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# What's the future of cardiac surgery? ——Hybrid procedure: Siemens solution

Experience from Fuwai Hospital: the world's largest heart center

Answers for Life 生命健康 知其道 用其妙

## Evolution

“阜外”院景照片



# National Center for Cardiovascular Disease & Fuwai Hospital



Fuwai Cardiovascular Hospital, was established in 1956. As the largest and best hospital devoted exclusively to cardiovascular diseases in China, it is also the National Center for Cardiovascular Disease, China (NCCD) for patient care, education, research and prevention in cardiovascular diseases.

The institution employs 2551 medical and other staff members, and owns 788,090 square meters, housing 8 research labs or centers, 37 wards, 19 operation rooms, 2 hybrid operation room, and 11 ICU with total 967 beds supervised by 14 Clinical Centers and 3 Management Committees of Cardiac Surgery, Cardiology, and Imaging Diagnosis. The hospital has state-of-the-art medical instruments for accessory medical examination of cardiovascular diseases, for example, cardiac MRI scanner and 64-slice cardiac CT scanner.

The institution is one of the world's largest centers and also the top center nationwide for diagnosis and treatment of cardiovascular diseases, in particular, all types of complex, rare or uncommon cardiovascular diseases. Our facility serviced over 470,000 outpatients and emergency patients, cared for more than 41,000 inpatients,

performed about 10,107 open heart procedures , 10,649 PCI procedure and more than 29,000 cardiac catheterizations in last year.

Fuwai Hospital is in leading position in its field and has several clinic centers of which are the top ones in the world.

- The Coronary Heart Disease Center is focused on complex coronary heart diseases in treatment and research; and comparable to many large coronary heart diseases centers in other countries. It has stepped in the line of internationally renowned center for percutaneous coronary intervention and through radial artery.
- The Cardiac Arrhythmia Center is the specialized national center for arrhythmia diagnosis and treatment, which leads in the electrophysiological diagnosis and therapies by means of radiofrequency catheter ablation, implantable cardioverter defibrillator and pacemaker implants.
- The Hypertension Center is recognized internationally by the differential diagnosis of secondary hypertension. It is a national leader in the treatment of peripheral vascular disease.

- Pulmonary Vascular Diseases Center is preceding nationwide in both treatment and research for pulmonary vascular diseases such as pulmonary hypertension, pulmonary embolism which has brought us international acclaim.

- Adult Cardiac Surgery Center mainly cures patients suffering from valve, coronary and arrhythmic diseases. They first performed some intricate surgical techniques, for example, off-pump coronary artery bypass graft(CABG), trans-thoracoscopic CABG, and hybrid approach to heart disease, which have been improving the treatment and prognosis for patients with complex cardiovascular diseases. Heart transplantation, extracorporeal membrane oxygenation and left ventricle assist device circulatory support are routinely used for end-stage heart failure patients. About 40 heart transplants are performed every year, which is ranked the first in China. The midterm and long-term survival rate after heart transplantation is higher than the world's average level.

- Pediatric Cardiac Surgical Center performs variety of surgical correction for Tetralogy of Fallot, transposition of the great arteries, pulmonary atresia, and double outlet of right ventricle. The surgical proportion, success rate, and therapeutic effect of infant patients with complex congenital heart defect are gradually increased or improved. The success rate for the applications of up-to-the-minute surgical techniques such as double root translocation and hybrid approach is bringing Fuwai to the front line in its field.

- Vascular Surgery Center performs a large amount of aortic arch replacement, elephant trunk procedure, and one-stop hybrid operation to cure the complex aortic diseases, which is leading domestic level and close to international level in the surgical therapy of aortic aneurysm and aortic dissection.

As a major national academic and medical institute for cardiovascular diseases, it provides innovative patient-centered care to prevent, diagnose and treat cardiovascular disease. It integrates clinical, hospital care and population prevention with research and education. Three key laboratories at ministerial level and three research technological platforms, to be opened to nationwide, provide research support. Faculties conduct a variety of research studies from lab-based, translational to clinic and population level, supported both domestically and internationally. More than 110 research activities are annually

published in the international peer-reviewed journals., such as NEJM, JAMA, Lancet and Circulation. During 2004-2009, more than 40 clinical excellence and scientific achievement prizes at the national level were awarded.

The institution cooperates with over 30 related organizations from 19 provinces, to have developed standardized community management network for prevention and treatment of hypertension disease nationwide. We have compiled and published cardiovascular disease Report of China since 2005, Chinese Hypertension Treatment and Prevention Guide, Chinese Adult Dyslipidemia Treatment and Prevention Guide, which are helpful to investigate and clarify the trend, strategies and measures for prevention and treatment of cardiovascular disease and its risk factors.

Fuwai Hospital is also the national education and training institute. We have 3 members of China Engineering Academy, 5 national experts who have made outstanding contributions, 108 professors, and 139 associate professors. It is the home for 6 key medical disciplines of the Ministry of Education. Since 1977, 29 postdoctoral fellows were ever trained, 591 M.S. and 570 M.D. or Ph.D. degrees were awarded and 11,703 trainees, including physicians, scientists and nurses, took part in educational programs in the institution.

The institution has international academic influence and has many international collaborators including WHO, NIH, Oxford University. More than 10 world-top cardiovascular specialists were awarded Honorary Professors. All of which are beneficial to raise the institution as one of the world's respected institutions in its field.

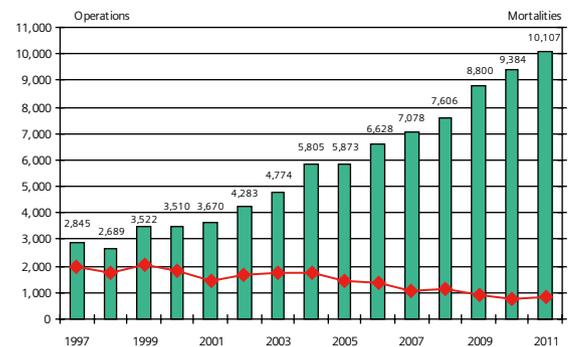
National Center of Cardiovascular Disease and Fuwai Hospital dedicated to Keep you healthy with our hearts. It will certainly make headline with such milestone in the future and will be continually dedicated to cardiovascular diseases' prevention and control in China, and carry out our mission: Provide the finest patient care; seek knowledge to improve that care; and educate the next generation towards excellence.



## Achievement of Cardiovascular Surgery Department

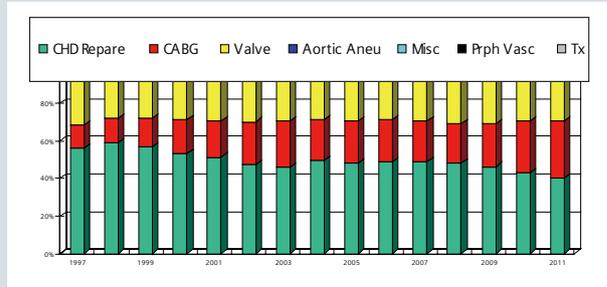
### Surgical volume and operative mortalities

In 2011 the surgical volume in Cardiovascular Surgery Department reached 10,107 in Beijing headquarters. This is a new milestone for Fu Wai Hospital, which positioned us one of the top cardiovascular surgical centers worldwide. Operative mortality has been controlled at a low level for many years as opposed to the rising surgical volume mentioned. In 2011, operative mortality for all cardiovascular surgical procedures was down to 0.84%.



