Pax Cardiaca: Hybrid Coronary Revascularisation

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Indications for CABG versus PCI in stable patients with lesions suitable for both procedures and low predicted surgical mortality

<table>
<thead>
<tr>
<th>Subset of CAD by anatomy</th>
<th>Favours CABG</th>
<th>Favours PCI</th>
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<tbody>
<tr>
<td>1VD or 2VD - non-proximal LAD</td>
<td>IIb C</td>
<td>I C</td>
</tr>
<tr>
<td>1VD or 2VD - proximal LAD</td>
<td>IA</td>
<td>IIa B</td>
</tr>
<tr>
<td>3VD simple lesions, full functional revascularisation</td>
<td>IA</td>
<td>IIa B</td>
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<tr>
<td>achievable with PCI, SYNTAX score ≤ 22</td>
<td>IA</td>
<td>IIa B</td>
</tr>
<tr>
<td>3VD complex lesions, incomplete revascularisation</td>
<td>IA</td>
<td>III A</td>
</tr>
<tr>
<td>achievable with PCI, SYNTAX score &gt; 22</td>
<td>IA</td>
<td>IIa B</td>
</tr>
<tr>
<td>Left main (isolated or 1VD, ostium/shaft)</td>
<td>IA</td>
<td>IIa B</td>
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<tr>
<td>Left main (isolated or 1VD, distal bifurcation)</td>
<td>IA</td>
<td>IIb B</td>
</tr>
<tr>
<td>Left main + 2VD or 3VD, SYNTAX score ≤ 32</td>
<td>IA</td>
<td>IIb B</td>
</tr>
<tr>
<td>Left main + 2VD or 3VD, SYNTAX score ≥ 33</td>
<td>IA</td>
<td>III B</td>
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• In the most severe patterns of CAD, CABG appears to offer a survival advantage as well as a marked reduction in the need for repeat revascularisation.
Disclosures

Scientific advisor and consultant for KIPS BAY MEDICAL, Minneapolis, MN, USA
...60 years ago
...today
Age specific crude incidence of major cardiovascular disease compared with angina and revascularisation procedures as first cardiovascular disease events. Curve for all cardiovascular disease includes angina and revascularisation in addition to major end points. Participants were considered to have cardiovascular disease at first end point reported.

Prevalence of previously diagnosed multimorbidity among patients hospitalized with acute myocardial infarction according to study period.

Rise of serious disease...


Source: Pacific Rim Disease Prevention Center
Exhibit 1. National Health Expenditures per Capita, 1980–2007

Average spending on health per capita ($US PPP)

- United States
- Canada
- France
- Germany
- Netherlands
- United Kingdom

Data: OECD Health Data 2009 (June 2009).
Why “Minimally Invasive”?  

“He went bankrupt slowly…slowly…then suddenly”

Necessity is the mother of invention

What we call 'Progress' is the exchange of one nuisance for another nuisance.  
Havelock Ellis *English sexual psychologist (1859 - 1939)*

Comfort food – Comfort Surgery
Applicable for

- Mitral valve surgery
- Tricuspid valve surgery
- Aortic valve surgery
- CABG/TECAB/MIDCABG
- ASD closure
- Maze Procedure
- Pediatric conditions
Emerging Trends:

Moving from Anatomical to “Functional” revascularisation

I. FFR guided revascularisation: more than 35% of anatomical stenosis may render a >0.8 FFR result, and may not be necessarily treated. At 1 year follow-up, no adverse events or symptoms.

II. Non LAD lesion, particularly non-culprit ones, are good to be stented and have a lesser risk of restenosis.

III. LAD as the culprit lesion: these patients will benefit primarily from a LIMA-LAD and stenting of secondary targets.

IV. Functionally complete revascularisation, less trauma.

The *intentional* combination of surgical and percutaneous treatment in patients with MVD

To combine the benefits of both “worlds”
Sequence

PCI first:
- Permitting aggressive MV treatment
- Stopping of anti-platelet R/?

