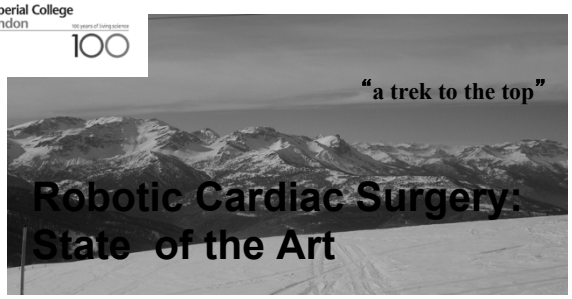
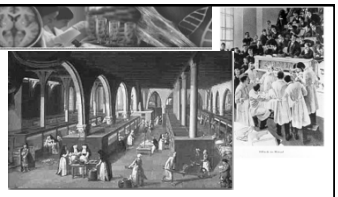


Robotic Cardiac Surgery: State of the Art

Mr Hutan Ashrafian & Prof. Thanos Athanasiou
Imperial College London
h.ashrafian@imperial.ac.uk



- Open surgery: mid-19th Century

- Minimally invasive surgery: late 1980's

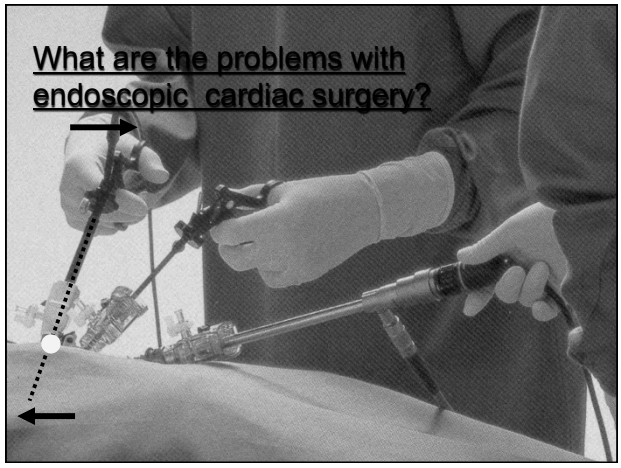
- Robotic (Intuitive) surgery With Da Vinci: 1999

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?



MINIMAL ACCESS =MINIMALLY INVASIVE AORT

Robotics in Surgery

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

Robotics in Surgery

www.icvts.org

New ideas – Coronary

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

Thanos Athanasiou*, Roberto Casula, Brian Glenville, Rex DeL Stanbridge

Department of Cardiothoracic Surgery, St Mary's Hospital, 70 St Olaf's Road, Fulham, London SW6 7DH, UK.

Received 16 June 2002; received 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 anastomosis of the distal end of the radial artery to its more proximal part after the division of the conduit 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.

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

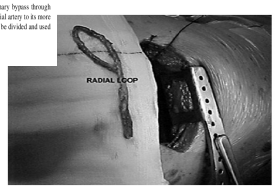
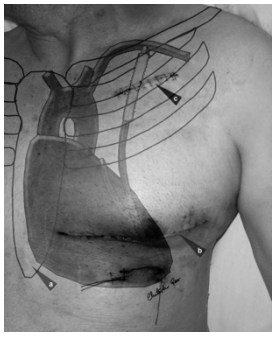


Fig. 1. Radial loop used through lateral MIDCAB for grafting of OM1 and distal Cx.

Robotics in Surgery

WHEN LITA IS NOT AVAILABLE



Robotics in Surgery

The Heart Surgery Forum #2004-1006

Totally Endoscopic Beating-Heart CAB in Jehovah's Witness and HIV Patients—Casula and Athanasiou

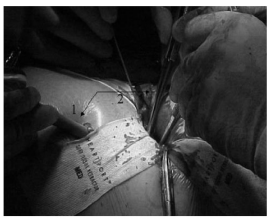


Figure 2. Atraumatic coronary artery bypass in a human immunodeficiency virus–positive patient. Arrow 1 shows the endoscopic stabilizer in place and arrow 2 the left internal thoracic artery.