### Etiology composition (by the year)

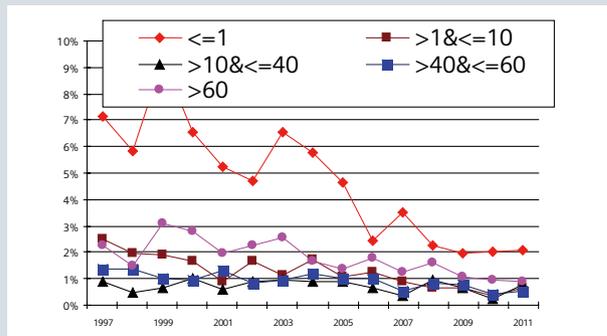
Fuwai Hospital accumulated the biggest number of experiences in treating a vast variety of cardiac diseases surgically in China. The figure demonstrated the etiological distribution of cardiac surgery from 1997 to 2011 in the department. Congenital Heart Disease always ranked the first, while Coronary Heart Disease increased obviously.



### Mortalities of Age Groups (by the year)

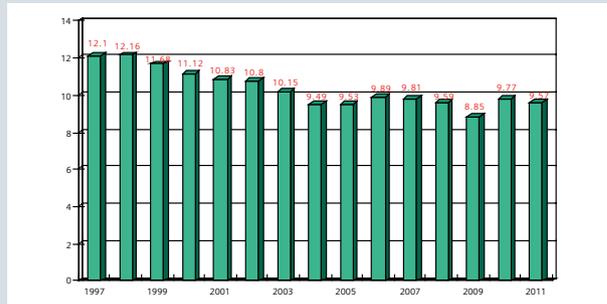
The department treated an increasing number of infants and elderly patients in recent years.

Advanced or junior age is known as risk factors that can seriously affect cardiac surgical outcome.



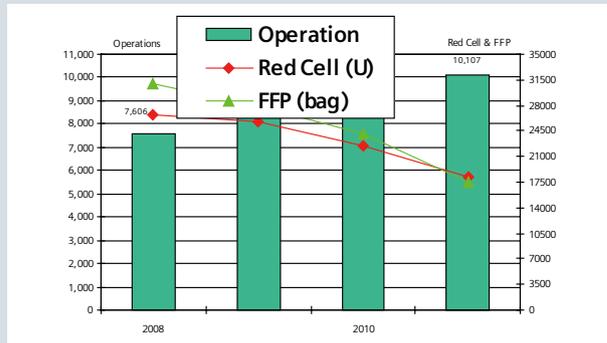
### Average post-op hospital stay

The department of cardiovascular surgery achieved a reduction in post-operative stay, based on the progress of surgical experiences and nursing qualities.



### Consumption of Red Cell and FFP

Compared to the surgical volume growth, the consumption of Red Cell and FFP noticeably decreased in recent years, which reflected our improvement on quality of health care and service.



# Fuwai Hospital One-stop Hybrid Surgery Center

In June 2007, Fuwai Cardiovascular Hospital founded the first one-stop Hybrid surgery centre in China. In this centre, the high standard imaging systems and surgical equipments were fully integrated. Therefore, the center was facilitated to perform not only the anaesthesia administration, common angiography /echocardiogram based examination and intervention, but also various cardiac surgeries with extracorporeal circulation and thoracotomy. Currently, this centre is the first "one stop" Hybrid platform in China even Asia for surgical and interventional treatments for

cardiovascular diseases.

Early in 1999, Fuwai Cardiovascular Hospital started the research on the hybrid surgical and interventional treatments for cardio-vascular diseases. The establishment of "one stop" hybrid surgery centre is a milestone of development of this innovative treatment strategy. So far, 763 procedures in total have been completed in the centre, i.e., 202 for coronary disease, 110 for aortic disease and 451 for congenital heart disease.



## Hybrid Study in Fuwai Hospital:

1. Hu S, Li Q, Gao P, Xiong H, Zheng Z, Li L, Xu B, Gao R. Simultaneous hybrid revascularization versus off-pump coronary artery bypass for multivessel coronary artery disease. *Ann Thorac Surg.* 2011; 91(2):432-8

This study compare early and midterm clinical outcomes of a simultaneous hybrid coronary revascularization procedure with those in a propensity-matched subset of patients undergoing conventional off-pump coronary artery bypass grafting. The researcher collected 104 consecutive patients (mean age  $61.8 \pm 10.2$  years) with multivessel coronary artery disease underwent elective simultaneous coronary revascularization. The result reveal that the hybrid procedure required longer operative time and incurred higher in-hospital costs, but had shorter median intubation time ( $11.6 \pm 6.3$  vs  $13.8 \pm 6.8$  hours,  $p=0.02$ ), intensive care unit length of stay ( $34.5 \pm 35.6$  vs  $55.3 \pm 46.4$  hours,  $p<0.001$ ), and postoperative in-hospital length of stay ( $8.2 \pm 2.6$  vs  $9.5 \pm 4.5$  days,  $p=0.01$ ). The hybrid group had significantly less chest tube drainage ( $789 \pm 389$  vs  $834 \pm 285$  mL,  $p=0.005$ ) and need for blood transfusion (28.8% vs 51.9%,  $p>0.001$ ). At a mean follow-

up of 18 months, the freedom from major adverse cardiac or cerebrovascular events is in favor of the hybrid group (99.0% vs 90.4%;  $p=0.03$ ).

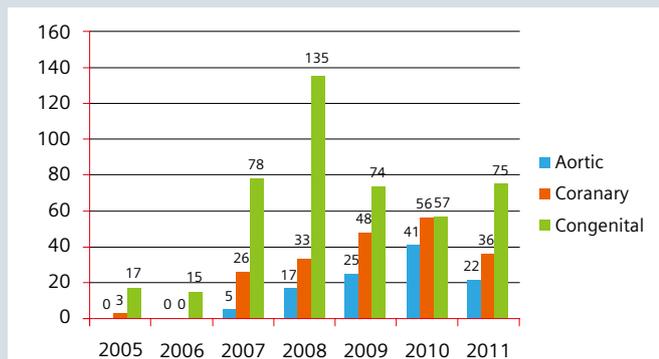
Compared with conventional off-pump coronary artery bypass grafting, simultaneous hybrid coronary revascularization shortens recovery time and has superior outcomes at a mean follow-up of 18 months. Simultaneous hybrid coronary revascularization provides a safe and reproducible alternative for selected patients with multivessel coronary artery diseases.

2. 1.Hu S.The surgical and interventional hybrid era: experiences from China.*J Thorac Cardiovasc Surg.* 2011; 141(6):1339-41.

3. Zhang H, Li SJ, Li YQ, Wang H, Hu SS. Open-chest device closure for the minimally invasive management of atrial septal defect in young children. *Heart Surg Forum.* 2007;10:E125-8.

4. Zhang H, Li SJ, Li YQ,Wang H, Hu SS. Hybrid procedure for the neonatal management of pulmonary atresia with intact ventricular septum. *J Thorac Cardiovasc Surg.* 2007;133:1654-6.

