# Future Applications of Hybrid Interventions

Oliver Reuthebuch
Clinic for Cardiac Surgery
University Hospital Basel
Switzerland

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## *What is a Hybrid Intervention?*

- Combination of traditionally available techniques in the *catheterization laboratory* as well as in the *operating theatre*
- Providing best available therapies for patient
- Minimizing procedural risk
- Staged by minutes, hours or days (weeks?)
- Triggered by advances in cardiac surgery (minimally invasive) and interventional cardiology (percutaneous interventions)

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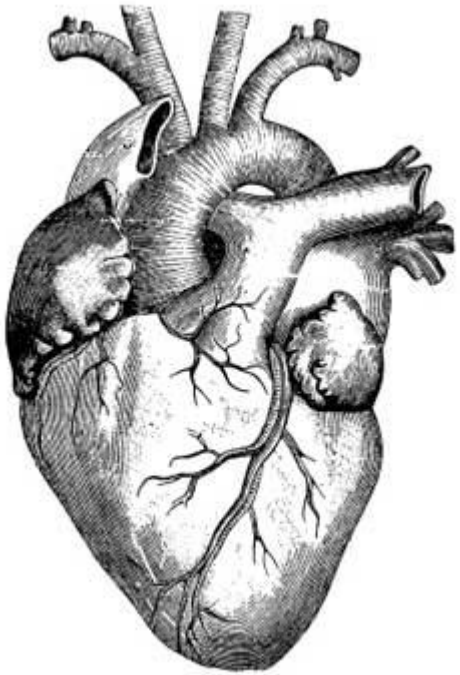
# *Common Targets of Hybrid Intervention?*

Cardiac electrophysiology



Valve disease

Coronary artery disease

Congenital heart disease

Aortic disease

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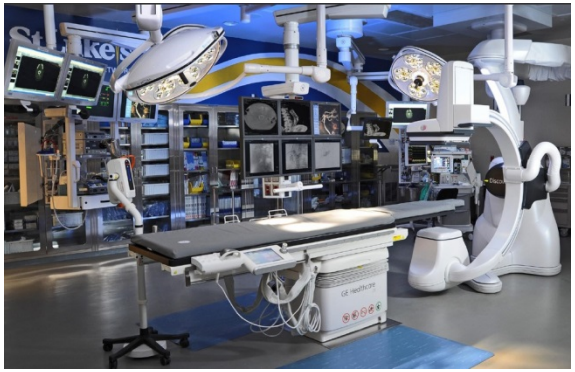
# *Prerequisites for Future Hybrid Interventions*

- ➢ Set-up of Hybrid operating room
- ➢ Who owns the Hybrid OR?
- ➢ Staffing:

- Dedicated multidisciplinary team model
  - Recruited from current OR or Cath-Lab staff
  - Reduces redundancy
  - Can be difficult to maintain over time
  - Leads to the development of unique hybrid skills

- Flex-team (pooled) model
  - More common today
  - Cross-training of current OR and Cath-Lab staff
  - Requires close scheduling coordination
  - May be less efficient



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# *Prerequisites for Future Hybrid Interventions*

- Adaption of cardiac surgeons to minimally invasive procedures
- Acceptance for surgical procedures through cardiologists/patients

  *"There is low interest on the part of the cardiologists for hybrid procedures. They would rather do it all themselves than ask a surgeon just to put a LIMA to the LAD."*

Friedrich Mohr

- Reimbursement issue
- Adequate staging: antiplatelet risk and bleeding risk

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# Present Hybrid Interventions

**TABLE 1**
**List of Procedures Performed in Hybrid Operating Room**

| |
|---|
| Endovascular abdominal aneurysm repair |
| Endovascular thoracic aneurysm repair |
| Hybrid arch reconstruction |
| Transfemoral aortic valve replacement |
| Trans-subclavian aortic valve replacement |
| Transapical aortic valve replacement |
| Endovascular mitral valve repair |
| Transpulmonary valve replacement |
| Transapical neochord replacement for mitral valve repair |
| Hybrid Maze procedure |
| Atrial septal defect with septal occluder |
| Ventricular septal defect with septal occluder |
| Endovascular repair of coarctation of the thoracic aorta |
| Hybrid coronary revascularization with coronary angiogram |
| Atrial fibrillation/Flutter ablation |
| Carotid artery stenting/carotid endarterectomy |
| Peripheral vascular stenting |
| CABG procedures |
| Minimal invasive aortic valve /mitral valve procedures |
| Hybrid therapies for congenital heart diseases |
| Pacemaker / AICD implantation |
| Neurovascular interventions |
| Interventional bronchoscopy |
| Endoleak coiling |

