The Edge and Limitations in Robotic Surgery in a Public System

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Introduction

- What is Robot in Medicine?
- What is the current application of robots?
- What are the advantages of robotic surgery?
- What are the limitations?
- What should we do with it in the local public system?

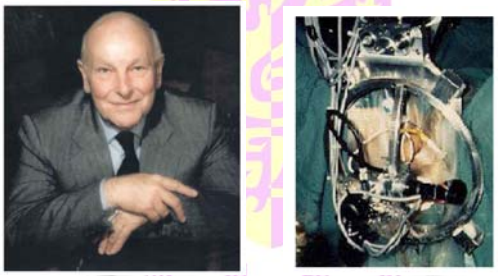
What is Robot in Medicine?

History of Robotic system

- First Robotic assisted surgery 1988
  - PUMA 560
  - Light duty industrial robotic arm to guide laser/needle for sterostactic brain surgery
- First Robotic urological surgery 1992
  - PROBOT-assisted TURP in Guy's Hospital in London leaded by Wickham
- First commercially available robotic system, 1992
  - ROBODOC for orthopaedic hip surgery
- First RCT of transatlantic telerobotics surgery
  - Between Guy's and John Hopkins Hospitals
  - PAKY-RCM percutaneous access robot (Kavoussi group developed in 1996)

Kwok et al IEEE Trans Biomed Eng 1988; 35: 153-60
Davies et al Proc Inst Mech Eng 1991; 205:35-8
Paul et al Clin Orthop 1992; 285: 57-66
Challacombe et al Comput Aided Surg 2005; 10: 165-71

PROBOT-assisted TURP



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Robotic system

- AESOP (Computer Motion), 1994
  - Automated Endoscopic System for Optimal Positioning – a voice-activated robotic arm for camera holder
  - First approved surgical robotic system by FDA
- ZEUS (Computer Motion)
  - Marketed in 1998
- Da Vinci (Intuitive Surgical)
  - Initially developed by US Department of Defence in 1991
  - Intuitive Surgical acquired the prototype and commercialized the system
  - Approved by FDA in July 2000
- In March 2003 – fusion of the two companies

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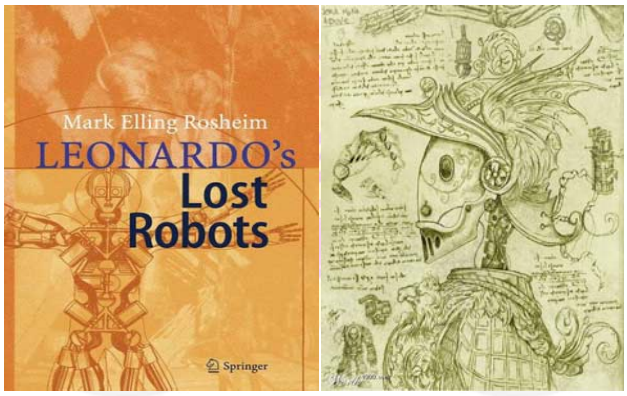
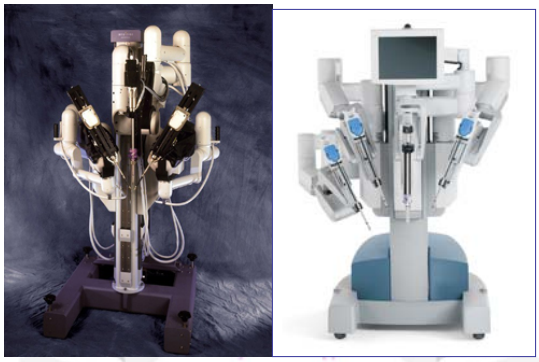




Current status in the World

- In 2007,
  - > 800 systems installed worldwide
  - ~ 50000 Robotic assisted laparoscopic prostatectomy, the most commonly performed robotic procedure, were done per year