MIDCAB first:
- Angiographic control
- Protection of PCI
- No stop anti-platelet R/ required

At the same time?
- Logistics?
  - Two specialists - planning
  - Adequate hybrid room - cost
  - Antiplatelet administration? bleeding
Which one first?

Two stage procedure:

PCI first:

- Anterior wall is unprotected

- Loss of opportunity to check the LIMA-LAD anastomosis angiographically

- Surgery on a heavily anticoagulated patient

- Stent may thrombose at reversal of intraoperative anticoagulation
CABG first

Advantages:

- Avoids Clopidogrel-related bleeding complications
  - Advantage of a protected environment
  - LIMA-LAD patency can be verified on the spot
  - (due to dose and time dependent Clopidogrel effect, 300 mg of Clopidogrel need to be administered right at the beginning of MIDCAB)

Disadvantages:

- In case of PCI failure, a second, much higher-risk Surgery is required
  - Acute stent thrombosis at reversal of anticoagulation
Which patients are eligible or benefit?

- Frail patients
- Patients with comorbidities
  - Diabetes
  - Major obesity
- Depressed pulmonary function
- Renal failure

Patients with long lesions and small vessels with accessible Drug eluting stent therapy for these targets, given the low restenosis rates

- Patients with severe bleeding events not to tolerate CPB
- 3-vessel disease patients, not well suited for all-PCI therapy and an LAD lesion: tortuosity, bifurcations, type of calcification, total chronic occlusion, calcified type C stenosis, complex ostial stenosis, complex LMS stenosis, proliferative in-stent-stenosis, failed attempts
Robotic Hybrid Revascularisation

“Integrated Coronary Revascularization: PCI + Robotic TECAB”
(Bonatti et al, Circulation 2006; 114 Suppl I: I-473-I-476)

- Pts treated with a mixed stent population
  - Excellent LIMA-LAD patency
  - Higher rates of Re-PCI at 1 year around 25% 

- But: not FFR, not standardized timing of MIDCAB vs. PCI
MIDCAB

- Access through a small left anterior thoracotomy
- Arterial grafting of the LITA to the LAD, multivessel approaches to CX (and RCA) possible
- No heart-lung machine required and no aortic clamping
MINIMALLY INVASIVE DIRECT CORONARY ARTERY BYPASS, MIDCAB

Left anterior thoracotomy

Xyphoid approach

Thoracoscopic approach

Left posterior thoracotomy

in situ internal thoracic artery

radial artery

free internal thoracic artery

MIDCAB Case Potential

Conventional CABG (291,920)

MIDCAB Potential (previously CABG)

4%

31%

Interventional Cases (170,880)

MIDCAB Potential (previously interventional)
Bilateral Thoracoscopic Minimally Invasive Direct Coronary Artery Bypass Grafting Using Internal Thoracic Arteries

Go Watanabe, MD, Takuro Misaki, MD, Keijyu Kotoh, MD, Akio Yamashita, MD, and Katsushi Ueyama, MD, PhD
Department of Surgery (1), Toyama Medical and Pharmaceutical University, Toyama, Japan

Conclusion: Bilateral thoracoscopic minimally invasive direct coronary bypass grafting is less invasive and can be used to treat patients with proximally diseased LAD and RCA.
Institutional report - Cardiac general

Long-term follow-up after minimal invasive direct coronary artery bypass grafting procedure: a multi-factorial retrospective analysis at 1000 patient-years

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Abstract

We provide a multi-factorial long-term follow-up following minimal invasive direct coronary artery bypass grafting (MIDCABG) to evaluate the long-term efficacy. From 1996 onwards, 390 patients and postoperative complications (<30 days) and we report. Early postoperative mortality was 0.8% and myocardial infarction (<30 days) was obtained in 238 patients (66.3%) and with a <50% stenosis (5.5%) and 8 with a >50% stenosis (2.1%). Long-term follow-up (completed 74.6%; 291/390 patients). Myocardial infarction occurred in 3.0%, redo CABG within (>30 days) of those 93.6% (n=73) had a patent graft stenosis (14.1%), but a patent graft. Only in five patients long-term anastomotic patency rates comparable with those of 2009 Published by European Association for Cardio-Thoracic Surgery.

