Totally Endoscopic Coronary Artery Bypass on Beating Heart

A Single Surgeon and Single Center Experience

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The ultimate goal of minimally invasive CABG is to:

1. Perform the entire anastomosis in a closed chest.
2. Avoid the deleterious effect of CPB.
3. Minimize the incision and surgical trauma.

TECAB on beating heart has brought minimally invasive CABG close to this goal.

References:
Didier Loulmet performed the first TECAB procedure on arrested heart in 1998. Despite this successful milestone, only a limited number of TECAB operations have been carried out worldwide.

TECAB on Beating Heart

The limiting factor of TECAB has been concern about safety and graft patency of the anastomosis.

This presentation describes our experience with TECAB on beating heart with robotic assistance and its midterm results.
The Distribution of Robotic Cardiac Surgery

- ASDR 28%
- MYXOMA 8%
- VSDR 3%
- MVP 14%
- MVR 5%
- MIDCAB 27%
- TECAB 15%
Early and midterm results of totally endoscopic coronary artery bypass grafting on the beating heart

Changqing Gao, MD, Ming Yang, MD, Yang Wu, MD, Gang Wang, MD, Cangsong Xiao, MD, Yue Zhao, RN, and Jiali Wang, BSc

Objective: Despite the early introduction of totally endoscopic coronary artery bypass on the beating heart, only a limited number of cases have been performed. The limiting factor has been the concern about safety and graft patency of the anastomosis. This study describes our experience with totally endoscopic coronary artery bypass on the beating heart with robotic assistance and its early and midterm results.

Methods: In 365 cases of totally endoscopic coronary artery bypass grafting on the beating heart, 264 cases were conducted on the beating heart with robotic assistance. The remainder were performed on the beating heart with conventional techniques. The robotic assistance cases included left internal thoracic artery (LITA) to left anterior descending artery (LAD) anastomosis in 264 cases (57.3%), left internal thoracic artery (LITA) to right coronary artery (RCA) in 264 cases (57.3%), and internal thoracic artery (ITA) to right coronary artery (RCA) in 264 cases (57.3%). The mean operation time was 264.8 ± 65.6 minutes (150-300 minutes). The average number of grafts was 6.4 ± 2.5. The early results of robotic assistance cases included 264 cases (57.3%), left internal thoracic artery (LITA) to left anterior descending artery (LAD) anastomosis in 264 cases (57.3%), left internal thoracic artery (LITA) to right coronary artery (RCA) in 264 cases (57.3%), and internal thoracic artery (ITA) to right coronary artery (RCA) in 264 cases (57.3%). The mean operation time was 264.8 ± 65.6 minutes (150-300 minutes). The average number of grafts was 6.4 ± 2.5.

Results: We completed 264 cases of totally endoscopic coronary artery bypass grafting on the beating heart with robotic assistance and 264 cases with conventional techniques. The mean operation time was 264.8 ± 65.6 minutes (150-300 minutes). The average number of grafts was 6.4 ± 2.5. After the operation, 50 patients received angiography. The results showed that all grafts were patent, and the study showed that robotic assistance is a valid and safe technique for coronary artery bypass grafting on the beating heart.

Conclusion: Totally endoscopic coronary artery bypass grafting (TECAB) on the beating heart is feasible and effective. It can be safely performed with robotic assistance. The robotic assistance can significantly reduce the operation time and improve the patent rate of the anastomosis. This study provides important insights into the feasibility and safety of TECAB on the beating heart with robotic assistance.
N= 56 cases


Work in progress report - Cardiac general

Totally robotic resection of myxoma and atrial septal defect repair

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Abstract

Resection of left atrial myxoma and large atrial septal defect (ASD) repair, which are not suitable for cardiological interventional treatment, have been performed by median sternotomy with conventional cardiopulmonary bypass (CPB). Since 1995, improvement in perfusion technology and intracardiac robotic-deployed cardiopulmonary bypass has allowed the da Vinci surgical system (Intuitive Surgical, Sunnyvale, CA) to be utilized in the heart centers for robotic-assisted cardiac procedures. In the last 3 years, our institution has performed 56 robotic cases (n=45) repairs with three cases of other concomitant procedures. Mean age of the patients was 38±12.2 years (range 12–61 years). All patients were treated with aortic cross-clamp, and antegrade cardioplegia was used in all the procedures. Median cardiopulmonary bypass times and aortic cross-clamp times were 248±36 min and 163±30 min, respectively. There were no device-related complications. One patient was discharged 5 days after surgery. da Vinci S surgical system was used in all cases, and the surgical results were excellent, and this technology is of most benefit to high-risk surgical patients.

