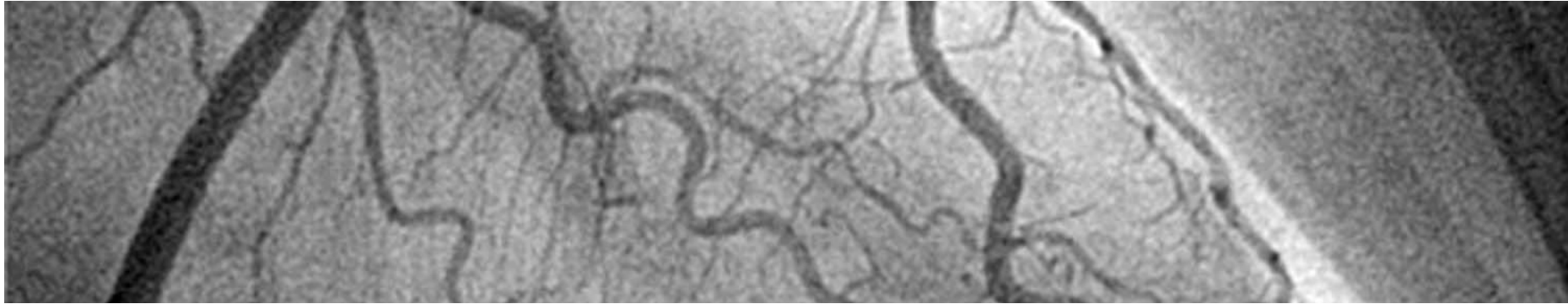
<http://www.hansenmedical.com/us/en/cardiac-arrhythmia/sensei-robotic-system/product-overview>





Percutaneous Coronary Intervention

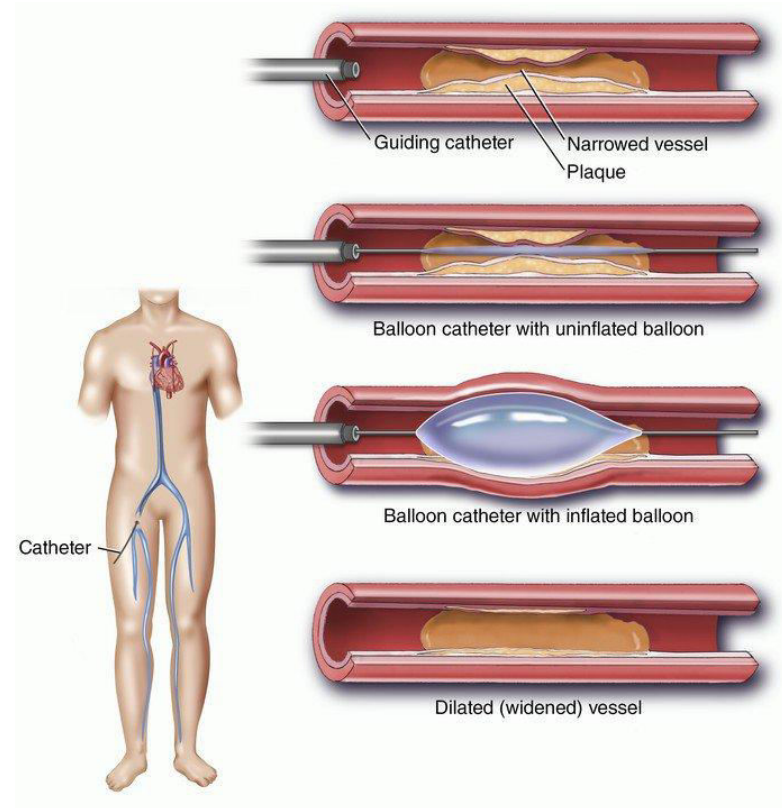
Robotic assistance challenges and possible improvements



by: , Dyava Rama krishna Reddy

PCI - Summary

- Pre-planning and localization of the stenosis
- Procedure
 - Catheter insertion
 - Navigation to stenosis
 - Dilation of vessel
 - Placement of stent



