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“a trek to the top”

# Robotic Cardiac Surgery: State of the Art

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## Evolution of Surgery

- Open surgery: mid-19<sup>th</sup> Century
- Minimally invasive surgery: late 1980's
- Robotic (Intuitive) surgery With Da Vinci: 1999

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## Cardiac Surgery: Definitions and overlap between concepts

- Minimally invasive
- Minimal access
- Robotically enhanced
- Completely robotically performed

Complexity-risk of error -efficiency

## What are the problems with endoscopic cardiac surgery?

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## MINIMAL ACCESS = MINIMALLY INVASIVE AORTIC SURGERY

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## MIH or ENDOSCOPIC: the future is robotic harvesting with multiarticulated biosensored robots



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New idea - Coronary

### A new method of grafting the circumflex through lateral MIDCAB with the use of the radial loop technique

Thanos Athanasiou\*, Roberto Casala, Brian Gemville, Rex Del. Stanbridge

Department of Cardiothoracic Surgery, St Mary's Hospital, 70 St Mary's Road, Fulham, London SW9 7JX, UK  
Received 16 June 2002; accepted in revised form 11 November 2002; accepted 19 November 2002

**Abstract**

We report a technique that allows total arterial revascularization of the circumflex territory without cardiopulmonary bypass through limited thoracotomy with the radial as a composite graft. The technique includes assessment of the distal end of the radial artery to be anastomosed just after the division of the conus from the brachial artery. In this way we create an adjustable loop that can be divided and used as bifurcated conduit in two coronary targets according to the needs of revascularization.

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**Keywords:** MIDCAB; Radial artery; Composite grafts; Arterial revascularization



Fig. 1. Radial loop severed through limited 'MIDCAB' with grafting of CIRC1 and distal Cx.

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## WHEN LITA IS NOT AVAILABLE



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The Heart Surgery Forum ©1996

Teach Teleports Being Used CAB in (Johann) Wilson and REV Thomas - Cases and Minutes




Figure 2. Atraumatic coronary artery bypass in a human immunodeficiency virus-positive patient. Arrow 1 shows the endoscopic stabilizer in place and arrow 2 the left internal thoracic artery.

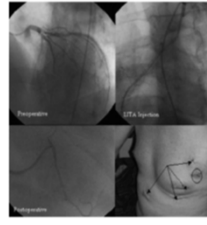


Figure 3. Preoperative and postoperative outcome of a (Johann) Wilson patient undergoing beating-heart totally endoscopic coronary artery bypass. The arrow indicates the 4 ports required, with the white representing the incision plane of the endoscopic approach to follow the coronary ostium. LTA indicates left internal thoracic artery.

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## MINIMALLY INVASIVE PULMONARY EMBOLECTOMY = THE NEW GENERATION OF EMBOLECTOMY WILL BE INTRAVASCULAR ROBOTIC CATHETER

**Minimally invasive off-pump pulmonary embolectomy**

Hutan Ashraffian, Pankaj Kumar, Thanos Athanasiou and Rex D. Stanbridge  
Department of Cardiothoracic Surgery, St Mary's Hospital, Praed Street, London W2 1NY, UK


We report the case of a 35-year-old female with acute massive right pulmonary embolism, successfully treated by a minimally invasive off-pump pulmonary embolectomy—the first case in the literature implemented via the J-ministernotomy.

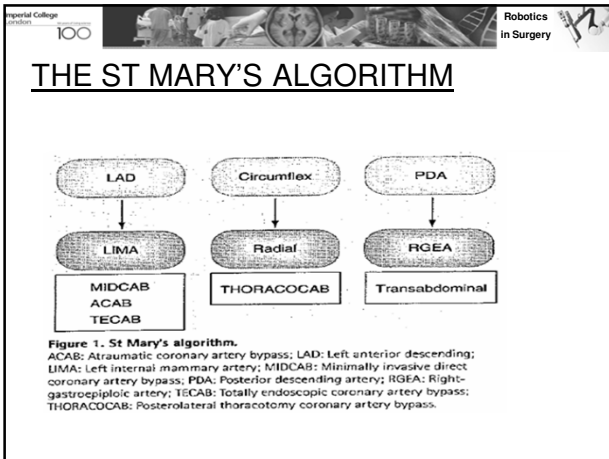
© 2003 The International Society for Cardiovascular Surgery. Published by Elsevier Ltd. All rights reserved.