Keywords: Minimally invasive cardiac procedures

1. Introduction

Traditionally, resections of left atrial myxomas and large atrial septal defect (ASD) repair, which are not suitable for cardiological interventional treatment, have been performed by median sternotomy with conventional cardiopulmonary bypass (CPB). Since 1995, improvement in perfusion technology and intracardiac robotic-deployed cardiopulmonary bypass has allowed the da Vinci surgical system (Intuitive Surgical, Sunnyvale, CA) to be utilized in the heart centers for robotic-assisted cardiac procedures. In the last 3 years, our institution has performed 56 robotic cases (n=45) repairs with three cases of other concomitant procedures. Mean age of the patients was 38±12.2 years (range 12–61 years). All patients were treated with aortic cross-clamp, and antegrade cardioplegia was used in all the procedures. Median cardiopulmonary bypass times and aortic cross-clamp times were 248±36 min and 163±30 min, respectively. There were no device-related complications. One patient was discharged 5 days after surgery. da Vinci S surgical system was used in all cases, and the surgical results were excellent, and this technology is of most benefit to high-risk surgical patients.

2. Patients and methods
42 cases on beating heart
Excision of atrial myxoma using robotic technology

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Objective: This study is to discuss a surgical approach for ideal and safe resection of atrial myxoma using the da Vinci S Surgical System (Intuitive Surgical, Inc, Sunnyvale, Calif).

Methods: Nineteen consecutive cases of atrial myxoma surgery were conducted using the da Vinci S Surgical System. Mean age of the patient was 59.6 years. Of the 19 cases, 11 tumors were in the left atrium, of which 7 tumors were in the anterior leaflet of the mitral valve. Overall, 1 from the root of the aorta, 1 from the coronary sinus, and 1 from the left atrial appendage. Atrial myxomas were resected using a combination of a left atriotomy and the da Vinci S Surgical System. A resection of a plane through the atrial muscle at the posterior wall, 1 from the root of the aorta, and 1 from the left atrial appendage were conducted using a 30° angled endoscope. The atrial myxoma was detached from the beating heart. The da Vinci instrument holder was inserted from the beating heart into the right side of the chest. Via 4 port incisions and a 1 port incision, a da Vinci instrument was inserted and facing upward with the da Vinci system. 

Results: Resection was successfully conducted in all cases. All the patients were discharged from the hospital within 7 d after surgery. One patient had a transient ischemic attack in the complete 1- to 18-month follow-up.

Conclusions: The excision of atrial myxomas with the da Vinci S Surgical System is feasible, efficacious, and safe. Surgical results are excellent.

Traditionally, left atrial myxomas have been resected by median sternotomy with cardiopulmonary bypass (CPB). Recent advances in robotic instrumentation have facilitated endoscopic intracardiac procedure. For example, the atrial retractors (Intuitive Surgical, Inc, Sunnyvale, Calif) is an exciting tool to assess the safety and efficacy of the procedure using robotic technology.

PATIENTS AND METHODS

Between January 2007 and June 2009, 19 consecutive patients (13 female, 6 male) were included in this study. N=36 cases
Mitral Valve Repair

Simplified technique
Hybrid Coronary Revascularization by Endoscopic Robotic Coronary Artery Bypass Grafting on Beating Heart and Stent Placement

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Background. Hybrid revascularization has been used in minimally invasive coronary artery bypass grafting and percutaneous coronary intervention for multivessel coronary artery disease (CAD). Very few endoscopic robotic coronary bypasses on the beating heart have been reported. The aim of this study was to assess hybrid revascularization by endoscopic robotic coronary artery bypass on the beating heart with percutaneous coronary intervention in a staged approach.