5. Li SJ, Zhang H, Sheng XD, Yan J, Deng XC, Chen WD, Hu SS. Intraoperative hybrid cardiac surgery for neonates and young children with congenital heart disease: 5 years of experience. *Ann Thorac Cardiovasc Surg.* 2010 Dec;16(6):406-9.



one-stop Hybrid surgery  
(not including isolated endovascular surgery)



Fuwai Hospital One-stop Hybrid Surgery Center

### Characteristics of Hybrid Cardiac Surgery

- 1.The procedure is strongly recommended to be performed in a hybrid OR, where multiple imaging systems are integrated.
- 2.A multidisciplinary professional team with interventional cardiologist and cardiovascular surgeon is required.
- 3.Applications of various imaging techniques for pre-procedural planning, intra-procedural guidance and post-procedural assessment.

Hybrid surgery is applicable for

1. Various complex congenital heart diseases.
2. Multi-vessel coronary disease. Hybrid coronary revascularization represents a minimally invasive alternative strategy that combines the durability and survival advantage of the LIMA-LAD graft with less-invasive PCI using drug-eluting stents to treat non-LAD vessels.
3. Aortic/Aneurysm Repair treatment with stent implantation.

### Fuwai Hospital One-stop Hybrid Surgery Center

Hybrid operation room is facilitated with

- 1.X-ray angiography system
- 2.Echocardiogram system
- 3.Anaesthesia equipment
- 4.Extracorporeal circulation equipment
- 5.Intra-aortic balloon pump (IABP)





# Comments by Experts



Professor Hu Shengshou

## In aspect of cardiac surgery

Cardiac surgery has entered into an era demanding imaginations and innovation the most. The history of cardio thoracic surgery was less than one century, but current common concepts and methods have been already unimaginable for the surgeon living one hundred years ago. In one-stop hybrid surgery, the surgeon is the core experts of the hybrid team, because of their profound understanding of the anatomy and excellent ability of tackling emergency situation. For example, when severe complications occur during intervention procedure, surgeons can immediately switch the procedure back into conventional surgery with cardiopulmonary bypass. At the same time, one-stop hybrid OR demands surgeon to adapt to this new workflow: not only to improve the surgery skill, but also to get used to interventional and imaging system. As a multi-disciplinary technology demanding more experiences from practices, Hybrid OR has still a long way to be the optimal patient-oriented treatment platform.



Professor Gao Runlin

## In aspect of percutaneous coronary intervention

Combined interventional and surgical therapy for cardiovascular disease has existed for a long time. Inter-disciplinary research and integration of different technologies not only are the trend of development of science, but also provide new idea for coronary heart disease treatment. Coronary heart disease hybrid surgery (Hybrid technology) complementarily combines new interventional treatment with traditional bypass surgery, completes the revascularization of coronary arteries in a single procedure. Combination of necessary intervention, surgery and reasonable medication therapy is the future of treatment of cardiovascular disease.



Professor Yang Yuejin

## In aspect of clinic routine

The most attractive benefit of one-stop surgery is its ability to solve the problem that can not be solved simply by interventional cardiologists and cardiovascular surgeons along. Hybrid OR establishes a new mode of treatment of cardiovascular disease through a smart combination of two complementary methods: less invasive surgery and minimal invasive intervention. If an operation room equipped with imaging tools of catheter lab, surgeon can also perform intervention through a small incision on chest. After the procedure, he can evaluate the outcome using imaging equipment immediately. Hybrid OR means a simplified clinic workflow, reducing the patient transfer between OR and radiology departments and minimizing the risk caused by multiple anaesthesia and patient transfer.

# Comments by Experts



Professor Chang Qian

## In aspect of aortic disease surgery

Endovascular intervention technique is a revolutionary progress of surgical treatment for aortic disease. Conventional surgery for ascending aorta and aorta arch with deep hypothermic circulatory arrest is still a quite important surgical option. However, for those patients with high risk, hybrid procedure of total aorta arch replacement with de-branching technique can significantly reduce the mortality and morbidity by avoiding deep hypothermic circulatory arrest. So far, Hybrid Technology is more likely a bridge from traditional open surgery to endovascular interventional treatment. I believe that the shift will continue and Hybrid technology will become more and more important.



Professor Li Shoujun

## In aspect of congenital heart disease surgery

One stop hybrid surgery is revolutionary for congenital heart disease for its concepts and techniques. Over all, it's simpler, safer and more effective. In some complex congenital heart disease, one stop hybrid surgery is superior to conventional surgery or percutaneous intervention. The development of one stop hybrid approach for congenital heart disease demands not only necessary operation room but also constantly improved technique and materials. Furthermore, the development of one stop hybrid approach for congenital heart disease is the embodiment of a cooperative and experienced heart team.



Professor Jiang Shiliang

## In aspect of congenital heart disease treatment

For congenital heart disease, the treatment method requiring a combination of surgery and intervention is called Hybrid technology. This technology has been applied to treat some complex congenital cardiovascular anomalies, congenital heart disease and acquired cardiovascular disease. The advantages of Hybrid technology are high degree of safety, less treatment time, and better clinical outcomes. Besides of skillful medical and technical personal, Hybrid technology also demands a well-equipped Hybrid operating room. Especially a flexible angio-system, which can be used for both angiography examination and surgery, plays a key role. The other facilities, like echocardiograph, anaesthesia equipment and extracorporeal circulation equipment, are need to fully integrated as well.

## Case 1 One-stop Hybrid surgery for coronary artery disease

Patient information

Male, 61 years old

Diagnosis

Acute myocardial infarction, unstable angina

Angiography results: (Fig. 1, Fig. 2)

- Diffuse lesions in right coronary artery (RCA)
- 60% stenosis at distal left main artery (LM)
- Diffuse-calcified lesions in the proximal to the middle part of Left Anterior Descending (LAD) with 80% stenosis
- 70% stenosis in the ostium of Left Circumflex Artery (LCX)
- 50% stenosis in the proximal of first Obtuse Marginal artery(OM)

Procedure:

- 1.Minimally Invasive Direct Coronary Artery Bypass (MIDCAB) was performed with the left internal mammary artery (LIMA) grafted to LAD (Fig. 5).
- 2.A 3.0 x 18mm Firebird 2 stent was implanted from the LM to the ostium of LCX (Fig. 6)

Comments:

Pre-procedural CT scan showed bifurcation lesion in LM and calcified lesions in LAD. It was too risky for pure interventional therapy. At the same time, the risk for bypass surgery was also high since the patient had chronic obstructive lung disease. So Hybrid surgery was selected.

One-stop Hybrid approach that combined MIDCAB and intervention was adopted in this case. With surgical minimally invasive bypass technology (Left Internal Mammary Artery bypassing), the unprotected LM was recanalized. It reduced the risk for the following intervention and was expected to achieve a better prognosis.

This was a live case performed by Fuwai hospital in TCT2007. The procedure was completed in one-stop Hybrid operation room. The stent was implanted in left main and left circumflex artery followed by bypass surgery after confirmation of the patency of the grafting vessel. This type of one-stop Hybrid surgery was not common around the world at that time, therefore it aroused heated discussion in TCT2007.