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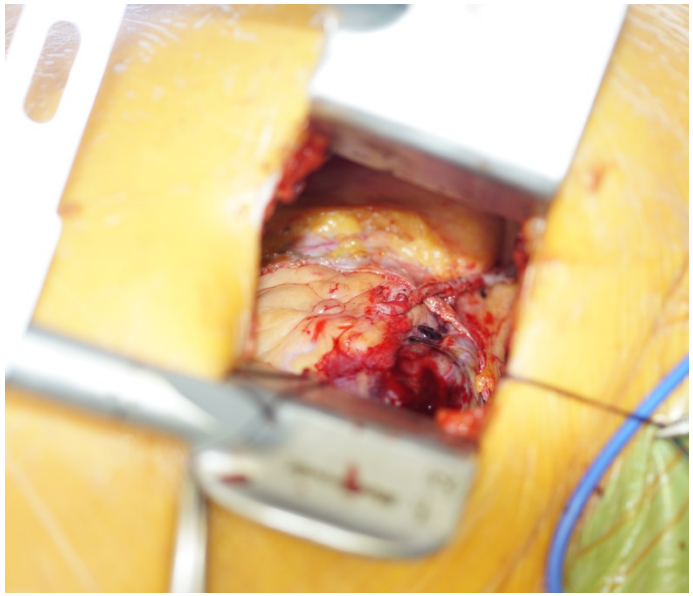
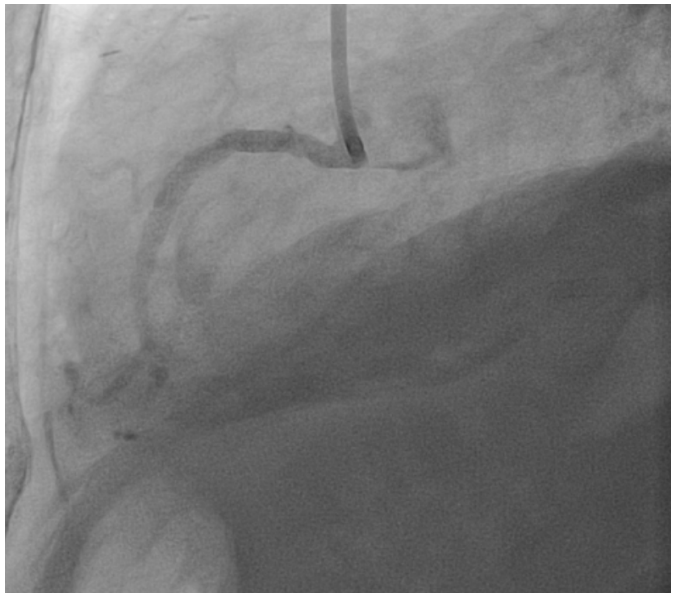
Kpoduno J. Hybrid Cardiovascular Suite: The Operating room of the Future. J Card Surg 2010;25:704-9

# *Present Hybrid Interventions*

Coronary Revascularization (1): **Patient F.S., * 1931**



MIDCAB: LIMA-LAD



PCI/Stent RCA

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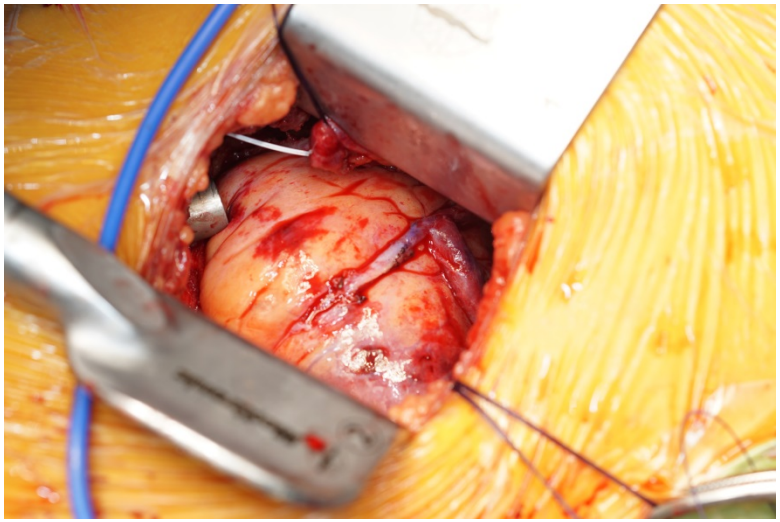
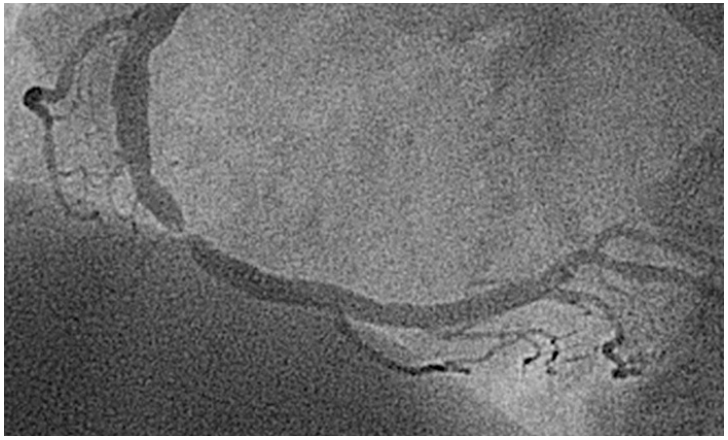
# *Present Hybrid Interventions*