Methods. Forty-two patients underwent selective robotic coronary artery bypass grafting on the beating heart. Ten patients with right coronary artery or circumflex coronary stenosis underwent stent placement after robotic left internal mammary artery (LIMA) anastomosis to the left anterior descending (LAD) artery surgery in a separate session. The average age of the patients was 62.3 ± 12.1 years old. Coronary arteriography showed significant stenosis or total occlusion of the LAD in all patients and significant stenosis in the right coronary or circumflex arteries. The LIMA was harvested by the da Vinci S robotic surgical system (Intuitive Surgical, Sunnyvale, CA) and manually anastomosed to the LAD off-pump in 6 patients, and by totally endoscopic bypass on the beating heart in 4 patients. Percutaneous coronary intervention with placement of a stent to stenotic non-LAD targets was performed 4 to 5 days after operation. All LIMA-LAD grafts were assessed angiographically.

Results. All 10 patients had off-pump robotic bypass surgery and stent placement using a staged approach without complications.

Conclusions. Our preliminary study shows that hybrid coronary revascularization by endoscopic robotic coronary artery bypass grafting on a beating heart and subsequent stent placement is a feasible integrated approach for patients with multivessel CAD.

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Hybrid revascularization has applied minimally invasive coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) for the treatment of multivessel coronary artery diseases. However, only very few endoscopic robotic coronary bypasses on the beating heart have been reported in treatment of multivessel coronary diseases [1].

The ultimate goal of minimally invasive coronary artery bypass grafting is to perform the entire anastomosis in a closed chest. With the advent of robotically enhanced telemanipulation, the latest in minimally invasive techniques is now available and thus enables true closed-chest totally endoscopic procedures [2–8]. The concept of hybrid revascularizations was first discussed and applied clinically when left internal mammary artery (LIMA) to the left anterior descending artery (LAD) placement became feasible through minithoracotomies [9–13]. Our Institution initiated the robotic surgery using the da Vinci S (4-arm) surgical system (Intuitive Surgical, Sunnyvale, CA) in China in 2007, and we have completed over 130 cases of robotic cardiac surgeries [14, 15]. In this study, we have assessed hybrid revascularization by endoscopic robotic coronary bypass on the beating heart and PCI in a staged approach.

Patients and Methods

Patients

From April 2007 to August 2008, 42 patients underwent selective robotic coronary bypass grafting on the beating heart, of which 10 patients with right coronary artery or circumflex coronary stenosis received stent placement after robotic LIMA to LAD surgery in separate session, with approval from the Institutional Review Board and informed consent, from June 2007 to August 2008. The average age of the patients was 62.3 ± 12.1 years old. Two patients were female and 8 male. All patients had a
Totally Endoscopic Robotic Ventricular Septal Defect Repair

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Objective: Recent advances in robotic instrumentation have facilitated totally endoscopic intracardiac procedures. In this study, the feasibility and efficacy of totally endoscopic robotic ventricular septal defect (VSD) repair were evaluated.

Methods: Three female patients underwent robotic VSD repair. Echocardiography was performed to determine the size, location, and orientation of the VSD. The robotic arms were used to perform the repair, and the incision was closed with absorbable sutures. The mean duration of the procedure was 120 minutes, and the mean hospital stay was 3 days.

Results: All the VSD repair procedures were successful, with no complications. The mean follow-up period was 12 months, during which time there were no recurrent defects.

Conclusions: The feasibility and efficacy of totally endoscopic robotic VSD repair were demonstrated. This technique offers a minimally invasive approach to VSD repair, with a low risk of complications and a short hospital stay.

Key Words: Robotic, VSD repair.