Limitations and challenges of robot assisted PCI

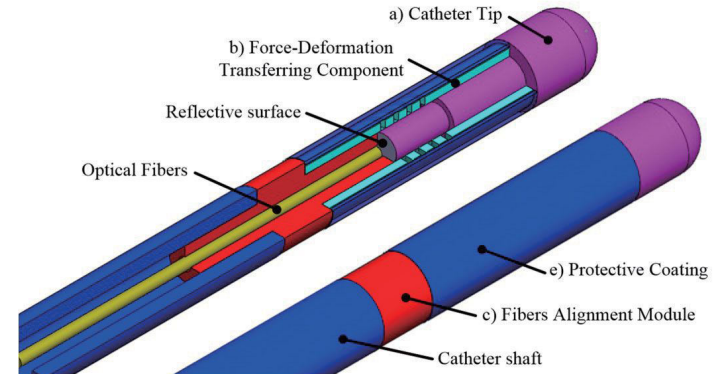
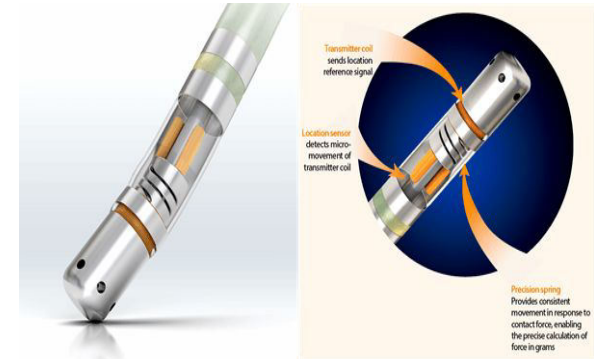
- Limited adoption of robot assisted equipment
 - Low cost efficiency compared to traditional methods
 - Costs
 - Training time
 - Procedure time
 - Accessing and navigating to the stenosis
 - Number of staff

Catheter collision avoidance of artery walls

Improvements for artery collision:

1. Through Haptic feedback

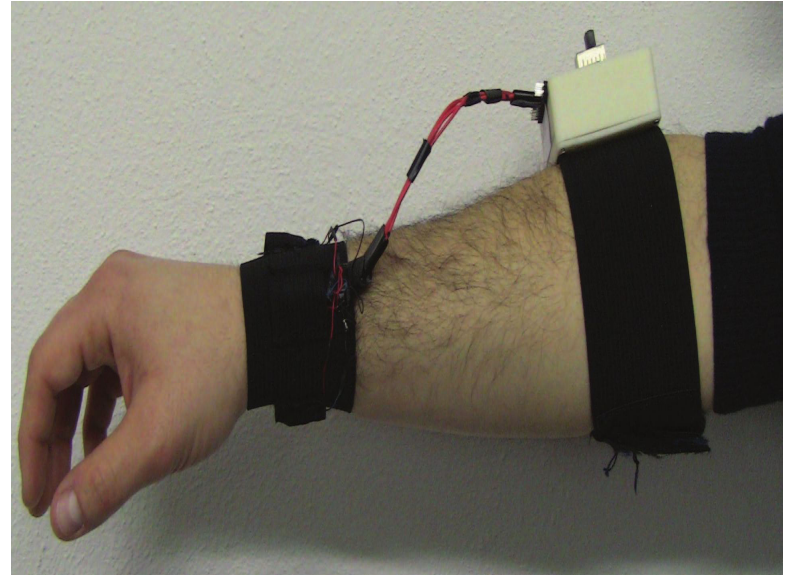
- Uses the force/torque sensors on catheter tip which gives collision feedback
- Optical fiber sensors



Catheter collision avoidance of artery walls

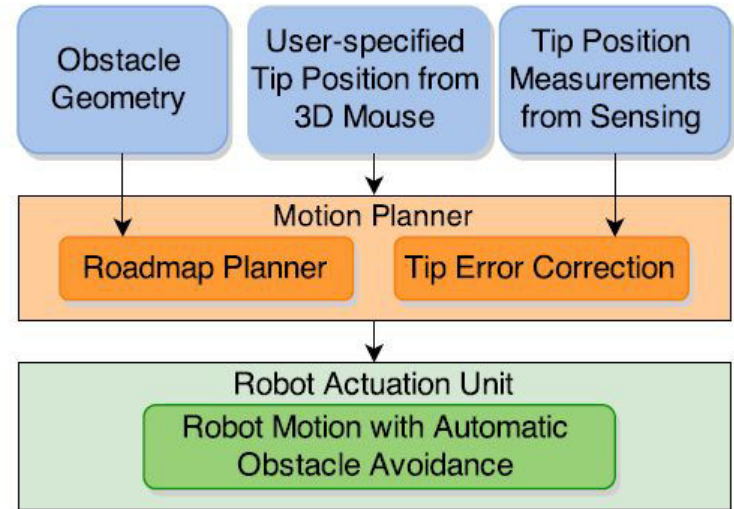
Vibrotactile wristband:

- When the collision crosses the threshold value, a signal is sent to the doctor's arm to warn him about the collision



Catheter collision avoidance of artery walls

2. Automatic collision detection algorithm
 - Using Concentric tube robot



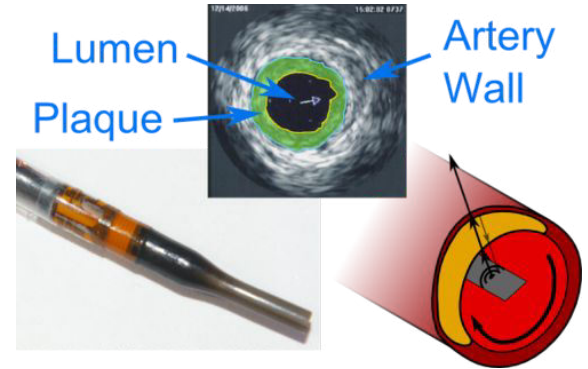
Intravascular ultrasound (IVUS)