Hong Kong Experience

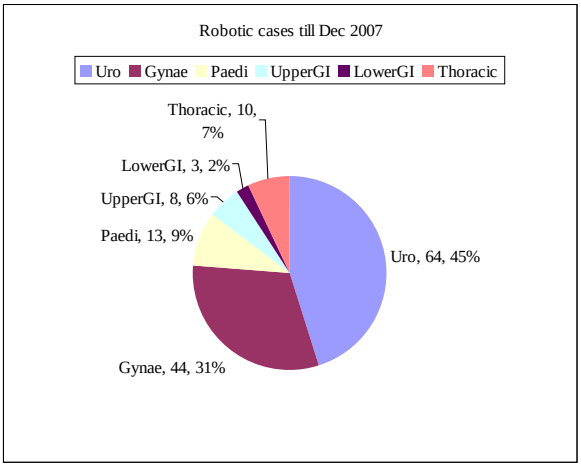
- First Machine
  - Installed in CUHK / PWH
  - Installed in November 2005
- Supported by donation by the Hong Kong Jockey Club and Kai Cheong Tong Foundation

Current status in Hong Kong

- Total 4 machines
  - 3 for services
  - 1 for training
- First Machine 11/2005 (PWH / CUHK)
- Second Machine 03/2007 (HK Sanatorium)
- Third Machine 10/2007 (QMH / HKU)
- Fourth Machine 12/2007 (PWH / CUHK)

- First machine is now used for training in CUHK

Current Applications



Case load for urology till 3/2008

Urological procedures	Number of patients
Radical prostatectomy	60
Radical cystectomy	4
Partial Nephrectomy	6
Pyeloplasty & ureteric surgery	4
Total	74

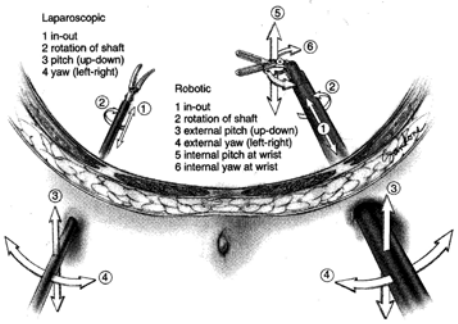
The Edges
The Advantages

Advantages of da Vinci system

- Technically
  - Patented Endowrist → 6 degrees of movement
  - 3-D vision (Dual channel endoscopy) and magnified view (x12)
  - Tremor suppression and scaling of movement
- Surgeon
  - Ergonomic advantage
  - Shorter learning curve
- Patient
  - Better outcome

Advantages

6 degrees of moment

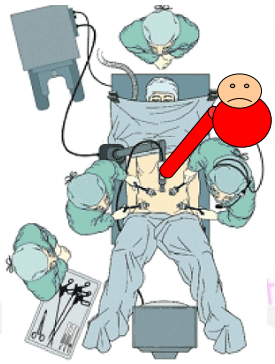


3-D vision

For Surgeon

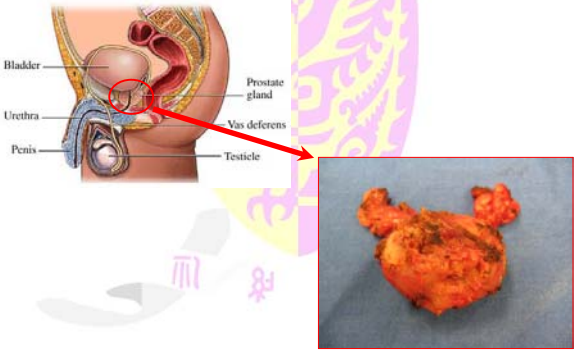
For Assistants

Laparoscopic Prostatectomy



Theoretical Advantages ? Real Clinical Benefits

Radical Prostatectomy



Surgical treatment – Localized Prostate cancer

- Open retropubic radical prostatectomy(OpRP)
- Laparoscopic
  - Pure laparoscopic (LapRP)
  - Robotic Assisted (RoRP)