Coronary Revascularization (2): **Patient A.N., * 1962**



MIDCAB: LIMA-Y-LAD-D



PCI/Stent RCA

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# Present/Future Hybrid Interventions

Coronary Revascularization (3): Multi-Vessel


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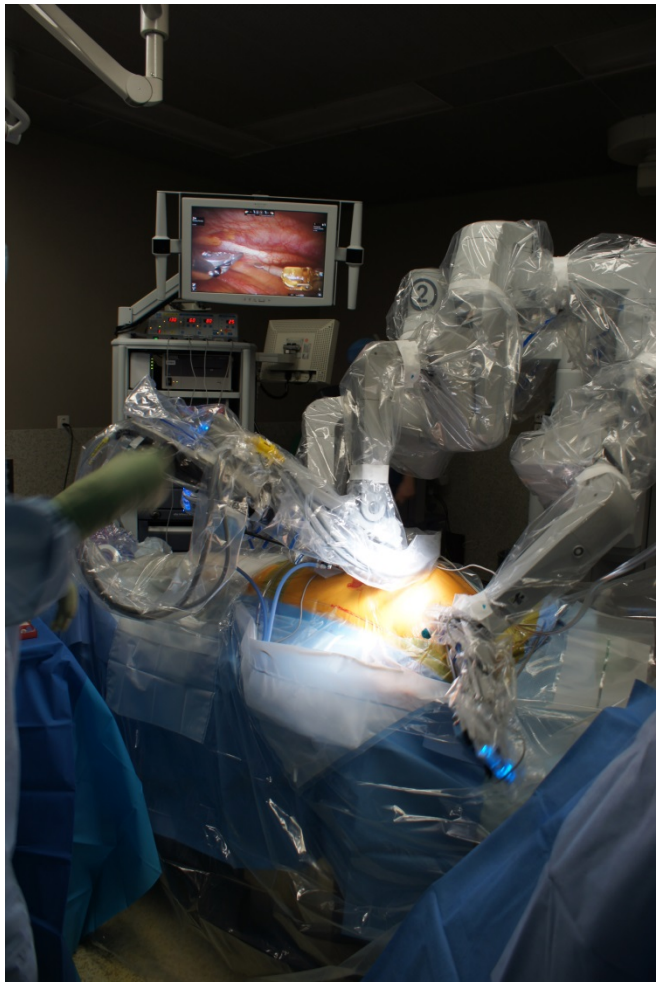
# Present/Future Hybrid Interventions

**TECAB**



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# Present/Future Hybrid Interventions

## Results

**Table 1. Results of Hybrid Coronary Revascularization**

| Author (Ref. #) | Year | Patients (n) | Mortality (30-Day) | In-Hospital Morbidity (%) | LIMA Patency (Immediate) (%) | PTCA/Stent Restenosis (6 Months) (%) | Mean Follow-Up (Months) | Event-Free Survival (%) |
|---|---|---|---|---|---|---|---|---|
| MIDCAB + PTCA | | | | | | | | |
| Lloyd et al. (20) | 1999 | 18 | 0 | 11 | 100 | 6 (TLR)* | 18 | 89 |
| Isomura et al. (21) | 2000 | 37 | 0 | NA | 100 | NA | 0–24 | 92 |
| de Cannière et al. (22) | 2001 | 20 | 0 | 15 | 100 | 5 | 24 | 95 |
| Presbitero et al. (23) | 2001 | 42 | 2 | 12 | 92 | 14 (TLR)† | 18 | 83 |
| Cisowski et al. (24) | 2002 | 50 | 0 | 4 | 100 | 10 | 12 | 87 |
| Stahl et al. (25) | 2002 | 54 | 0 | 0 | 100 | NA | 12 | 87 |
| MIDCAB + PTCA + PCI | | | | | | | | |
| Angelini et al. (1) | 1996 | 6 | 0 | NA | NA | NA | NA | NA |
| Lewis et al. (26) | 1999 | 14 | 0 | 21 | 100 | 0 | 1–44 | 93 |
| Wittwer et al. (27) | 2000 | 35 | 0 | 0 | 100 | 7 | 11 | 87 |
| Riess et al. (28) | 2002 | 57 | 0 | 7 | 98 | 24 | 24 | NA |
| MIDCAB + PCI | | | | | | | | |
| Zenati et al. (29) | 1999 | 31 | 0 | 6 | 100 | 10 | 11 | 90 |
| Us et al. (30) | 2006 | 17 | 0 | 0 | 100 | 18 | 21 | 87 |
| Gilard et al. (31)‡ | 2007 | 70 | 1.4 | 4.2 | NA | 2.3 | 33 | 97 |
| Kon et al. (32)‡ | 2007 | 15 | 0 | 0 | 100 | 3 | 12 | 93 |
| TECAB | | | | | | | | |
| Lee et al. (33) | 2004 | 6 | 0 | 0 | NA | 16 | 12 | NA |
| Davidavicius et al. (34) | 2005 | 20 | 0 | 0 | 100 | 0 | 19 | 100 |
| Kiaii et al. (35) | 2005 | 1 | 0 | 0 | 100 | 0 | 6 | 100 |
| Katz et al. (36)§ | 2006 | 27 | 0 | 3.7 | 96 (3 months) | 30 (BMS), 23.5 (DES) | 3 | 70 |
| Vassiliades et al. (37)‡ | 2006 | 47 | 0 | 0 | 99 | 6.6 | 7 | 90 |
| Bonatti et al. (38) | 2007 | 5 | 0 | 0 | 100 | 0 | 6 | 100 |