4.1. Comparison of MIDCABG with CABG outcome

Our long-term results with regard to mortality, postoperative infarction and re-interventions are similar to those reported for conventional CABG patients [14]. Bleeding and blood requirements were even lower than those reported by others, such as by Arom et al. for CABG patients [15]. Various other complications, such as pulmonary edema or neurological complications, were all less frequent in our series.
Results of the Prospective Multicenter Trial of Robotically Assisted Totally Endoscopic Coronary Artery Bypass Grafting

Michael Argenziano, MD, Marc Katz, MD, Johannes Bonatti, MD, Sudhir Srivastava, MD, Douglas Murphy, MD, Robert Poirier, MD, Didier Loulmet, MD, Leland Siwek, MD, Usha Kreaden, MSc, and David Ligon, MS, for the TECAB Trial Investigators

Milstein Hospital, Columbia University, New York, New York; Henrico Doctors’ Hospital, Richmond, Virginia; Leopold-Franzen-Universität Innsbruck, Klinische Abteilung für Herzchirurgie, Innsbruck, Austria; Alliance Hospital, Odessa, Texas; St. Joseph Hospital of Atlanta, Atlanta, Georgia; Saint Agnes Medical Center, Fresno, California; Department of Cardiothoracic Surgery, Lenox Hill Hospital, New York, New York; Sacred Heart Medical Center, Spokane, Washington; Intuitive Surgical Inc, Sunnyvale, California

Background. Robotic technology has been proven safe and efficacious in the performance of mitral valve repair and atrial septal defect repair. This report describes a Food and Drug Administration-sanctioned multicenter study of the safety and efficacy of the da Vinci system (Intuitive Surgical, Inc, Mountain View, CA) for totally endoscopic coronary artery bypass (TECAB) surgery.

Methods. Patients requiring left anterior descending (LAD) coronary artery revascularization were eligible. The procedure was performed with femoro-femoral cardiopulmonary bypass (CPB), endoaortic balloon occlusion, and thoracoscopy. All aspects of the procedure were performed with the robotic system, from internal mammary artery harvest to coronary anastomosis.

Results. Ninety-eight patients requiring single-vessel LAD revascularization were enrolled at 12 centers. Thirteen patients (13%) were excluded intraoperatively (eg, failed femoral cannulation, inadequate working space). In 85 patients (69 men, age 58 ± 10 years) who underwent TECAB, CPB time was 117 ± 44 minutes, cross-clamp time was 71 ± 26 minutes, and hospital length of stay was 5.1 ± 3.4 days. There were five (6%) conversions to open techniques. There were no deaths or strokes, one early reintervention, and one myocardial infarction (1.5%). Three-month angiography was performed in 76 patients, revealing significant anastomotic stenoses (> 50%) or occlusions in 6 patients. Overall freedom from reintervention or angiographic failure was 91%.

Conclusions. Robotic TECAB was accomplished with no mortality, low morbidity, and angiographic patency and reintervention rates comparable with published data. Although the use of CPB was a limitation of the technique, this experience represents a step toward more advanced procedures, such as multivessel or off-pump TECAB.

Feasibility, safety, and efficacy of totally endoscopic coronary artery bypass grafting: Multicenter European experience

Didier de Cannière, MD, PhD, Gerhard Wimmer-Greinecker, MD, PhD, Romuald Cichon, MD, Vassilios Gulielmos, MD, Frank Van Praet, MD, Usha Seshadri-Kreaden, MSc, and Volkmar Falk, MD, PhD

Objective: The invention of robotic systems has begun a new era of endoscopic cardiac surgery. Reports on totally endoscopic coronary artery bypass grafting are limited, however, and data regarding feasibility, safety, and efficacy are needed to determine this technique’s position in the therapeutic armamentarium. This study describes the largest multicenter experience in the literature with robotic totally endoscopic coronary artery bypass grafting specifically addressing procedural feasibility, safety, and efficacy.