The ideal situation

- Good clinical outcomes
  - Complications
  - Oncological
  - Functional
- Transferrable technology
  - Short Learning Curve
- Affordable cost

Advantages of MIS

- Reduced trauma to the body
- Reduced blood loss and need for transfusions
- Less post-operative pain and discomfort
- Less risk of infection
- Shorter hospital stay
- Faster recovery and return to normal daily activities
- Less scarring and improved cosmesis

OpRP vs RoRP

- Menon et al
  - 200 RoRP vs 100 OpRP
  - Open vs Robotics
    - Blood loss – 910 vs 150 ml
    - Transfusion rate – 67% vs 0
    - Hb level at discharge – 10 vs 13 g/dL
    - Complications – 20% vs 5%
    - Hospital stay – 3.5 vs 1.2 days
    - Duration of catheterization – 15.8 vs 7
    - Positive margin rate – 23% vs 9%
- Ahlering et al
  - Similar conclusion

Tewari et al BJU int 2003; 92: 205

Ahlering et al Urol 2004; 63: 819

Review of LapRP vs RoRP

- Intraoperative and postoperative outcomes – comparable
- OT time
  - RoRP 182 min (141-250)
  - LapRP 234 min (151-453)
- Estimated blood loss
  - RoRP 234 ml (75-500)
  - LapRP 482 ml (185-850)
- Single centre complications - similar

Rozet et al World J Urol 2006; 24: 171

Open vs Robotic in PWH/CUHK

	Open	Robotic
Last	20 (12/03 – 2/05)	10 (10/07 – 1/08)
Transfusion rate	13/20	1/10
DAT (median)	4	4
Off drain (median)	4	3.5
Mobilization (median)	4	3
Off catheter (median)	14.5	7
Margin positive	4/20	1/10

Comparison

	OpRP	LapRP	RoRP
• Good clinical outcomes			
– MIS / Complications	↓	↑	↑↑
– Oncological			
– Functional			
• Learning curve			
• Cost			

Oncological Outcomes

- Long term results still lacking
- 5 year outcomes
  - Bicochemical free survival = 84%

Badani et al Cancer 2007; 110: 1951

- From current data
  - Extrapolated → should meet the standards

Herrmann et al World J Urol 2007; 25: 149

Margin positive: OpRP vs RoRP

- Non-randomized trial
- Positive surgical margin rate higher in OpRP vs RoRP

Tewari et al BJU int 2003; 92: 205
Ahlering et al Urol 2004; 63: 819
Joseph et al J Urol 2007; 178: 2385

Margin positive rate

TABLE 4. *Risk profile and surgical technique for surgical margin positivity*

	No. Pos Margins/Total No. (%)		
	Robotic	Open	p Value
Risk profile:			
Low*	14/129 (10.9)	25/94 (26.6)	0.002
Intermediate†	9/58 (15.5)	28/74 (37.8)	0.005
High‡	7/13 (53.8)	18/32 (56.3)	0.883
Surgical technique:			
Nerve sparing	22/174 (12.6)	36/113 (31.9)	<0.001
Nonnerve sparing	8/26 (30.8)	35/87 (40.2)	0.366
p Value	0.054	0.221	

* PSA 10 ng/ml or less, Gleason score 6 or less, clinical stage T2A or less.
† PSA greater than 10 to 20 ng/ml or less, Gleason score 7, clinical stage T2B.
‡ PSA greater than 20 ng/ml, Gleason score 8 or greater, clinical stage T2C or higher.