*Calculated on a per-patient basis. †TLR including revision or stenting of LIMA graft. ‡All DES used for PCI. §DES (63% of patients).
BMS = bare-metal stent; DES = drug-eluting stent; LIMA = left internal mammary artery; MIDCAB = minimally invasive direct coronary artery bypass grafting; NA = not applicable; PCI = percutaneous coronary intervention; PTCA = percutaneous transluminal coronary angioplasty; TECAB = totally endoscopic coronary artery bypass; TLR = target lesion revascularization.

Byrne JG. Hybrid Cardiovascular Procedures. JACC Intv 2008;1:459-68

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# Present/Future Hybrid Interventions

## Aortic Valve/PCI

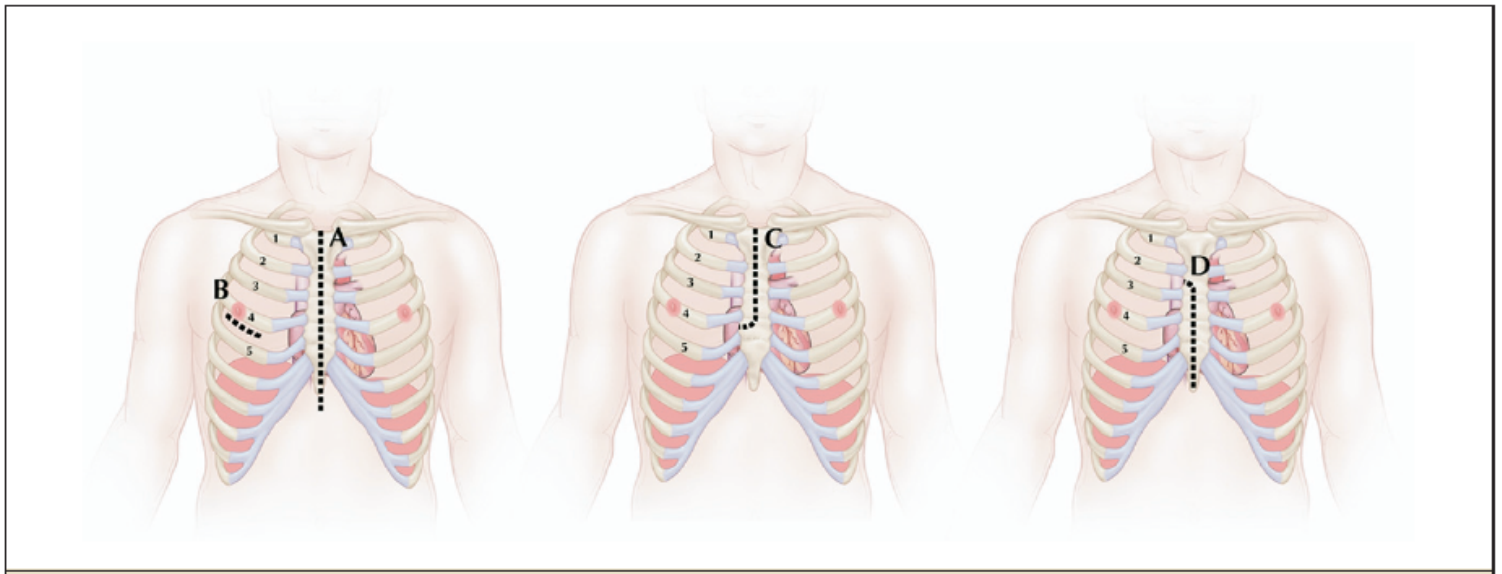


**Figure 4. Incisions for Valve Surgery**

**(A)** Median sternotomy (aortic, mitral, or tricuspid valve). **(B)** Right thoracotomy (mitral or tricuspid valve). **(C)** Upper hemi-sternotomy (aortic valve). **(D)** Lower hemi-sternotomy (mitral or tricuspid valve). Figure illustration by Rob Flewell.