Equipment

- Modified catheter with ultrasound head
- IVUS echocardiographic imaging system

How it work's

- The ultrasound head rotate 360
- The data is transformed in an image
- Algorithm helps to localise the stenosis and reconstruct the vessel



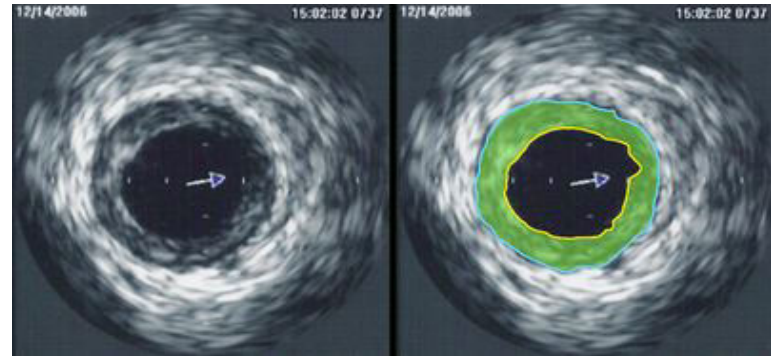
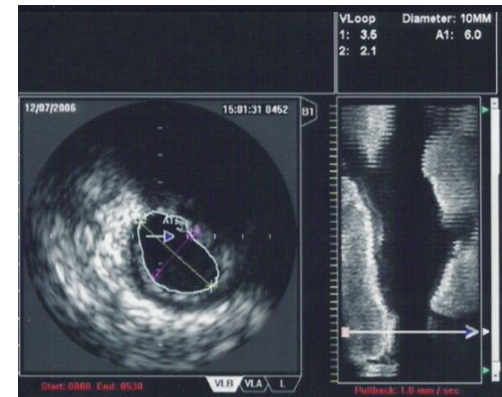
Intravascular ultrasound (IVUS)

Advantage

- See through blood
- Visualise tissue and plaque
- Gives more insight

Challenge

- Reproducing an accurate image
- Computer intensive
- Expensive \$\$\$



Artery width measurement

Equipment

- Intravascular ultrasound
- X-Ray (CT imaging)

How it work's

- Uses the x-ray to create the 3D representation of the heart
- Fuses it with the ultrasound of the artery
- Gives a 3D representation of the artery system



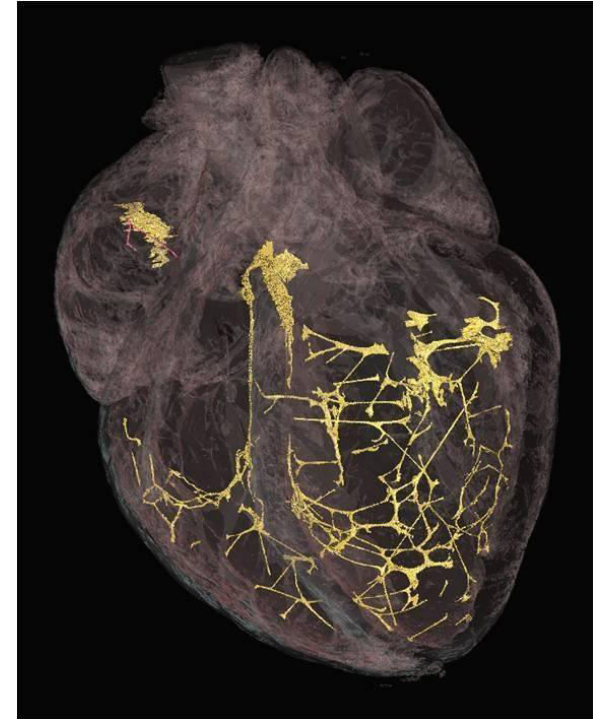
Artery width measurement

Advantage

- Could give better visualisation of the situation
- Faster way to find the stenosis

Challenge

- Requires a lot of data and complex algorithm
- Would need dedicated hardware
- Expensive \$\$\$



Complete Procedure Automation

Combine suggested improvements:

- Collision detection
- Ultrasound catheter
- Artery width measurement



Search and treatment of affected artery becomes mostly automated

- More efficient
- Reduced cost in long term
- Real time assessment of surgery
- Safety



Papers review:

1. A miniature force sensor for catheter based on optical micro deformation detection.
2. A motion planning approach to Automatic Obstacle Avoidance during Concentric Tube Robot Teleoperation

Source

- <https://www.ncbi.nlm.nih.gov/pubmed/24964905>
- <https://usa.healthcare.siemens.com/ultrasound/cardiovascular/acunav-ultrasound-catheter/features>
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- <http://www.sciencedirect.com/science/article/pii/S0735109798002496>



Conclusion

- Bigger picture: First step in an automated hospital
- Automation can potentially save money and reduce staff
- PCI is already a MIS (minimally invasive surgery) so improvements are mostly in automation and costs