Methods: Between September 1998 and November 2002, a total of 228 patients with coronary artery disease were scheduled for totally endoscopic coronary artery bypass grafting with the da Vinci Surgical System (Intuitive Surgical Inc, Sunnyvale, Calif.) at five European institutions. Patients underwent totally endoscopic coronary artery bypass grafting with either an on-pump (group A, n = 117) or an off-pump approach (group B, n = 111). Patients underwent postoperative angiography or stress electrocardiography and were followed up for 6 months.

Conclusion: Both on- and off-pump totally endoscopic coronary artery bypass grafting are feasible, with a conversion rate that diminishes with increasing experience. Conversion does not adversely affect outcome and thus constitutes a safe alternative. Although target vessel reintervention may be slightly higher than that reported for open coronary artery bypass grafting, graft patency and major adverse cardiac events for both approaches are comparable to those reported in the Society of Thoracic Surgeons database, demonstrating the safety and efficacy of the totally endoscopic coronary artery bypass grafting procedure.
Some more considerations on Hybrid

- In spite of contrast media administration, still a low risk of renal failure (we recommend to avoid hybrid if Crea>2mg/dl)

- The procedural costs are higher. However, its still bears financial benefits through less hospital stay, coordinated procedures etc.

Limitations:
- Need for a learning curve
- Hybrid approaches a great perspective through technological advancement, improved percutaneous and minimally invasive techniques, availability of hybrid suites
Trends and improvements toward a “Less Invasive Cardiac Surgery”
Fig. 1 – Patient positioning and the site marks for minithoracotomy incision, transthoracic aortic clamping, trocars for optical device, left atrial aspirator, and left atrial retractor. (LA = left atrium; AAL = anterior axillary line; MAL = midaxillary line; PAL = posterior axillary line)
Totally Percutaneous CBP

- Venous drainage:
  - Jugular vein
  - Femoral vein

- Arterial access: Femoral Artery
  - PercloseProGlide System
Perclose ProGlide Suture-Mediated Closure System
Provides the security of suture for vascular closure of 5-8F femoral artery access sites.

Needle deployment

**Versatile**
- Ability to maintain vascular access throughout deployment
- Flexibility to pre-close and close over the wire

**Secure**
- Simplified knot delivery with pre-tied knot
- Mechanical Closure – hemostasis is not clot dependent
- Challenge and confirm on the table gives you the close you can trust

**Control**
- Device numbered with deployment sequence
- Immediate re-access if prior arteriotomy repairs were achieved with Abbott Vascular SMC devices
- Reduced time to hemostasis, ambulation, and discharge in patients who have undergone diagnostic and interventional catheterization procedures without complicating clinical conditions.

Right mini-thoracotomy

4th ICS anterolateral mini-thoracotomy

CPG line from aortic root
Aortic Cross Clamp:
Glauber Aortic Clamp

Apply clamp to ascending aorta
Remove clamp holder
Clamp tip left inside the chest
Hybrid approach in a 75 year old patient with

- Athero-occlusive disease of coronary and renal arteries
- Long-standing mitral stenosis and tricuspid regurgitation
- Other comorbidities: Atrial fibrillation and severe pulmonary hypertension and right ventricular dysfunction. The patient was cachectic and admitted with heart failure NYHA Class IV, chronic renal failure, severe peripheral edema, liver congestion and ascites. Right ventricular pressure was 90 mm Hg and mitral valve area was 1.0 cm²

Procedures and Results

- Bare-metal stenting to the right coronary and left renal artery
- Next day:
  - beating heart video-assisted mitral valve replacement,
  - tricuspid valve repair
  - ligation of left atrial appendage.

Patient was discharged on POD 7. At six months postoperatively, pulmonary hypertension had decreased to mild level, with right ventricular systolic pressure of 48 mm Hg.