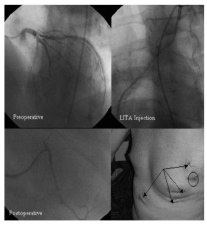


Figure 1. Preoperative and postoperative outcome of a Jehovah's Witness patient undergoing beating-heart totally endoscopic coronary artery bypass surgery. The 4 arrows indicate the 4 ports required, with the circle representing the insertion point of an endoscopic instrument to facilitate the coronary anastomosis. LITA indicates left internal thoracic artery.

Robotics in Surgery

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

Minimally invasive off-pump pulmonary embolectomy

Hutan Ashrafian, 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.

Keywords: pulmonary embolectomy, minimally invasive, off-pump, J-ministernotomy

Robotics in Surgery

TRANSABDOMINAL BYPASS GRAFTING

Robotics in Surgery

THE ST MARY' S ALGORITHM

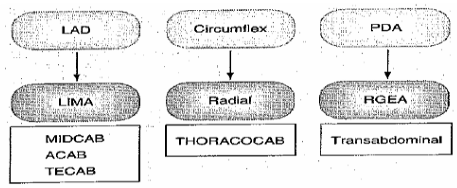
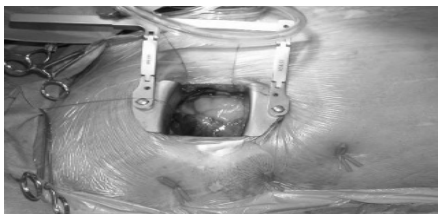


Figure 1. St Mary's algorithm.
ACAB: Atraumatic coronary artery bypass; LAD: Left anterior descending; LIMA: Left internal mammary artery; MIDCAB: Minimally invasive direct coronary artery bypass; PDA: Posterior descending artery; RGEA: Right-gastroepiploic artery; TECAB: Totally endoscopic coronary artery bypass; THORACOCAB: Posterolateral thoracotomy coronary artery bypass.

Robotics in Surgery

MINIMALLY INVASIVE ABLATION :A NEW PROCEDURE WITH I SNAKE ROBOT



Robotics in Surgery

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
Transabdominal:		
- 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.

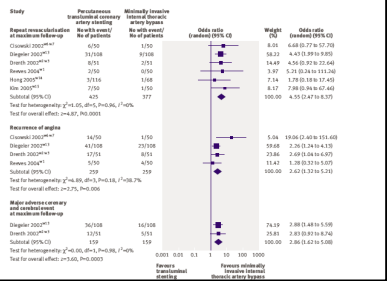
Expert Rev. Cardiovasc. Ther. 2(4), (2004)

Robotics in Surgery

BMJ **RESEARCH**

Meta-analysis of minimally invasive internal thoracic artery bypass versus percutaneous revascularisation for isolated lesions of the left anterior descending artery

Omer Aziz, clinical research fellow,[1] Christopher Rao, research fellow,[1] Sukhmeet Singh Panesar, research fellow,[1] Catherine Jones, research fellow,[1] Stephen Morris, senior lecturer,[2] Ara Darzi, professor of surgery,[1] Thanos Athanasiou, consultant cardiac surgeon[1]



Robotics in Surgery

St Mary' s Robotic Program

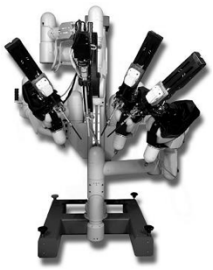
- First TECAB in UK
- First Mitral in UK
- First AF Ablation in UK
- First ASD Closure in UK
- First Epicardial lead
- First Myxoma excision
- First Tricuspid valve repair

Robotics in Surgery

da Vinci™ Surgical System

Slave Unit

- 3 to 4 Instrument arms
- One-piece design for quick set up



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

Minimally Invasive Surgery

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

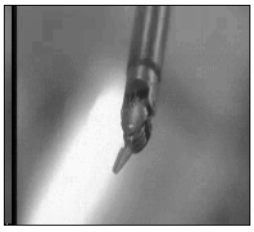
Why so few?