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Personal Experience for OPCAB
(1997 – 2010, N=1600)
After double lumen intubation for single lung ventilation, the patient is placed on the operating table in a supine position with the left side of chest being elevated 30, the camera port is placed into the 5th ICS in the anterior axillary line and CO2 is insufflated into chest, right and left ports are placed sequentially, in the 3rd and 7th ICS. Usually CO2 infusion pressures should be 6 to 8 mmHg, carefully avoiding hypotension secondary to excessive thoracic pressure.
- Cut open pericardium to expose LAD
- Make port for endostabilizer 3 cm below the left subcostal area
- Pass S-18 U-Clips through the spatulated LIMA
- Place the Saddleloops proximally and distally around LAD
- Perform LIMA to LAD anastomosis
Verification of Patency

For all patients, the blood flow and flow waveform of the LIMA are measured by transit time ultrasound with the flexible flow probe.
Incisions & Drains

The wound S/P TECAB
IMA harvesting time was 37.3±10.5 min (18~60 min)

\[ y \ (\text{min}) = 55.925 - 4.905 \ln (x) \ (r^2=0.285; \ P<0.01) \]
Anastomosis time was 11.3±4.7 min (5~21 min)

\[ y \text{ (min)} = 19.116 - 2.857 \ln(x) \quad (r^2=0.346; \ P < 0.01) \]
Operating time was 264.8±65.6 min (150~420 min)

\[ y \text{ (min)} = 400.889 - 49.613 \ln(x) \]  \( r^2=0.595; P<0.01 \)
Coronary Angiography
Results

The distal anastomosis of a graft is often obscured by stitches or clips causing substantial *image noise* on CTA, so we assess graft patency not only at the anastomotic site, but along the main body of the graft as well.
Results

70/177 cases

Mean age 56.97 ± 9.7 years old (33 ~ 77)
The average flow: 35.8 ± 18.2 (10~103) ml/min.
The average drainage: 164.9 ± 83.2 (70~450) ml.
45 (85%) patients underwent coronary angiography
8 patients underwent CTA scan after surgery
Studies showed that graft patency rate was 100%.
Average follow-up time was 12.67±9.43 (1 to 40 months)
Results

- Unexpectedly, LIMA graft in the middle segment had a collateral branch in 2 patients.

- 2 patients were converted to MIDCAB during operation.
Discussion

Patient Selection

Although beating heart TECAB is safe, proper planning and patient selection are paramount for success. Grafting strategy should never be compromised to complete revascularization.
Discussion

Since the heart is not decompressed by using CPB, space in the thoracic cavity is limited, therefore, CO$_2$ pressure may be increased above the suggested value as long as the heart is filled sufficiently and contractility is not impaired.
Due to the lack of tactile feedback, it is important to remember to rely on visual cues. Sometimes it is difficult to assess the quality of the vessel wall.
Discussion

Suturing of the anastomosis is the most demanding part of TECAB on beating heart, even the slightest movement of the target vessel impairs surgical manipulation due to the 10x magnification.
1. Any new surgical approach requires a learning curve, robotic cardiac surgery is no exception.

2. We feel that robotic cardiac surgery requires real teamwork and since we started our robotic surgical program, our robotic team has not changed.

3. Our learning curve was truncated because the author, as console surgeon, simultaneously performed a large volume of various kinds of robotic surgeries with the same team in a relatively short time.
Our experience showed that with well trained robotic team and after a substantial learning curve, we could achieve optimal results for robotic surgeries.

da Vinci is a surgical tool, what kind of surgical procedure surgeon can perform depends on
Conclusions

- TECAB on beating heart is a safe procedure in selected patients, and produces excellent early and midterm patency of anastomosis and surgical results
- TECAB on beating heart should be conducted by surgeons with extensive surgical experience in open techniques, and requires a stable and well trained robotic team
- The learning curve is substantial
The Robotic Surgical Team
Roc – makes me think of Rock & Roll.
One of the earliest meanings in the English language for rock and roll is “to shake up, or to disturb”
This is very fitting to describe the disruptive technology that is robotic surgery – it is changing the way we perform surgery, the way we interact with our teams and the way we utilize virtuality to modify reality. Welcome to our BISROCS 2012
Thank you

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