Joseph et al J Urol 2007; 178: 2385
200 OpRP vs 200 RoRP

Comparison

	OpRP	LapRP	RoRP
• Good clinical outcomes			
– MIS / Complications	↓	↑	↑↑
– Oncological	↓	↔	↑
– Functional			
• Learning curve			
• Cost			

Potency

- OpRP: 21 – 90 %
- LapRP: 39 – 72 %
- RoRP: 36 – 84 %
- Comparable

Herrmann et al World J Urol 2007; 25: 149

Recovery of Continence

Table 3 Regain of continence after radical prostatectomy over time in ORP, LRP and RALP

Follow-up	ORP		LRP			RALP	
	Eastham [61]	Harris [32]	Salomon [30]	Stolzenburg [42]	Rassweiler [36]	Menon [46]	Joseph [54]
1 month (%)	28	38	45	NA	28	50[a]	28
3 months (%)	65	62	63	67.9	51	90[a]	93
6 months (%)	79	85	74	85	70	NA	96
12 months (%)	92	96	90	91.9	84	95.2[a]	NA
24 months (%)	95	NA	NA	NA	97	NA	NA

Herrmann et al World J Urol 2007; 25: 149

Comparison

	OpRP	LapRP	RoRP
• Good clinical outcomes			
– MIS / Complications	↓	↑	↑↑
– Oncological	↓	↔	↑
– Functional	↔	↔	↑
• Learning curve			
• Cost			

Transferrable techniques

- "See one, do one, teach one"
- NOT for Radical Prostatectomy
- Take time to learn

Learning curve
Initial experience of LapRP

- OpRP → LapRP
  - In 1992, Kavoussi and Clayman group, first successful lap RRP
  - "Offer No advantage"
  - No much report till 2000
  - European groups revisit the procedure

Schuessler et al J Urol 1991; 145: 988
Schuessler et al J Urol 1992; 147: supp: 246A abst 130

Learning Curve:
Real Life situation for RoRP

- In 2000, first cases by Binder and Kramer
- In 2001 ~ 250 cases done in US
- In 2007 estimated ~ 50000 per years

Binder and Kramer. Br J Urol 2001; 87: 408

Learning Curves - RoRP

- OpRP → RoRP
  - Menon = 18 cases
  - Ahlering = 12 cases
- Lap fellowship → RoRP
  - Patel = 18 cases
- Based on OR time

Menon et al J Urol 2002; 168: 945
Ahlering et al J Urol 2003; 170: 1738
Patel et al J Urol 2005; 174: 269

Short learning curve

- 8-10 cases for RoRP vs 80-100 cases for lapRP

Ahlering J Urol 2003; 170: 1738-41

What are the problems?

- During the learning phase
  - Suboptimal performance
- "supervised trial & error"
- To the patients
  - More bleeding
  - Longer operating time
  - More complications
  - More positive margins
  - Poor functional outcomes

Menon et al J Urol 2003; 169: 2289
Menon et al J endourol 2003; 17: 785
Ahlering et al Urol 2004; 64 1224-8

What are the problems?

- Low incidence in Chinese → even longer periods to be mature

At the end

- "Do you want to be operated by a learner?"
- If you don't want it, don't do it on the other

"己所不欲，勿施于人"

Comparison

	OpRP	LapRP	RoRP
• Good clinical outcomes			
– MIS / Complications	↓	↑	↑↑
– Oncological	↓	↔	↑
– Functional	↔	↔	↑
• Learning curve	↔	↓	↑
• Cost			

The Limitations

Disadvantages

- Cost
- Availability
- Lack of tactile sensation
  - Compensated by improved vision

What is the cost for Robotic surgery

- Machine purchase
  - HKD 18 millions
- +/- OR set up
  - Platform
- Yearly maintenance cost
  - HKD 1.2 million
- Consumable cost
  - ~ 15000 to 20000 per cases

Cost comparison (with respect to Open approach)

	OpRP	LapRP	RoRP	
			+ purchase / maintenance cost	No purchase / maintenance cost
Overall	**5544**	**6041**	**7280**	**6709**
Operating room	2428	**2876**	2204	2204
Equipment	**75**	533	1705	1705
Surgeon professional fee	1594	1688	1688	1688
Hospital room + board	**988**	**514**	**474**	**474**
IV fluid / Drugs	**150**	78	72	72
Robot cost	NA	NA	**857**	**286**