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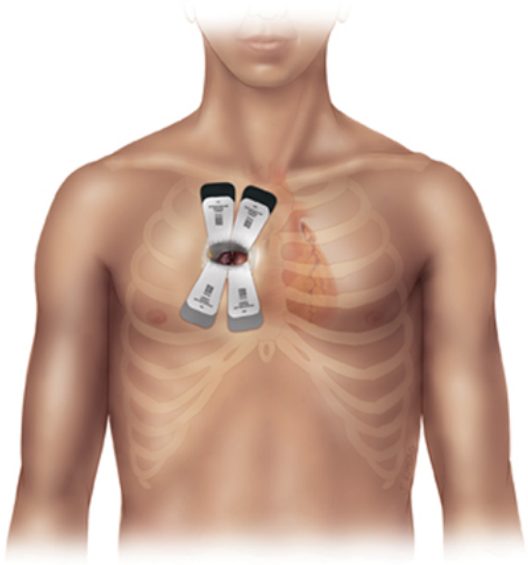
# Present/Future Hybrid Interventions

Aortic Valve/PCI



Small upper antero-lateral thoracotomy

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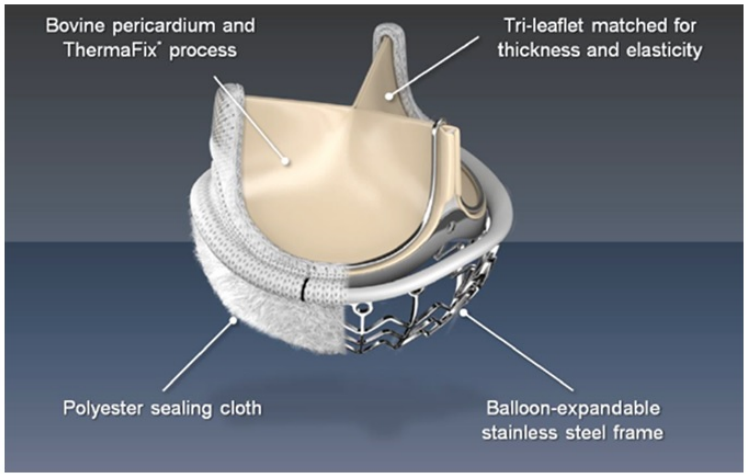
# Present/Future Hybrid Interventions

## Aortic Valve/PCI: Sutureless Valves

Sorin *Perceval*




Edwards *Intuity*

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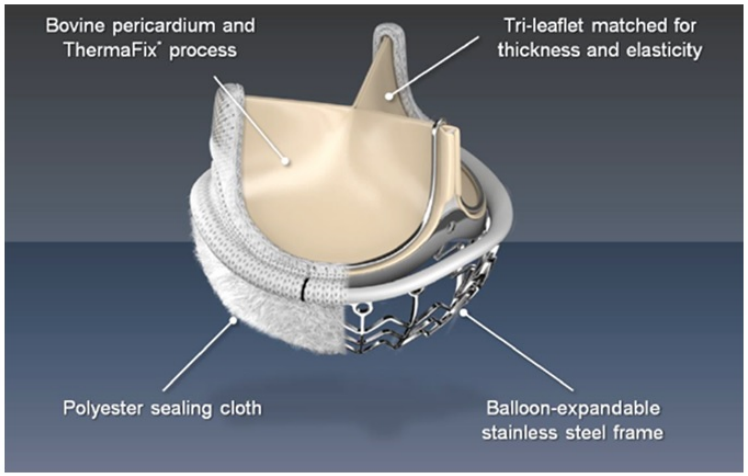
# Present/Future Hybrid Interventions

Aortic Valve/PCI: Sutureless Valves

Sorin *Perceval*




Edwards *Intuity*

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# Present/Future Hybrid Interventions

## Aortic Valve/PCI: Rationale

- Patients with poor conduit quality for CABG surgery
  - poor SVG failure rate at 1 year 30%*
- Convert high-risk valve/CABG into a lower risk isolated valve
  - valve/CABG has twice the mortality rate of isolated valve surgery**
- Convert reoperative valve/CABG into reoperative isolated valve surgery

* Magee MJ. Coronary artery bypass graft failure after on-pump and off-pump coronary artery bypass: findings from PREVENT IV. Ann Thorac surg 2008;85:494-9
** Hannan EL. Risk index for predicting in-hospital mortality for cardiac valve surgery. Ann Thorac Surg 2007;83:921-9

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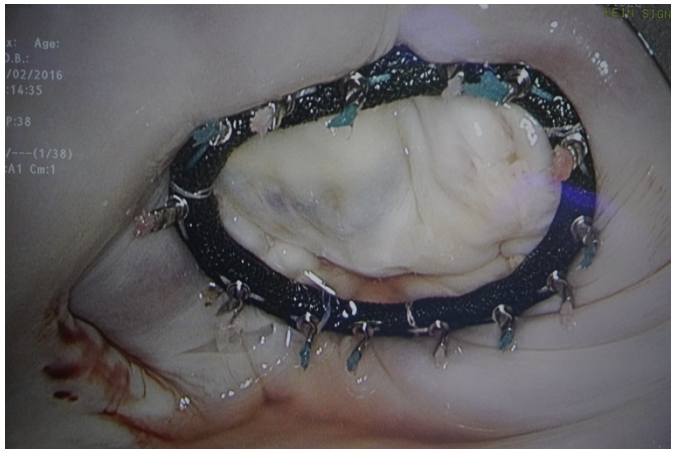
# Present/Future Hybrid Interventions