Conclusions:

Video-assisted beating heart mitral and tricuspid surgery can be safely performed in patients with poor right ventricular function and severe pulmonary hypertension. Avoidance of myocardial ischemia, less surgical trauma and PCI resulted in a successful outcome in this high-risk patient.

A complex case of
- peripheral vascular disease (PVD),
- coronary artery disease (CAD), and
- three prosthetic heart valves,
- severe mitral regurgitation (MR) due to healed endocarditis.

She was successfully managed with a hybrid approach utilizing
- **percutaneous coronary intervention (PCI) followed by**
- **minimally invasive mitral valve surgery (MIMVS) through right minithoracotomy.**

This was the patient's fifth cardiac surgery and she was discharged home on the fourth postoperative day (POD).
Results:

- **130 after-closed-chest hybrid-coronary procedures** in two institutions.

- **Hybrid procedures using robotic technology and PCI allow closed chest treatment of multivessel coronary artery disease.**

- Single- and double-bypass grafts are feasible and simultaneous interventions can be performed.

- The overall safety of the procedure seems to be adequate and perioperative clinical results are satisfactory.

- Intermediate term survival and freedom from angina are excellent.
Many of high-risk surgical patients with severe aortic stenosis have significant coexisting coronary artery disease.

An 82-year-old man with significant comorbidities, underwent combined procedures of

- off-pump transapical aortic valve implantation and
- minimally invasive direct coronary artery bypass via a left mini-thoracotomy

**Conclusion**

This combined procedure is technically feasible and can be performed safely in selected patients with aortic stenosis and left anterior descending artery lesion that is not suitable for percutaneous intervention.
Feasibility of complex coronary intervention in combination with percutaneous aortic valve implantation in patients with aortic stenosis using percutaneous left ventricular assist device (TandemHeart).

Piazza N, Serruys PW, de Jaegere P.
Department of Interventional Cardiology, Thoraxcenter, Erasmus Medical Center, Rotterdam, The Netherlands.

Coronary atherosclerosis is a common finding in patients with severe aortic stenosis. Indeed, aortic stenosis is associated with risk factors similar those of coronary atherosclerosis such as older age, hypertension, diabetes, hypercholesterolemia and smoking.

In light of the evolution of percutaneous aortic valve implantation (PAVI) and ongoing improvements in techniques of PCI, a combined approach using PCI and PAVI can be proposed for patients with complex coronary artery and aortic valve disease.

This report describes the feasibility of the combination of percutaneous coronary intervention and percutaneous aortic valve implantation with peripheral left ventricular assist device (TandemHeart) support in 3 elderly patients with complex coronary artery disease and aortic stenosis considered too high risk for conventional surgical therapy.
OBJECTIVES: Evaluate the 30-day and long-term clinical outcomes of patients with carotid obstructive disease (COD) and concomitant coronary artery disease (CAD) undergoing a combined percutaneous revascularization, in 4 high-volume centers skilled for the treatment of multilevel vascular disease.

METHODS: 239 consecutive patients between 01/ 2006 and 04/2010, Staged or simultaneous carotid artery stenting and percutaneous coronary intervention

RESULTS
- The incidence of the primary endpoint at 30 days was 4.2% (95% confidence interval [CI]: 2.02 to 7.56). The rate of death, myocardial infarction, and stroke at long-term follow-up (median 520 days) was 4.2%, 2.1%, and 3.8%, respectively.
- At long-term follow-up, patients with previous cardiovascular disease had significantly higher rates of major cardiac and cerebrovascular events than did patients with a first clinical episode (17% vs. 6%, hazard ratio: 3.34; 95% CI: 1.46 to 7.63; p = 0.004).