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

EndoWrist™ Instrumentation

Precision and Control

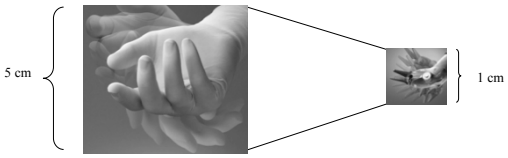
- Modeled after the human wrist
- Full range of motion
- High-strength cable system
  - Transpose fingers to instrument tips
- 7 Degrees of Freedom Instruments



EndoWrist™ Instrumentation

Motion scaling

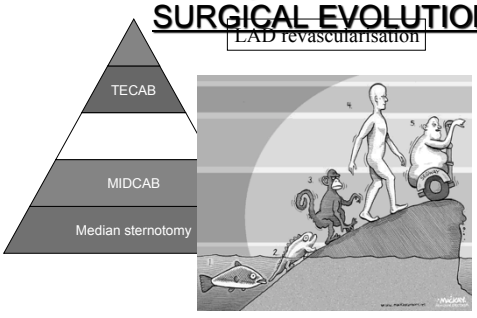
2:1 to 5:1



Tremor Elimination

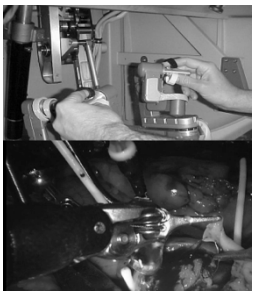
Ambidextrous Capability

Meeting the Patient Needs:THE SURGICAL EVOLUTION



Robotics in Surgery

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

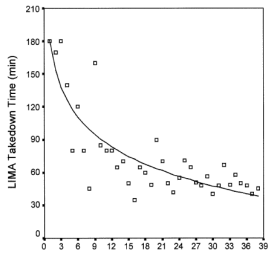


Robotics in Surgery

ROBOTIC CLOSURE OF ASD

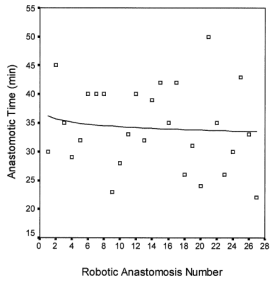
Robotics in Surgery

ROBOTIC LIMA TAKEDOWN



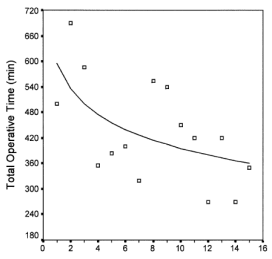
Robotics in Surgery

TOTAL ANASTOMOTIC TIME TECAB



Robotics in Surgery

TOTAL OPERATIVE TIME TECAB



Robotics in Surgery

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 ± 65.6	34.5 ± 8.2	30.5 ± 9.7	34
Morh *et al.*	8	da Vinci	NR	NR	24–29	75
Boehm *et al.*	8	ZEUS	270–320	43–74	36.6 (24–50)	NR
Dogan *et al.*	3	da Vinci	NR	NR	NR	NR
Casula *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.