## Mitral Valve/PCI: Rationale

- Mitral valve repair is superior to replacement
- Minimally invasive is superior to sternotomy



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# Present/Future Hybrid Interventions

## Atrial Fibrillation: Rationale Surgical

- Lone atrial fibrillation
- Closed chest armamentarium is available or under invention
- Surgical approach is faster
- Surgical approach has no radiation exposure
- Surgical approach is more extensive

- Percutaneous approach may create some lesions more easily

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# Present/Future Hybrid Interventions

Atrial Fibrillation: Rationale Percutaneous

- Percutaneous approach may create some lesions more easily:
  Coronary sinus, cavotricuspid isthmus
- Mapping to ensure PVI and block lines
- Potential for complex mapping of rotors

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# Present/Future Hybrid Interventions

## Atrial Fibrillation: Results

**Table 2** List of reported hybrid AF studies

| Author | Year | Patients | Mean age | AF duration (years) | Mean LA diameter (mm) | Persistent AF (%) | Access | Sinus rhythm |
|---|---|---|---|---|---|---|---|---|
| Mahapatra *et al*. | 2011 | 15 | 59.5 | 5.4 | 52.3 | 100 | B-Thor | 86.7 |
| Krul *et al*. | 2011 | 31 | 57 | 8 | 47 | 48 | B-Thor | 86 |
| La Meir *et al*. | 2012 | 35 | 57.1 | 5 | 52 | 54 | B-Thor | 85.7 |
| Pison *et al*. | 2012 | 26 | 56.8 | 5.6 | 43.1 | 42 | B-Thor | 92 |
| La Meir *et al*. | 2012 | 19 | 61.2 | 5 | 49 | 74 | R-Thor | 36.8 |
| Zembala *et al*. | 2012 | 27 | 55.2 | 3.5 | 45.5 | 100 | LAP | 66.5 |
| Muneretto *et al*. | 2012 | 36 | 62.3 | 6.1 | 50.3 | 100 | R-Thor | 77.7 |
| Gersak *et al*. | 2012 | 50 | 56.4 | 5 | 48 | 94 | LAP | 88 |
| Gehi *et al*. | 2013 | 101 | 62.9 | 5.9 | 51 | 84 | SubX | 60.7 |
| Bisleri *et al*. | 2013 | 45 | 62.3 | 7 | 51.3 | 100 | R-Thor | 88.9 |
| Gilligan *et al*. | 2013 | 42 | 60 | 3.9 | 45 | 81 | LAP | 95 |
| Gersak *et al*. | 2014 | 73 | 56.3 | 4.3 | 46.5 | 100 | LAP | 80 |

AF, atrial fibrillation; LA, left atrial. Adapted with permission from (8).

Driver K. Hybrid approaches in atrial fibrillation: why, where and who? J Thorac Dia 2015;7(2):159-164

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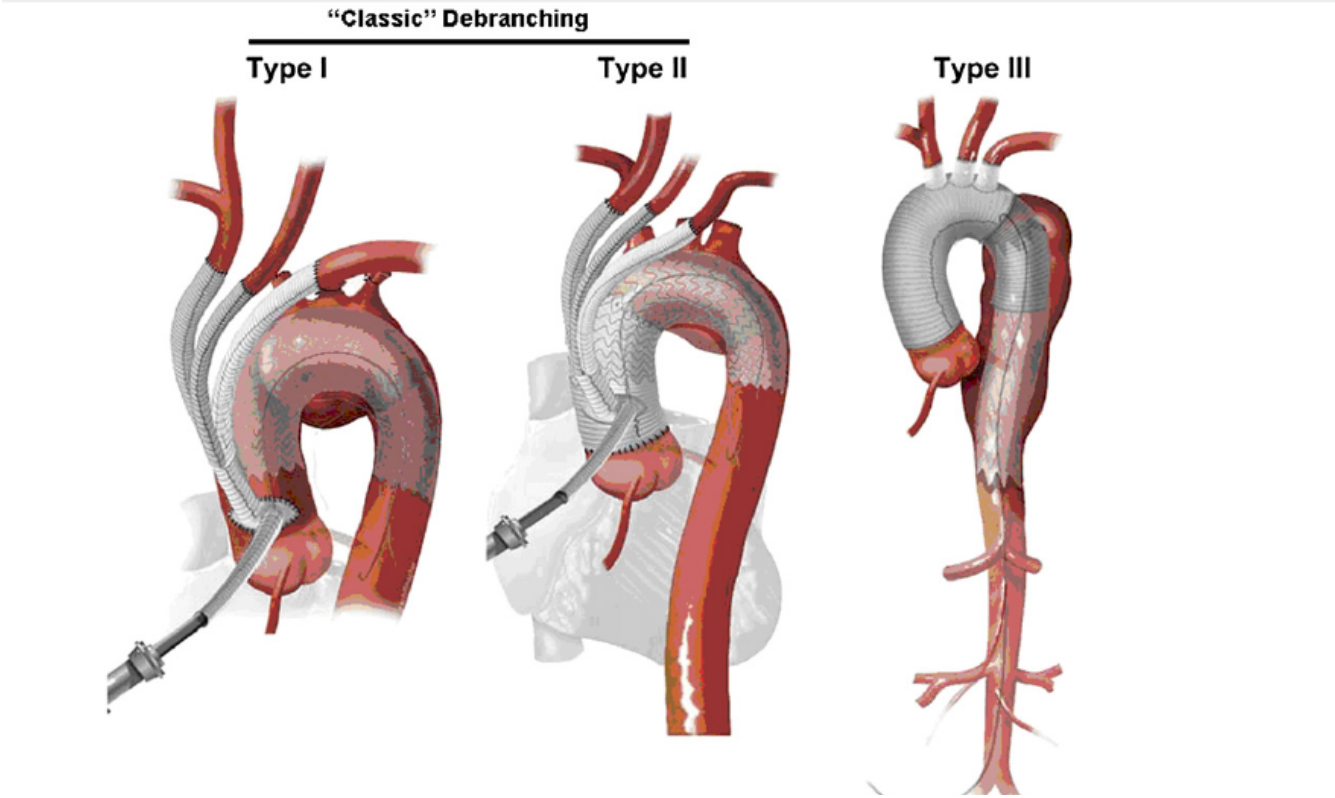
# Present/Future Hybrid Interventions