**Keywords:** pulmonary embolism, minimally invasive, off-pump, J-ministernotomy

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## TRANSABDOMINAL BYPASS GRAFTING





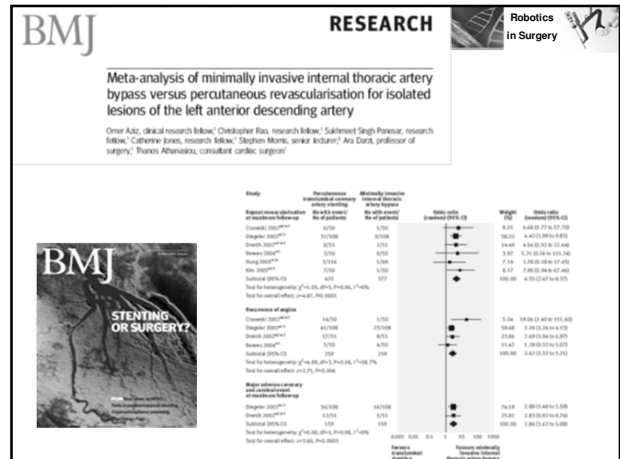
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**Table 1. MIDCAB procedures for revascularization without cardiopulmonary bypass.**

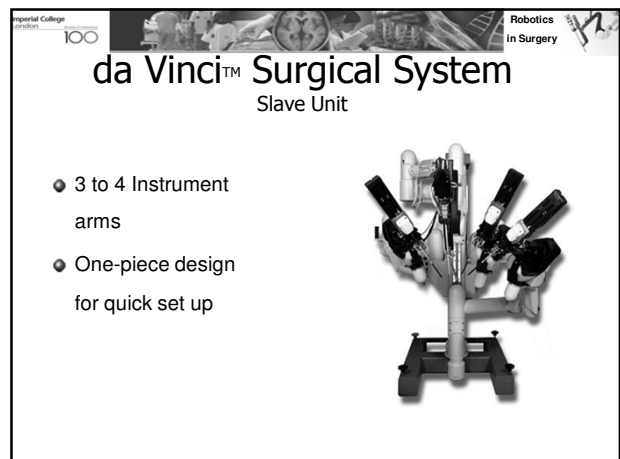
Incision	Conduit	Target vessels
Parasternal (right)	RITA	Proximal RCA
Parasternal (left)	LITA	Proximal LAD
Minithoracotomy (right)	RITA	Proximal RCA
Lateral thoracotomy	LITA, radial	LAD, Cx
Posterolateral thoracotomy	LITA, radial	LAD, Cx
Left anterior small thoracotomy	LITA	LAD
Subxiphoid distal RCA, PDA	LITA, RITA	LAD, distal RCA
<b>Transabdominal:</b>		
- with vertical incision	RGEA	Distal RCA, PDA
- with transverse incision	RGEA	PDA, distal Cx
Totally endoscopic coronary artery bypass	LITA	LAD

Cx: Circumflex artery; LAD: Left anterior descending artery; LITA: Left internal thoracic artery; MIDCAB: Minimally invasive direct coronary artery bypass; PDA: Posterior descending artery; RCA: Right coronary artery; RGEA: Right gastroepiploic artery; RITA: Right internal thoracic artery.

*Expert Rev Cardiovasc Ther* 2(6), LN004



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- ## St Mary's Robotic Program
- First TECAB in UK
  - First Mitral in UK
  - First AF Ablation in UK
  - First ASD Closure in UK
  - First Epicardial lead
  - First Myxoma excision
  - First Tricuspid valve repair





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## da Vinci™ Surgical System

Surgeon Console

- Superior 3-D imaging
- Hand to eye alignment
- Comfortable ergonomic surgeon position
- Navigator™ camera control
- One-piece mobile unit

HANDS-EYE ALIGNMENT IS PRESERVED



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## Minimally Invasive Surgery

- Potential benefits
  - Less pain
  - Shorter recovery
  - Fewer complications
- Patient-driven

Why so few?