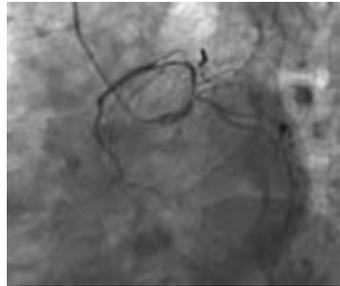


Fig. 1 Left coronary

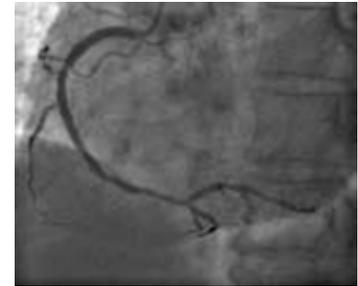


Fig. 2 Right coronary artery

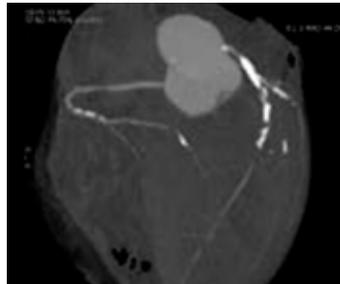


Fig. 3 Cardiac CT scanning

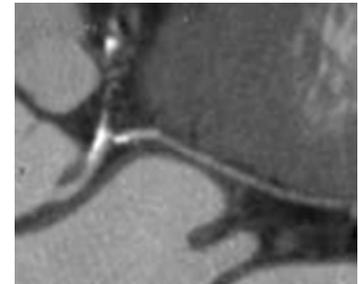


Fig.4 Cardiac CT scanning

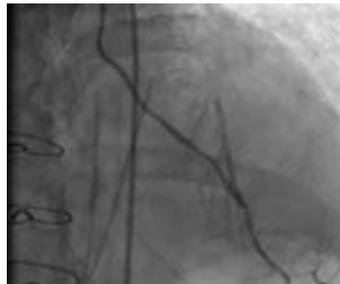


Fig. 5 Left Internal Mammary Artery to Anterior descending branch bypass

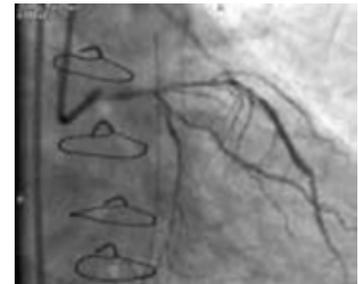


Fig. 6 After implantation of stent from the left main to the ostium of the circumflex branch

## Case 2 One-stop Hybrid surgery for coronary artery disease

### Patient information

Male, 72 years old

### Diagnosis

Multi-vessel coronary disease

Angiography results: (Fig. 1, Fig. 2)

Total occlusion lesion in Left anterior descending branch. There was no information provided by pre-procedural LAD retrograde angiography about vessel condition distal to the occlusion lesion of LAD.

### Procedure:

Graft patency was confirmed by angiography after bypass surgery, however, one stenosis lesion 1 cm distal to the anastomosis was also detected (fig.3). Off-pump bypass was performed again to move anastomosis forward beyond the stenosis section, the following angiography indicated LAD revascularization was satisfactory (Fig. 4). Then the stents were implanted in severe stenosis positions at the middle and distal parts of the right coronary artery (Fig.5). Angioplasty was performed at the proximal part of left circumflex artery where there was sub-total occlusion lesion (Fig. 6). The flow status of the above vessels was satisfactory after intervention. In this case the Hybrid surgery offered a better way to monitor the outcome of bypass grafting in order to avoid unsatisfactory bypass.

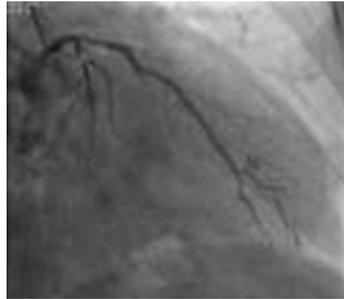


Fig. 1 Left coronary artery

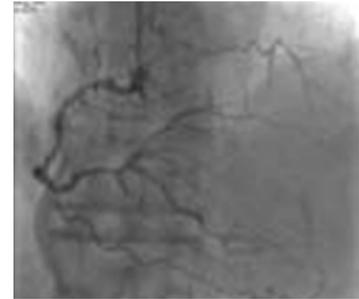


Fig. 2 Right coronary artery with collateral circulation of left anterior descending branch visible



Fig. 3 After first bypass surgery



Fig. 4 After moving anastomosis forward



Fig. 5 After stent implantation at the middle and distal parts of the right coronary artery

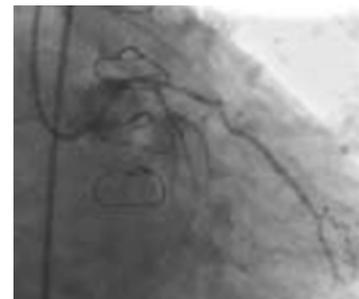


Fig. 6 After dilation of the proximal part of left circumflex artery where there was sub-total

## Case 3 One-stop Hybrid surgery for coronary artery disease

Patient information

Male, 52 years old

Diagnosis

Coronary heart disease

Angiography results: (Fig. 1, Fig. 2)

Left anterior descending branch total occlusion, 85% stenosis at the proximal of the right coronary artery;

Procedure:

Left internal mammary coronary artery was taken to perform the anterior descending branch bypass by minimally invasive surgical method. After the surgery, immediate angiography indicated good graft patency and satisfactory flow condition in the anterior descending branch (Fig.3, Fig. 4). For RCA, no residual stenosis remained after drug eluting stent implantation at the proximal part and the post-procedural blood flow was satisfactory (Fig. 5, Fig. 6).

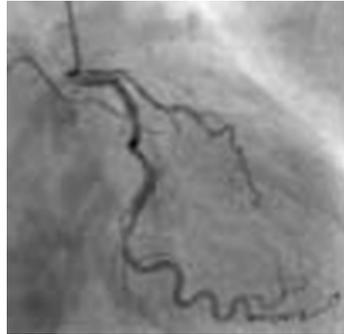


Fig. 1 Left coronary artery, total occlusion of anterior descending branch

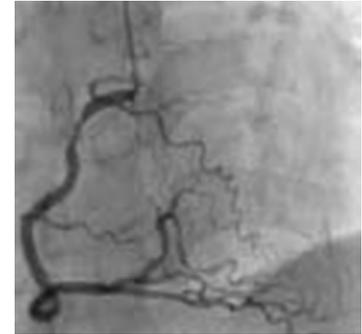


Fig. 2 Right coronary artery



Fig. 3 Bypass from internal mammary artery to anterior descending branch



Fig. 4 Bypass from internal mammary artery to anterior descending branch



Fig. 5 Before implantation of right coronary artery stent



Fig. 6 After implantation of right coronary artery stent

## Surgeons in Hybrid: Experience in Fuwai Hospital

### One-stop Hybrid approach for multivessel coronary artery disease

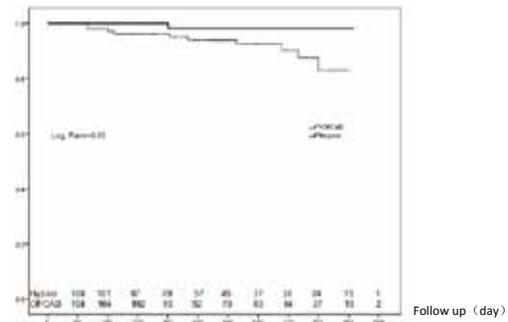
◆ time: 2007.6 - 2009.12;