## Aortic Interventions




Bavaria J. Classic hybrid evolving approach to distal arch aneurysms. Toward the zone zero solution. J Thorac Cardiovasc Surg 2010;140:S77-80

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# Present/Future Hybrid Interventions

## Aortic Interventions: Results

**TABLE 3. Postoperative outcomes**

| Outcomes | Hybrid | | Type 1 | | Type 2 | |
|---|---|---|---|---|---|---|
| N | 27 | | 23 | | 4 | |
| Thirty-day mortality | 3 | 11% | 3 | 13% | 0 | |
| Stroke | 3 | 11% | 3 | 13% | 0 | |
| Permanent paraplegia | 2 | 7% | 2 | 9% | | |
| Transient neurologic deficit | 3 | 11% | 2 | 9% | 1 | 25% |
| Renal failure | 2 | 7% | 2 | 9% | 0 | |
| Renal failure requiring new hemodialysis | 1 | 4% | 1 | 4% | 0 | |
| Reop for bleeding | 0 | 0% | | | | |
| Atrial fibrillation | 12 | 44% | 10 | 43% | 2 | 50% |
| Mean hospital stay (d) | 17.2 | ± 14.0 | 16.3 | ± 14.0 | 22.0 | ± 9.6 |

Bavaria J. Classic hybrid evolving approach to distal arch aneurysms. Toward the zone zero solution. J Thorac Cardiovasc Surg 2010;140:S77-80

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# Present/Future Hybrid Interventions

## Congenital Interventions: Hypoplastic left heart

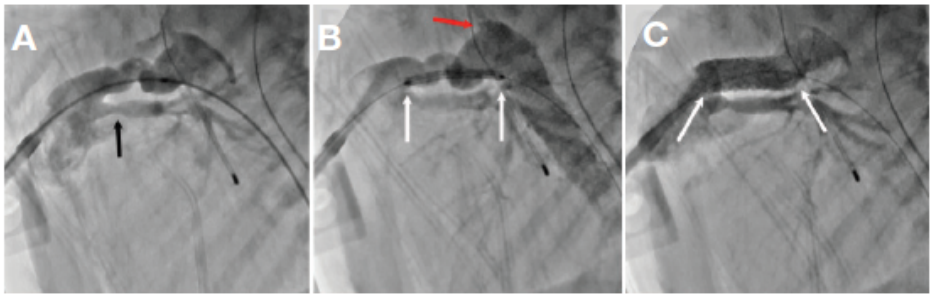


**Figure 1.** Hybrid stage I palliation for hypoplastic left heart syndrome. (A) In a hybrid setting and after the LPA and RPA bands (black arrow) have been placed via a small median sternotomy off cardiopulmonary bypass, an angiogram is performed through a short sheath placed directly into the main pulmonary artery above the valve after a guide wire has been placed through the PDA into the descending aorta. (B) A balloon expandable stent (white arrows) was chosen because the PDA was tortuous and displayed some narrowing. The red arrow represents retrograde flow to the aortic arch. (C) A final angiogram is performed after deployment to demonstrate the stent covering the entire length of the PDA (white arrows). LPA: left pulmonary artery; RPA: right pulmonary artery; PDA: patent ductus arteriosis.