CONCLUSIONS: In patients with COD and concomitant CAD, a combined percutaneous treatment compares favorably with previous surgical or hybrid experiences. Such strategy may be particularly suited to complex patients at high surgical risk.
2.3. *Coronary angiography and percutaneous transluminal intervention (PCI)*

For patients with a known history of coronary heart disease or cardiovascular risk factors, such as hypertension, diabetes, hyperlipidemia, aging >45 years in males, and >50 years in female, outline coronary angiography was performed before endovascular stent-graft deployment. If necessary, PCI was performed three days to three months after endovascular stent-grafting through the right radial artery according to the American College of Cardiology (ACC) and the American Heart Association (AHA) guideline [15].
The combined treatment of aortic stenosis and abdominal aortic aneurysm using transcatheter techniques: a case report.

Ghosh-Dastidar M et al.
Departments of Cardiac Surgery, King's College Hospital/King's Health Partners, London, UK

85 year old lady with
- symptomatic aortic stenosis (AS) + history of previous coronary artery bypass grafting (CABG) referred for consideration of aortic valve replacement (AVR).
- Echocardiography: severe AS, peak gradient 92 mmHg, orifice area : 0.6 cm², preserved LVEF
- CT aortogram: diffusely calcified aorta and an infrarenal abdominal aortic aneurysm (AAA) measuring 6.5 cm.
- For symptomatic and prognostic reasons she needed treatment of both the AAA and AS.
- Logistic EuroSCORE for AVR was 39%.

Transcatheter techniques were selected for both pathologies.
- Transcatheter aortic valve implantation (TAVI) via the transapical approach to treat her AS,
- 3 months later, endovascular stenting of her infrarenal AAA.

She recovered well from both procedures.
- At 6 week follow up, her cardiac symptoms had improved considerably, and echocardiography revealed a mean AV gradient of 7 mmHg with good left ventricular function. Ultrasound of her abdomen revealed exclusion of the aneurysm sac with no endoleak.
- This is the first described case of TAVI and endovascular treatment of an AAA as a staged procedure.
- Mitral valve repair
  - Percutaneous mitral valve repair
    - Coronary bypass surgery
      - MIDCAB
      - OPCAB
  - Aortic valve replacement
- Transcatheter aortic valve replacement
  - Transfemoral approach
  - Transapical approach
- Assist Device Implantation in Heart Failure
- Robotic cardiac surgeries
- Endovascular surgery
- Pediatric Surgery

- High-End Imaging Equipments
  - Echocardiography
  - Mobile Fluoroscopy
  - Wire-based procedures/equipment
    - DaVinci System
  - Equipment for Endoscopic surgery
    - Heart Lung machine
  - Conventional Cardiac Equipment
In summary: Hybrid portfolio to be expanded and explored

- Mitral valve repair + PCI
- Percutaneous mitral valve repair + MIDCAB or MVST
  - Coronary bypass surgery
    - MIDCAB + TAVI (PAVI)
    - OPCAB + TAVI+(PAVI)
- Aortic valve replacement, beating heart + PCI
- Mitral Valve replacement (beating heart) + PCI
- Transcatheter aortic valve replacement + PCI
  - Transfemoral approach
  - Transapical approach
- Assist Device Implantation in Heart Failure + Causal Therapy (+PCI, +Mitral clip etc)
- Robotic cardiac surgery
- Endovascular Surgery (+ all the components above)
- Open aortic surgery (and the components above)
- Atrial fibrillation therapy (+all the components above).
  - Combined pediatric cases
Propose:

A Double-arm, prospective, randomized, multicentre trial
Stratified for Syntax and Euroscore
2x2 matrix for clustered populations
N=1000

Centres: Singapore, KL, Aalst, Greece

Methodology: 1-shot, functional, hybrid, full revascularization (Fluoroscopy, FFR)

Sponsors: Government Funds, Singapore Medtronic?
The Hybrid “Mantra”

“The greatest barrier is the ability of Cardiologists and Cardiac Surgeons to work together, to engage in “hybrid thinking” with close collaboration between the two disciplines. The willingness and ability to create this collaborative culture is the largest barrier to creating a successful hybrid program”

(JG Byrne et al, JACCIntv 2008;1:459-68)