#### Consumption of medical resource

Outcome <sup>a</sup>	Hybrid (n=104) <sup>a</sup>	OPCAB <sup>b</sup> (n=104) <sup>a</sup>	P Value
Conversion <sup>c</sup>	1 (1.0) <sup>a</sup>	0 (0) <sup>a</sup>	1.00 <sup>d</sup>
LOS <sup>e</sup> in ICU <sup>d</sup> (hours) <sup>a</sup>	34.5 ± 35.6 <sup>a</sup>	55.3 ± 46.4 <sup>a</sup>	<0.001 <sup>d</sup>
LOS in hospital (days) <sup>a</sup>	8.2 ± 2.6 <sup>a</sup>	9.5 ± 4.5 <sup>a</sup>	0.01 <sup>d</sup>
Intubation time (hours) <sup>c</sup>	11.6 ± 6.3 <sup>a</sup>	13.8 ± 6.8 <sup>a</sup>	0.02 <sup>d</sup>
Extubation in OR <sup>e</sup>	4 (7.7) <sup>a</sup>	0 (0) <sup>a</sup>	0.04 <sup>d</sup>
Intraoperative blood loss (mL) <sup>a</sup>	287 ± 111 <sup>a</sup>	341 ± 124 <sup>a</sup>	0.002 <sup>d</sup>
Chest tube drainage (mL) <sup>a</sup>	789 ± 389 <sup>a</sup>	834 ± 285 <sup>a</sup>	0.005 <sup>d</sup>
Chest tube drainage on POD <sup>f</sup> 1 (mL) <sup>a</sup>	610 ± 332 <sup>a</sup>	719 ± 395 <sup>a</sup>	0.08 <sup>d</sup>
PRBC <sup>g</sup> transfusion <sup>a</sup>	30 (28.8) <sup>a</sup>	54 (51.9) <sup>a</sup>	<0.001 <sup>d</sup>
Operative time (hours) <sup>a</sup>	4.1 ± 1.4 <sup>a</sup>	3.4 ± 0.7 <sup>a</sup>	0.005 <sup>d</sup>
In-hospital cost (\$) <sup>a</sup>	13,318 ± 3,261 <sup>a</sup>	10,301 ± 4,329 <sup>a</sup>	<0.0001 <sup>d</sup>

#### Freedom from MACCE



Ann Thorac Surg 2011;91:432-8

## Case 4 One-stop Hybrid surgery for complex congenital heart disease

### Patient information

Female, 3 years old

### Diagnosis

Congenital heart disease, tetralogy of Fallot

### Angiography results:

Lateral shunt from aorta to right lung (Fig. 1)

Embolization of the lateral shunt from aorta to right lung (Fig. 2)

### Comments:

The clinical advantages of the Hybrid surgery for complex congenital heart disease lie in the reduction of time between embolization and surgery. It helps to avoid serious anoxic blue spell and save time for surgery procedure. Severe complications as hemorrhage after surgery of malposition of great artery and overload of heart could be avoided.



Fig. 1 Shunt from aorta to right lung

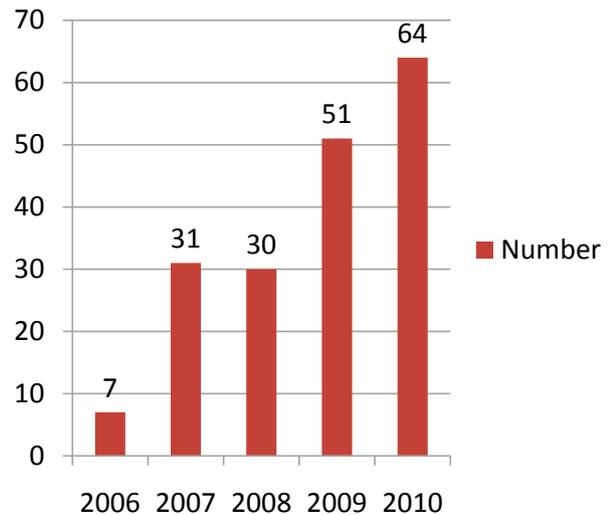
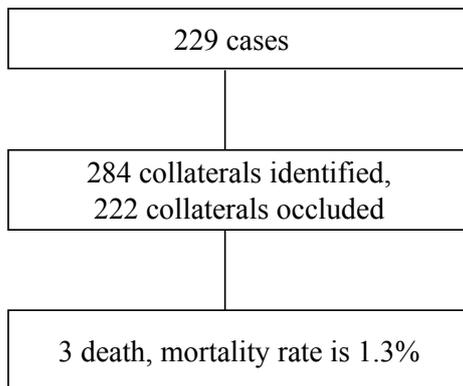


Fig. 2 Shunt embolized by coils

## Surgeons in Hybrid: Experience in China

### One-stop Hybrid approach for Sever cyanotic diseases with collateral

229 cases in Fuwai hospital from 2005 to 2010



## Case 5 One-stop Hybrid surgery for complex congenital heart disease

Patient information

Male: 2 days old

Diagnosis

Congenital heart disease, pulmonary atresia combined with intact ventricular septum

Surgical approaches:

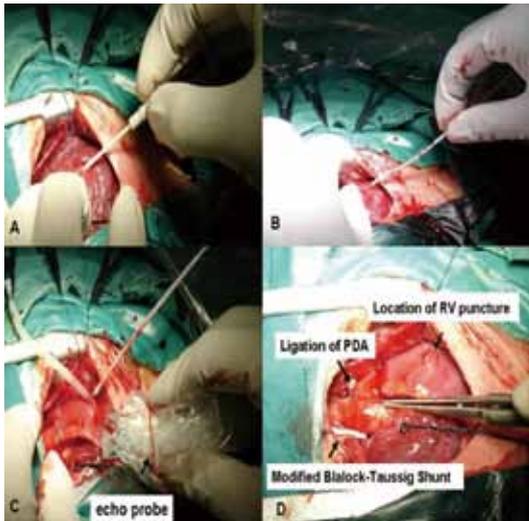


Figure 1: Trans-ventricular Balloon Valvuloplasty

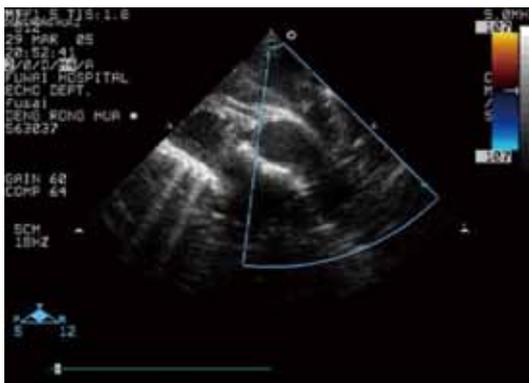


Figure 2: Guide wire was passed into PA



Figure 3: Balloon enter into PA



Figure 4: After a smaller diameter balloon (6-8) dilation

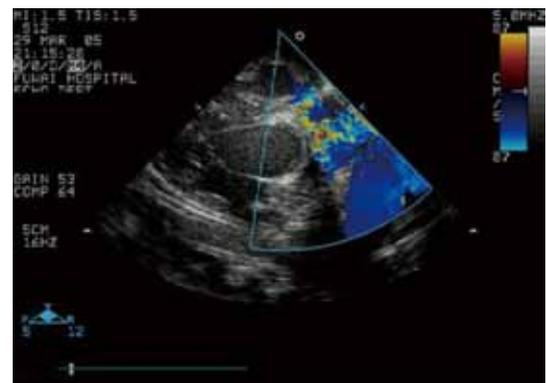


Figure 5: After a larger diameter balloon (10-12) dilate

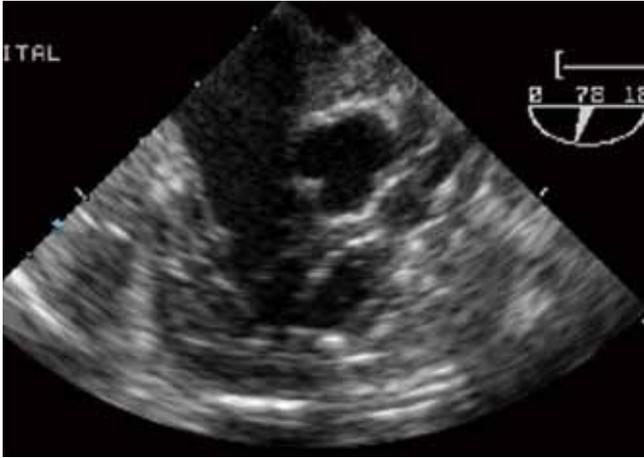


Figure 6: Balloon hemi-dilation: see a waist

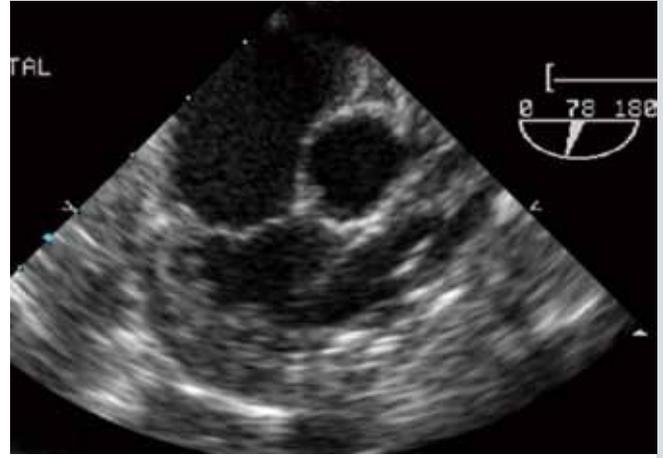


Figure 7: Balloon full-dilation: no waist

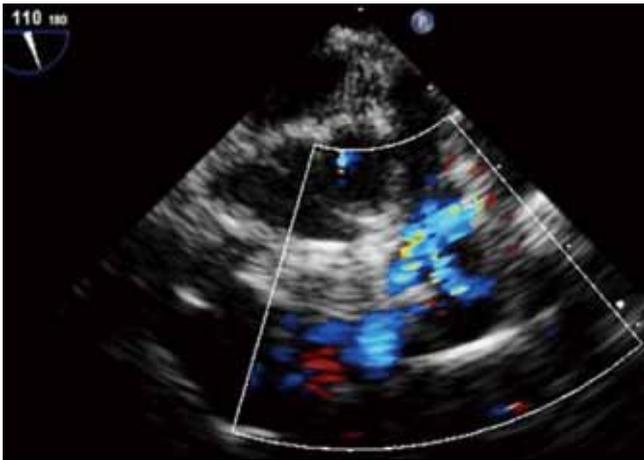


Figure 8: CDFI: show a forward blood flow

Comments:

- Clinical advantages of PAIVS Hybrid surgery lie in
1. A simple, safe, effective operation
  2. Lowering the possibility of reintervention before the definitive repair

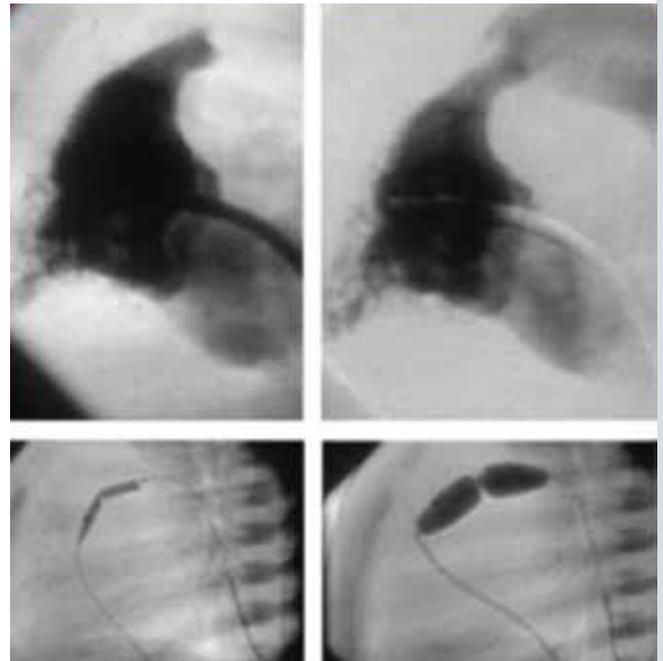
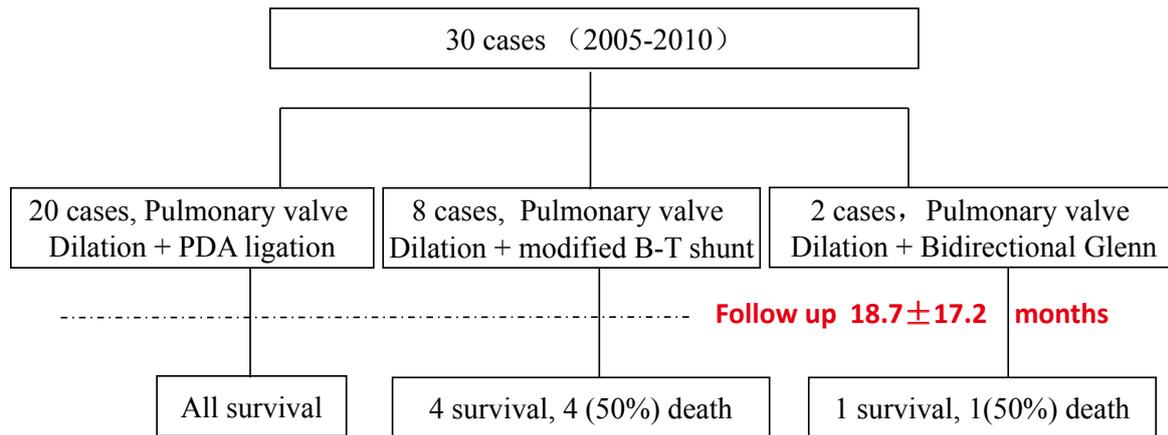


Figure 9: Angiography image

## Surgeons in Hybrid: Experience in China

### One-stop Hybrid approach for Pulmonary Atresia with Intact Ventricular Septum



Shou-jun Li et al, Ann Thorac Cardiovasc Surg 2010;16:407-409

## Surgeons in Hybrid: Experience in China

### One-stop Hybrid approach for Pulmonary Atresia with Intact Ventricular Septum

Hybrid approach	Conventional surgery	
Fuwai hospital	CHSS1 (multicentre, prospective)	CHSS2 (multicentre, prospective)
N=30	N=171	N=408
Time: 2005-2010	Time: 1987-1991	Time:1987-1997
1 month survival: 100%	1 month survival: 81%	1 year survival: 85%
5 year survival: 83.3%(25/30)	four years survival: 64%	5 years survival: 60%

Hanley FL et al. J Thorac Cardiovasc Surg. 1993;105:406

Ashburn DA et al. J Thorac Cardiovasc Surg 2004; 127;1000

## Case 6 One-stop Hybrid surgery for Aortic dissection

Patient information  
Female, 58 years old

Diagnosis  
Aortic dissection

Angiography results: (Fig. 1)

Aortic dissection in the descending aorta formed through blood flow impact on the wall ulcer (Left figure). Implantation of aorta stent and performance of endovascular stent-graft exclusion treatment (right figure) .