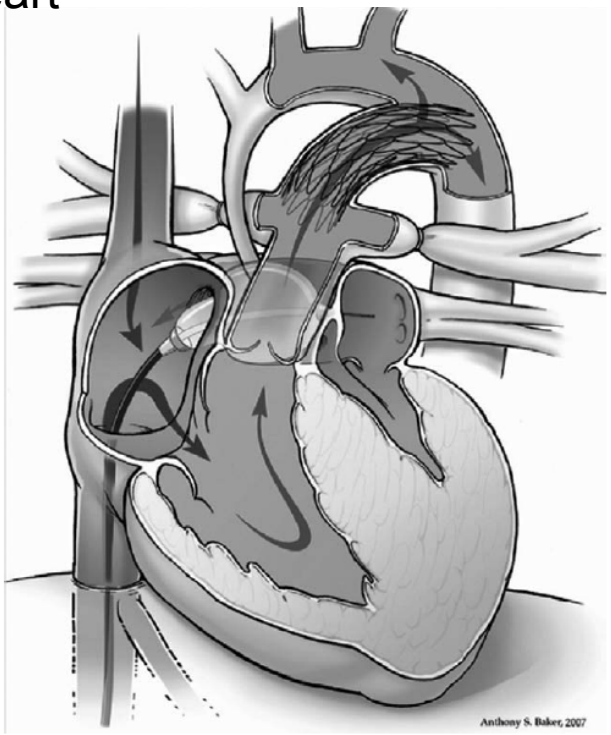


**Figure 5.** Hybrid stage 1 procedure for hypoplastic left heart syndrome. It combines bilateral pulmonary artery banding through sternotomy and ductal stenting. Reprinted from Galantowicz et al[52] with permission of the publisher. Copyright © 2008, Elsevier.

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# Present/Future Hybrid Interventions

## Congenital Interventions: VSD

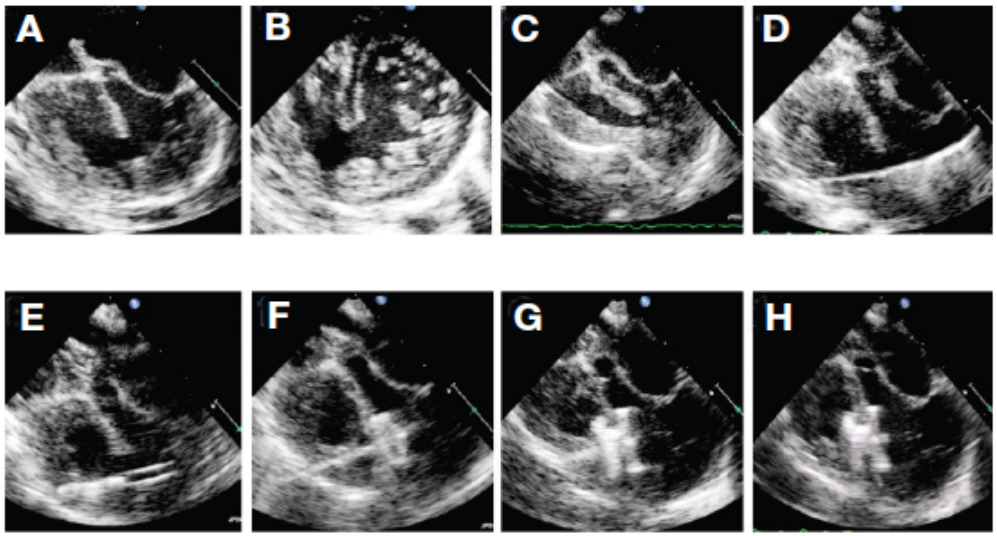


**Figure 3.** Perventricular closure of a large muscular ventricular septal defect. The defect is imaged in two different planes (A, B) with the site of proposed ventricular puncture indicated by digital pressure on the right ventricular wall (C). Once the wire is across the defect (D), the sheath is advanced into the left ventricle and the device advanced through the sheath (E). Initially the left ventricular device is deployed (F) followed by the right ventricular disk (G), with the device sitting in a good position across the defect following release (H).

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Conclusion:

- Hybrid interventions will overall decrease in number
  - advent of future interventional techniques
  - insufficient adaption of cardiac surgeons to MIC procedures
  - high planning hassle
  - complex staff training
  - Costs/reimbursement issue
  - Staging (antiplatelet therapy-bleeding)

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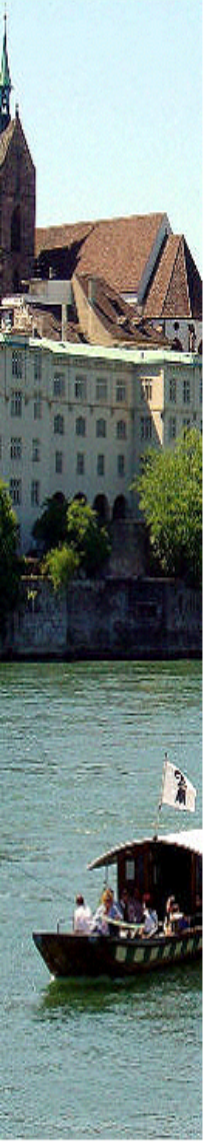

Conclusion:

- Sloping downwards 
  - hybrid coronary interventions
  - hybrid coronary/valvular interventions
    - except: in combination with valvular reconstruction
- Sloping upwards 
  - electrophysiologic hybrid procedures
  - aortic interventions
  - congenital interventions

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Thank you very much for your attention!

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