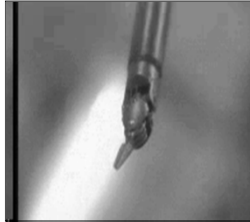
- Steep learning curve
- Many are not trained to hit a technological wall

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## EndoWrist™ Instrumentation

Precision and Control


- Modeled after the human wrist
- Full range of motion
- High-strength cable system
  - Transpose fingers to instrument tips
- 7 Degrees of Freedom Instruments



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## EndoWrist™ Instrumentation

Motion scaling  
2:1 to 5:1

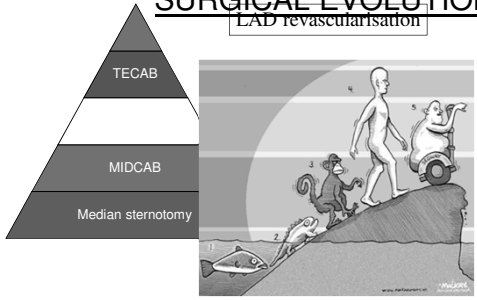


Tremor Elimination  
Ambidextrous Capability

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## Meeting the Patient Needs: THE SURGICAL EVOLUTION

LAD revascularisation



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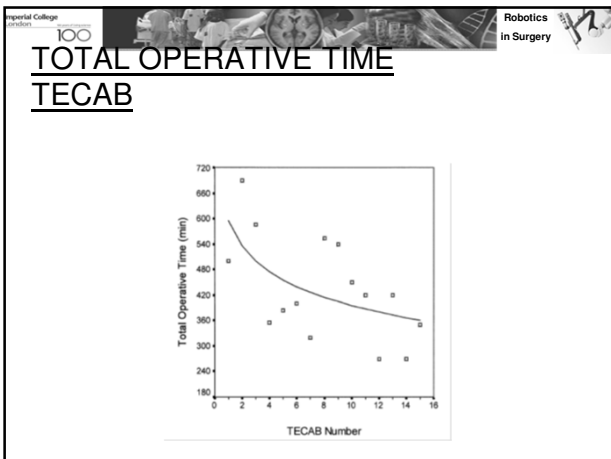
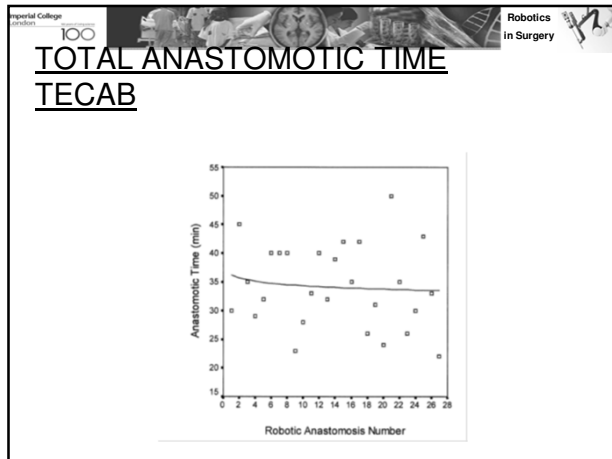
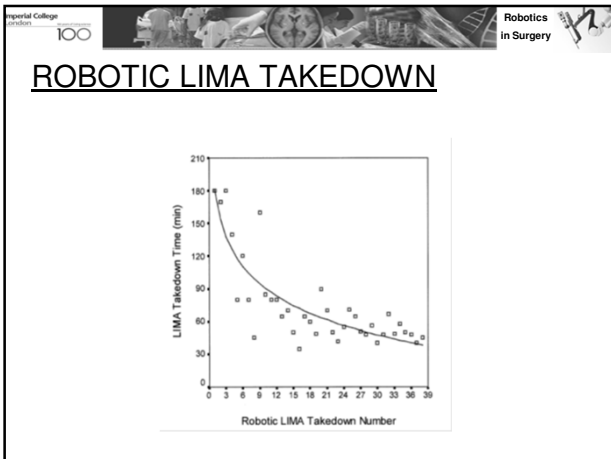
### Totally Endoscopic robotically Enhanced Coronary Artery Bypass (TECAB) on the "beating heart"

Totally endoscopic robotically enhanced coronary artery bypass on the beating heart

Professor Dr Giuseppe MULLER-TYBIRACCHIA  
 Head of the Department of Cardiothoracic Surgery, Imperial College School of Medicine  
 St Mary's Hospital, London W2 1PG

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### ROBOTIC CLOSURE OF ASD



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### COMPARATIVE SERIES: 1 IN 3 CONVERSION TO MIDCAB

Table 3. Beating heart totally endoscopic coronary artery bypass.

Author	Number of patients	Robotic system	OT (min)	LHT (min)	AT (min)	Conversion to MIDCAB (%)
Kappert et al.	8	da Vinci	174 ± 95.6	34.5 ± 8.2	30.5 ± 9.7	34
Wirth et al.	8	da Vinci	NR	NR	24-29	75
Boehm et al.	8	ZELUS	270-320	43-74	36.6 (24-50)	NR
Dogan et al.	3	da Vinci	NR	NR	NR	NR
Casola et al.	15	da Vinci	200-330	24-56	28 ± 9	32

AT: Anastomotic time; LHT: Left internal thoracic artery harvesting time; MIDCAB: Minimally-invasive direct coronary artery bypass; NR: Not relevant; OT: Operative time.