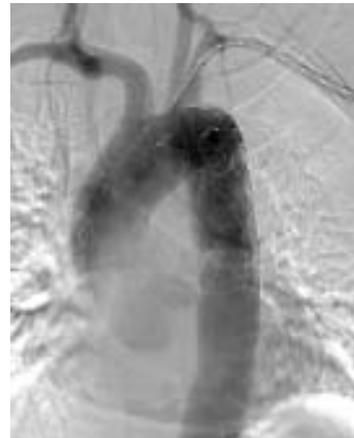


Fig. 1

## Case 7 One-stop Hybrid surgery for Aortic dissection

Patient information

Female, 65 years old

Diagnosis

Aortic dissection

Angiography results: (Fig. 1)

Giant dissection aneurysm started from aorta arch (left figure), implantation of aorta stent and performance of endovascular stent- graft exclusion treatment (right figure).

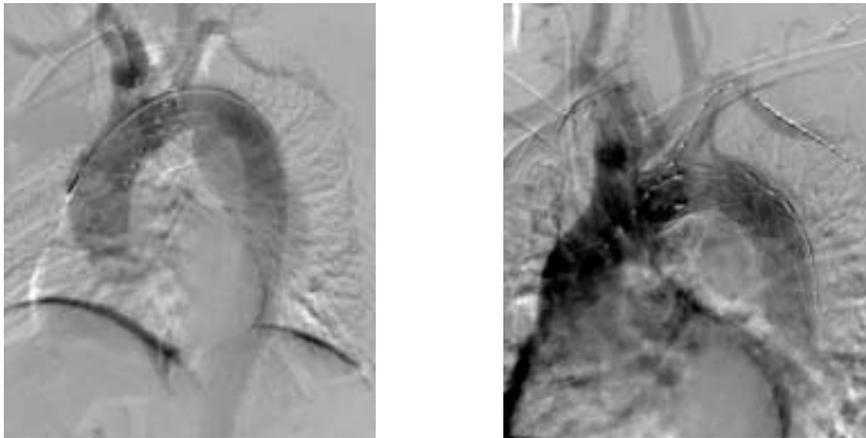


Fig. 1

## Case 8 One-stop Hybrid surgery for Stanford type A aortic dissection

Patient information

Male, 60 years old

Diagnosis

Stanford type A aortic dissection

CT and Angiography results:

Stanford type A aortic dissection (Fig. 1), Endovascular stent-graft exclusion after ascending aorta replacement + brachiocephalic vessel bypass surgery (Fig. 2), CT reexamination after surgery (Fig. 3).

Comments:

In whole process of Hybrid surgery of Stanford type A aortic dissection, no deep hypothermic circulatory arrest is needed. Complications of surgery are obviously reduced compared with traditional ascending aorta + full aortic arch replacement + "elephant trunk" stent-graft. It offers surgical opportunity for aged, high-risk patients with chronic renal insufficiency, COPD, blood coagulation disorders, etc. Also it significantly reduced blood consumption at the same time.



Fig1

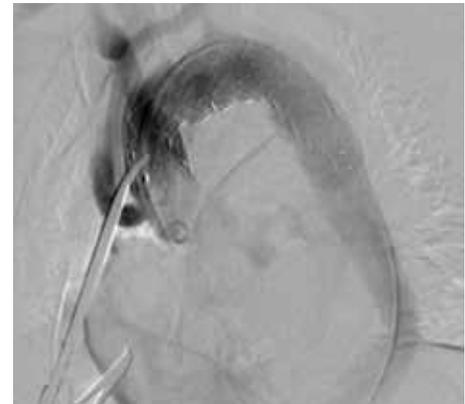


Fig2



Fig3

## Case 9 One-stop Hybrid surgery for aortic coarctation combined with other cardiac diseases

Patient information

Male: 32 years old

Diagnosis

Aortic coarctation, aortic root aneurysm

CT and angiography results

Aortic coarctation, aortic root dilatation (Fig. 1), aortic coarctation (Fig. 2), implantation of aortic balloon angioplasty stent (Fig.3), after implantation of aortic coarctation balloon angioplasty stent, performing BENTALL surgery by conventional method. CT re-examination after surgery (Fig. 4).

Comments:

Hybrid treatment for aortic coarctation combined with other cardiac diseases can be completed in one stage, avoiding the complexity of staging surgery and complication brought to the patient by traditional thoracic surgery. Balloon angioplasty stent treatment for aortic coarctation has revealed great clinical effect.