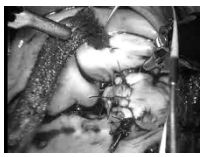
Robotics in Surgery

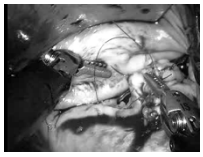
arteriotomy

Robotics in Surgery

Robotics in Surgery

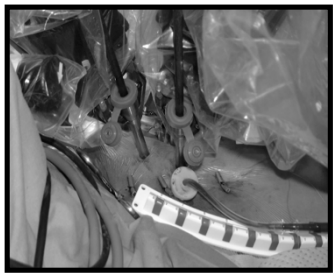
Mitral valve repair





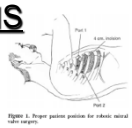
Robotics in Surgery

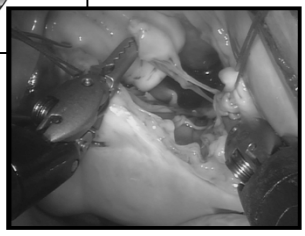
Complex set up

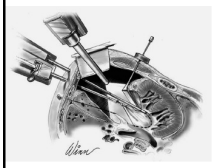


Robotics in Surgery

OPERATING TO THE MITRAL FROM THE RIGHT SIDE IS MORE DIRECT

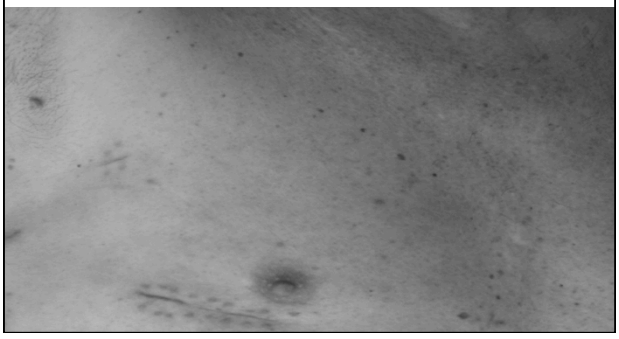






Robotics in Surgery

ROBOTIC MITRAL VALVE REPAIR



Robotics in Surgery

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

Robotics in Surgery

CRITICISMS

Robotic cardiac surgery: Time told!

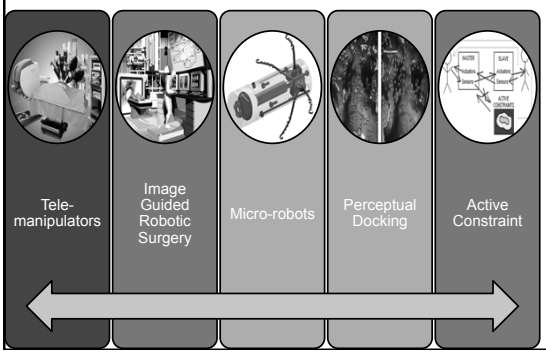
Francis Robicsek, MD, PhD*

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.[1]
Evelio Rodriguez, MD, and W. Randolph Chitwood, Jr, MD, 2006

Robotics in Surgery

Surgical Technology Platform



Robotics in Surgery

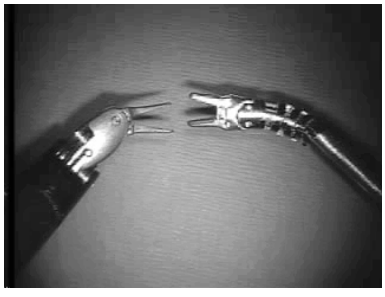
Who is eligible to do robotic cardiac surgery with safety?

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

Robotics in Surgery

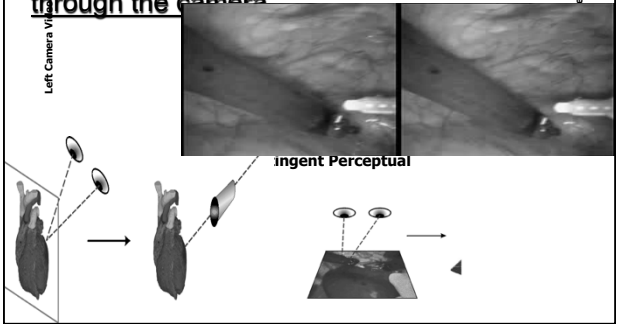
da Vinci System Newest Technology

5mm instruments



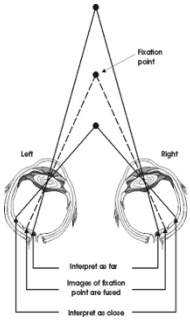
Robotics in Surgery

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



Robotics in Surgery

Binocular Eyetracking=fixation point through ocular vergence



Mylonas et al

Robotics in Surgery

21st century: NOTES?

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

Robotics in Surgery

ANNEX A - PAGE 1

i-Snake Surgical Robot

A TRANSLATION AWARD

wellcome trust

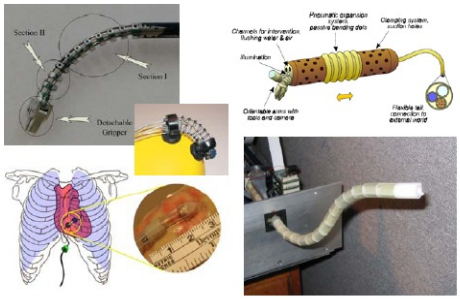
Confidential

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

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

Robotics in Surgery

New robotic designs for cardiac surgery



Robotics in Surgery

FLUOROSCENCE IMAGING

Current intra-operative imaging approaches mainly include transit time flowmetry 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

Questions ?