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### arteriotomy




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### Mitral valve repair



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### Complex set up



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### OPERATING TO THE MITRAL FROM THE RIGHT SIDE IS MORE DIRECT

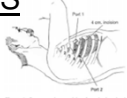

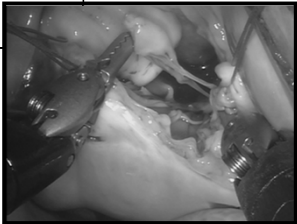


Figure 2. Proper patient position for robotic mitral valve repair.



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### ROBOTIC MITRAL VALVE REPAIR



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## REQUIREMENTS

However, there are as yet no guidelines on the eligibility of surgeons to perform robotic coronary operations. It could be speculated that in the near future, hospital institutions will require the following criteria:

- Board certification
- Satisfactory completion of a training course in the safe use of the robotic surgical system
- Performance of robotic operations in animate models
- Observation of clinical cases of robotic surgery by an expert surgeon
- Acting as an assistant surgeon in robotic operations or supervision by a preceptor during the surgeon's initial operations and ongoing monitoring of surgical outcomes of robotic operations

This process will facilitate the safe and orderly introduction of robotic operations into clinical practice in our hospitals

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## CRITICISMS

### Robotic cardiac surgery: Time told!

Francis Robicsek, MD, PhD\*

*I do not see a widespread use of (robotics) in cardiac surgery in the future because most cases are really way too complex, and many surgeons should learn to do the simple video-assisted surgery with the same quality avoiding the high cost of robotic technology.*

Friedrich Wilhelm Mohr, MD, PhD, personal communication, 2006

*Assimilation of this (robotic) technology by cardiac programs has been slow!*

Evelio Rodriguez, MD, and W. Randolph Clatwood, Jr, MD, 2006

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## Surgical Technology Platform

Tele-manipulators

Image Guided Robotic Surgery

Micro-robots

Perceptual Docking

Active Constraint

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## Who is eligible to do robotic cardiac surgery with safety?

- More than 200 off-pump cases
- At least 25 MIDCAB lima-takedown
- Femoral cannulation in less than 5 min
- Training course
- Laboratory practice

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## da Vinci System

### Newest Technology

5mm instruments

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## Depth reconstruction through surgeon's eyes=binocular eyetracking and loop the fixation point to the robot and compensate through the camera

Left Camera View

Right Camera View

Perceptual Docking

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### Binocular Eyetracking=fixation point through ocular vergence

Mylonas et al

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### 21st century: NOTES?

NOS includes the transgastric, trans-douglas, transuterine, transurethral and transanal approaches for performing traditional intra-abdominal surgery

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ANNEX A - PAGE 1

### I-Snake Surgical Robot

A TRANSLATION AWARD

wellcometrust

Confidential

I-Snake (Imaging-Sensing Navigated And Kinematically Enhanced) Surgical Robot

The I-Snake team at Imperial's Institute of Biomedical Engineering

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### New robotic designs for cardiac surgery

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### FLUOROSCOPE IMAGING

Current intra-operative imaging approaches mainly include transit time tomometry which measures the blood flow through the graft, thermal coronary imaging based on visualization of temperature differences between the myocardium and a (warm or cold) solution injected into the graft. Fluorescence imaging based on the injection of indocyanine green into the central venous line and epicardial high-frequency ultrasound. Most of these techniques involve bulky probes, and therefore are not suitable for MIS procedures. They are also compounded by sensitivity and specificity issues. With the emergence of miniaturised ultrasound probes, the use of epicardial intra-operative ultrasound is becoming increasingly popular. A natural progression of the technology would be to combine in vivo, in situ imaging devices with articulated MIS instrument design to provide intra-operative guidance and morphological characterisation.

Figure 4. Our initial results of using miniaturised white light super-continuum and laser induced fluorescence imaging for robotic assisted MIS by linking point based imaging with large area tissue characterisation.



### The Operating Room of the Future

Imaging and robotics will be integrated in the future cardiac surgery OR



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# Questions ?



f..k you

NEVER BE AFRAID TO SAY WHAT YOU FEEL