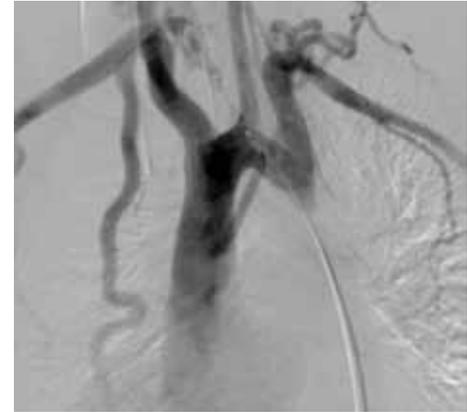


Fig2

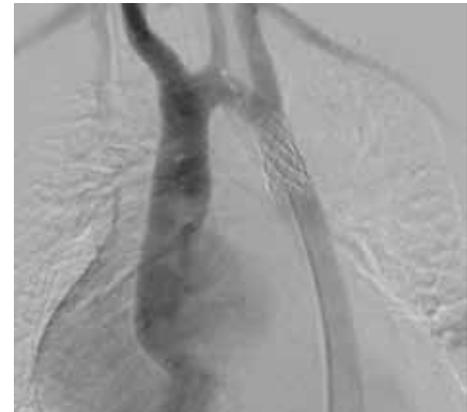


Fig3



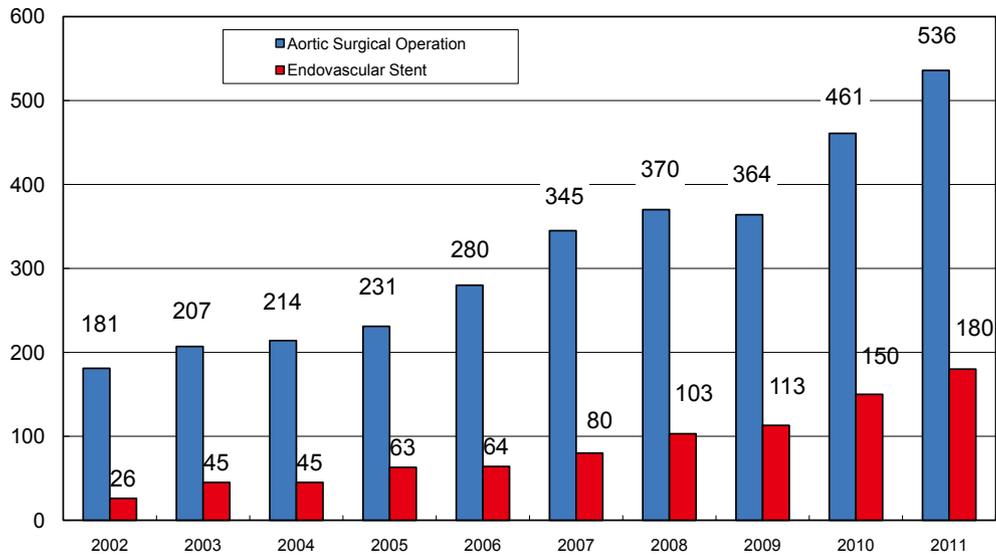
Fig1



Fig4

## Surgeons in Hybrid: Experience in Fuwai Hospital

### Volume of aortic surgery and endovascular stent in recent ten years



## Surgeons in Era of Hybrid: Experience in Fuwai Hospital

### One-stop Hybrid approach for type A acute aortic dissection

Outcome	Hybrid 2008-2011 (n=29)	Total arch replacement + stent elephant trunk 2003-2011 (n=616)
Cardiopulmonary bypass time (min)	132.0±24.0	181±51.7
Clamping time(min)	49.2±12.1	101±30.7
Deep hypothermic circulatory arrest time(min)	0	23±10.3
Plasma consumption (ml)	1616.67±947.56	2162.71±1336.65
Red blood cell consumption (u)	9.85±4.58	13.34±10.92



## Going hybrid?

**Go with a full service provider for hybrid operating rooms**

Artis zeego

This top-of-the-line C-arm system- the first to employ robotic technology- pushes the envelope. With its exceptional positioning flexibility, Artis zeego seamlessly adapts itself to your surgical workflow. Robot control systems enable unique imaging capabilities. As a floor-mounted unit, Artis zeego is ideally suited for the laminar airflow in operating rooms. It easily fulfills the high sterility standards of a hybrid OR, saving you construction costs during installation. What's more, system movements do not conflict with ceiling equipment such as OR lighting and imaging booms.



## How does a hybrid OR fit into my hospital?

Installing a hybrid operating room is a big decision for institution.

After all, every hospital is unique.

When planning a hybrid OR, there are lots of questions: Who will use the room?

What procedures will be performed there? What are the space requirements for equipment and team members? How will hospital workflow be impacted, particularly during surgery? What's the best way to finance it and how will utilization impact return on investment?

As a rule: The better the planning up front, the lower the costs. Siemens has been equipping hybrid ORs for more than 12 years. It has extensive experience in designing and installing customized hybrid operating suites, as the references in the back document.

With its in-depth knowledge of operating room dynamics and holistic approach to OR environments, Siemens can offer expert assistance at all stage of your hybrid journey.

## What will we put in it?

When you've determined the room's utilization, careful consideration should first be given to the imaging system. Fixed C-arms differ greatly in their space requirements, their body coverage capabilities during fluoroscopy, surgical positions to the support 3D imaging, their impact on OR hygienic standards,

and their level of surgical workflow integration. The imaging system forms the centerpiece of every hybrid operating suite.

Siemens provides a complete portfolio of fixed C-arm systems- everything from ceiling-mounted to robot control imaging solutions. Its broad Artis zee family of imaging systems has an appropriate solution. Its broad Artis zee family of imaging systems has an appropriate solution for virtually any hospital situation.

### Artis zee floor-mounted system

Featuring an extremely small footprint, Artis zee floor fits into virtually any operating room. Equipped with Multi-space.F, The system's C-arm and integrated OR table allow tremendous positioning flexibility.3D volumes with syngo DynaCT 3D support even highly complex structural interventions.

### Artis zee ceiling-mounted system

With its C-arm and flat detector positioning flexibility. Artis zee ceiling enables imaging at all angles around the patient and head to toe. Features such as InFocus and IsoTilt hold the projection on the region of interest during gantry and table movements.3D imaging with syngo DynaCT is excellent even for peripheral cases.

### Artis zee biplane system

With its two detectors, Artis zee biplane is a preferred choice for a broad range of neurosurgical and neurointerventional applications, and for treating patients for whom contrast media can pose a high risk (e.g. Pediatric patients). Its isocentric working position enables full patient coverage from head to toe.



## How will it all work together?

A hybrid OR is a crowded space. The imaging equipment, including ceiling-mounted monitors, is tightly integrated with the surgical table. It must allow unrestricted movement of other equipment like surgical lighes, anesthesia booms or hear-lung machines, Third-party information such as ultrasound or hemodynamics needs to be integrated into the overall system. The impact on laminar airflow should be kept to a minimum. Also, each team member requires enough space to work comfortably.

Installing a hybrid operating suite is a challenging undertaking. The Siemens Hybrid OR Planning Department can offer assistance in identifying key project stakeholders and ensuring that the needs of all parties are fully met. Detailed architectural room planning, including schematic drawings of floor and ceiling equipment as well as interactive 3D room models, are a great help for optimizing room utilization. Working in a hybrid environment and performing new procedures requires additional training by the entire OR staff. Other factors such as service support for key equipment are also essential. Siemens can provide assistance with all of these considerations.

### 1. Advanced imaging applications

Both 2D and 3D. For example, syngo Aortic ValveGuide, which supports transcatheter aortic valve implantations (TAVI), by automatically segmenting intra-operative 3D images, displaying anatomic landmarks and overlaying them with 2D fluoroscopy.

### 2. Monitors

The Artis zee large Display, a full-color, 56-inch medical-grade

screen, lets you view multiple inputs simultaneously directly at tableside.

### 3. Patient table

Easy access, superb positioning and a maximum weight capacity of 200kg (441 lbs) make the Artis OR surgical table an excellent choice for many specialties.

### 4. Laminar airflow

Floor-mounted systems such as Artis zeego offer clear advantages in the OR environment. Having no ceiling-mounted components, there is only minimal impact on the room's laminar airflow.

\*Under development. Not available for sale in the U.S.

\*CAUTION: Investigational Device. Limited by U.S. Federal Law to investigational Use. The information about this device is preliminary. The safety and effectiveness of the devices for the uses discussed have not been established. The device is under development and not commercially available in the United States; and its future availability cannot be ensured.

"The Guardian Program has been a great asset to our clinic. Siemens proactively responds, quickly, in real-time. Minor issues are only really minor if a system can continue to run. Siemens does what they need to do so we can get our job done faster."

Bill Crummer | Biomedical Engineer, Medical University of South Carolina, USA



## How can we operate it cost effectively?

Healthcare today is a dynamic and complex business with many economic challenges. System uptime, utilization, staffing and long-term profitability are key considerations with every investment. Siemens has a sizeable service portfolio to help you meet your performance and growth targets, including various financing solutions.

### Helping you finance your hybrid plans

Siemens offers various financing solutions to help you realize your hybrid OR plans and proactively pursue your business objectives.

### Continuous customer satisfaction

At Siemens, customer care is ongoing and takes many forms, covering everything from application training to full technical support, including equipment installation, maintenance, remote diagnostics and software upgrades. Our broad offering includes Enhanced Productivity Services such as the Siemens Guardian Program, which proactively monitors system performance in real time to detect and resolve potential errors before malfunctions occur and ensure optimal availability.

## Who can do all that?

As a major driving force behind numerous healthcare trends, Siemens has helped customers around the world plan and install a hybrid operating room ideally suited to their specific needs-and future needs.

### Partnerships with major OR suppliers

Siemens fosters long-standing partnerships with several leading OR equipment manufacturers to ensure seamless system integration and hardware compatibility.

The references in the back include hybrid OR installations where accessories from other OR suppliers were integrated.

### Going hybrid?

Go with a full service provider for hybrid operating rooms

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