New Technologies for Coronary Heart Disease

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Disclosures

Inventor/Founder: 3DT Holdings, IVG, IDS, SARP, Revma, GRest, Cardiopathways, GI Bionics
Diagnostics/Therapy Delivery
("smart" needles, guidewires, catheters, balloons)

Coronary Heart Disease

Myocardial Salvage/Support
(Reduce reperfusion injury/cardiac support)

Revascularization through Venous System (Novel device for “No-option” patients)
Conductance

Diagnostic Integration

Diagnosis of **structure** and **function**
using **existing therapeutic tools**
for **improved cath. lab. work flow and patient outcomes**

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- **Structure** – Size, composition, location
- **Function** – Fractional Flow Reserve (FFR)/Coronary Flow Reserve (CFR)
- **Existing Tools** – Guide wires, catheters, balloons, stents
- **Improved Cath. Lab. Work Flow** – Reduced steps; co-registration
- **Improved Patient Outcomes** – Improved therapy
- **Healthcare Costs** – Cost effective
Integration of Sizing and FFR

**Sizing**
Goldilocks of Sizing: Not too large and not too small – just the right size!

Craig Walker, MD

**Fractional Flow Reserve (FFR)**
FAME Trials (I and II)
Efficiency through Integration

- Fractional Flow Reserve (FFR Wire - $600)
- Cross Sectional Area (CSA) and Diameter (IVUS Catheter - $650)
- Therapy Delivery (Workhorse Wire - $100)

Integrated FFR + Sizing Guide Wire
- Multi-function tool
- Reduced procedure steps for physicians
- Reduced costs for hospitals
- Improved outcomes for patients

Aggregate price: $1,350
Preliminary pricing: $500
Pilot Clinical Study for Peripheral Lumen Recon. (LR) Sizing Wire – Dr. Pradeep Nair

- Repeatability (2 Repeat Measures at Same Point in Vessel)
- Comparative Study

![Graph showing LR Measure 1 vs LR Measure 2 with error bars and a scatter plot.]

![Bar graph showing the difference vs. LR for DUS, Angio, QA, IVUS, and IVUS Core.]

\[ \text{Difference vs. LR (\%)} \]

- DUS
- Angio
- QA
- IVUS
- IVUS Core
Summary: Diagnostics/Therapy Delivery ("smart" catheters, guidewires, balloons,...)

- **Multi-functionality**: FFR + Sizing on workhorse guidewire
- **Time Efficiency**: Real-time, no subjective interpretation of images or training required
- **Cost efficiency**: No costly capital equipment, less expensive than either IVUS or FFR (substantially less expensive than combined IVUS+FFR)
- **Improved Outcome**: Integration of structure and function (Sizing + FFR) and image co-registration (precision, evidence-based medicine)
Acute Selective Auto-Retro-Perfusion: SARP

Support catheter to augment supply in the supply/demand equation (contrast to current demand reduction technologies): **Attenuation of Reperfusion Injury.**
SARP: Use of Venous System as an Alternative to Diseased, Flow Constrained Arterial System for Delivery of Oxygenated/Arterial Blood to Heart Prior to Reperfusion

- Aorta
- Quick Connector (A-V)
- Pressure Regulation
- Inferior Vena Cava
- Balloon Retroperfusion Cannula
- Femoral Artery
- Femoral Vein
- Quick Connector (A-V) – Pressure Regulation
Reperfusion Injury – Swine Studies

A) **ST-segment deviation.** ST-segment changes in response to LAD occlusion followed by SARP and MH-SARP and reperfusion.
B) **Arrhythmic events.** Number of arrhythmic events in the control, normothermia, and hypothermia groups during reperfusion.

**Cardiac troponin levels.** Cardiac troponin (cTnI) levels over time in the control, normothermia, and hypothermia groups.

*Significance between control and normothermia groups.
†Significance between control and hypothermia groups.
A) Infarct size. Infarcted area (relative to the area at risk) in the control, normothermia, and hypothermia groups. B) Myocardial double staining. Myocardial sections from control (left), normothermia (center), and hypothermia (right) groups double-stained with Evans blue and TTC demarcating area of infarction.

Caspase-3 immunostaining. Representative histological samples stained for the reperfusion injury marker caspase-3 (red) in healthy viable myocardium (A) and control (B), normothermia (C) and hypothermia (D) groups.
Summary: Myocardial Salvage/Support
(Reduce reperfusion injury/cardiac support,…)

- **Perfusion Bridge**: Augments blood supply in the supply/demand balance of heart (contrast to all current demand reduction technologies)

- **Backdoor Access**: Selective Auto-Retroperfusion (SARP) delivers oxygen/nutrients without interfering with PCI and without external machines

- **Cost efficiency**: No costly capital equipment, less expensive than LVADs, Impella, IABP, etc.

- **Improved Outcome**: SARP preconditions myocardium for 95%+ reduction in myocardial infarct of swine which would be transformative if it translates to patients…
Revascularize myocardium through selective venous system for no-option patients that will otherwise progress to heart failure: Pre-arterialization of the venous system to revascularize the heart.
Scientific Basis

- Although arteries develop atherosclerosis, veins do not.
- There is redundancy in the venous system with multiple outlets and interconnections.
- Veins rupture when suddenly exposed to arterial pressure (> 60 mmHg).
- Veins functionally arterialize when the increase in pressure (< 50 mmHg) is gradual (in 2 weeks in swine).
VPP design and CVBG. Frame design with open ring configuration (A) that prevents obstruction of side branches (B) to enable focal occlusion (elevation of venous pressure) in preparation for CVBG (C).
VPP-Induced Pressure Increase in Veins

Assessment of changes in pressure waveforms before and after occlusion of coronary LAD vein showing a large increase in pulsatility (A) and mean pressure (B). Results from open-chest in vivo studies were used for performance evaluation of the VPP device in bench studies with a pulse duplicator which showed similar changes in pulse width (C) and maximum pressure (D).
Pre-arterialization of coronary veins for CVBG. Cross-section of LAD epicardium (A) from control (top) and experimental swine (bottom) following occlusion for two weeks. Compared to the thin walled and collapsed control vein, the arterialized vein is thick walled and open similar to adjacent native coronary artery. Pre-arterialization support CVBG patency and retrograde myocardial perfusion as supported by angiograms at 4 weeks post-graft in swine with total occlusion of the LAD (B). These findings correspond with restoration of ejection fraction following CVGB (C).
Summary: Revascularization through Venous System (Novel device for “No-option” patients)

- **Revascularization of heart**: Functional arterialization of venous system (contrast to saphenous vein grafts).

- **Embryological Mechanism**: Increase in local mechanical stimuli cause veins to transform to functional arteries and in the process collateralize to existing arteries to bypass occlusive arterial disease; i.e., creates a new arterial network of vascularization.

- **Cost efficiency**: Miniscule cost of device relative to staggering costs of treatment of heart failure per patient.

- **Improved Outcome**: Option for no-option patients that will reduce or eliminate progression to heart failure.
Peripheral Applications

• Sizing Technology
  • 035 Sizing Workhorse Guidewire
  • Peripheral FFR (Sizing+FFR)
  • Arterial Navigation (X-ray exposure reduction)
  • Sizing DCB
  • Balloon Sizing/Radial Force (venous stenting)

• Retroperfusion
  • Reperfusion Injury (renal, vertebral, mesenteric, etc.)
  • Limb Salvage
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