Lotan et al J Urol 2004; 172: 1431

- If not include the purchase of the machine
- Robotic RP
  - ~ US 1150 (~ HKD 9000) > Open RP
  - ~ US 700 (~ HKD 5500) > Lap RP

Lotan et al J Urol 2004; 172: 1431

Indirect cost

- Hospital
  - Cost for the management of Complications
  - Cost for the management of poorer outcomes (oncological etc)
- Patients
  - Loss of Work-productivity due to longer recovery
- Patients' expense
  - For continence devices ...
- Surgeons
  - Cost for Occupational health problems

The ideal situation

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• Good clinical outcomes			
– MIS / Complications	↓	↑	↑↑
– Oncological	↓	↔	↑
– Functional	↔	↔	↑
• Learning curve	↔	↓	↑
• Cost	↑	↔	↓(?)

The evidences

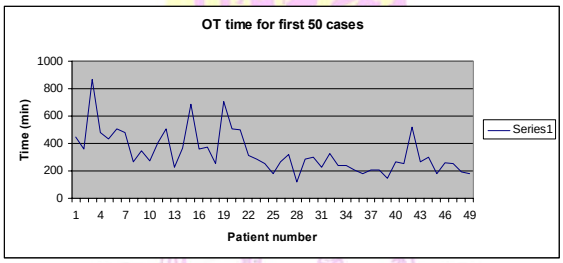
- No doubt
  - Better outcomes and results
  - More expensive (in simple calculation)
- How can we get the balance?
  - Decrease the cost

How to cut cost?

- Decrease the cost
  - Shorten OR time & hospital stay
  - Both can be improved with experience
- Increase case load
  - Share out the Maintenance cost

Scales et al J Urol 2005; 174: 2323

Our learning curve



Hospital stay

- Most patients insist to be catheter free before discharge
- Open surgery → 2 weeks

Open vs Robotic in PWH/UHK

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Hospital stay

- Most patients insist to be catheter free before discharge
- Open → RoRP
  - Median off catheter time shortened from 14.5 to 7 days
  - Cost saved = ~HK$ 3000 x 7 days
  - = HK$ 21000

- If not include the purchase of the machine
- RoRP
  - ~ US 1150 (~ HKD 9000) > OpRP
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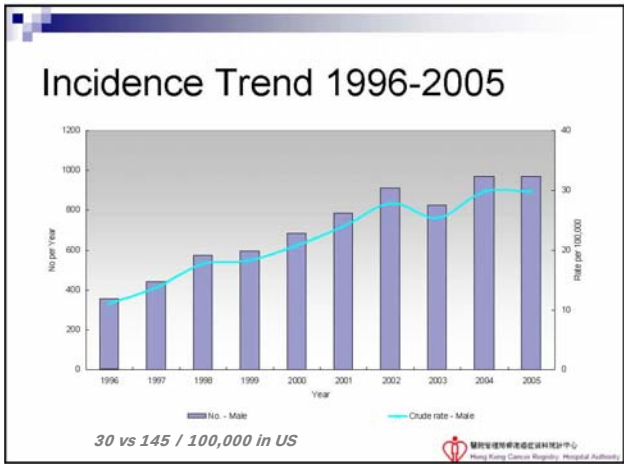

Case loads in Hong Kong

- New case per years
  - Around 30 per 100000
  - About 1000 new cases per years
- From PWH experience
  - About 1/3 clinically localized disease
  - Options
    - Radical prostatectomy
    - Radiotherapy
    - Watchful waiting

Prostatectomy cases

- From CDARS system
  - 1/4/2007 to 31/7/2008
  - Total 160 radical prostatectomy done in HA Hospital
- In Private Hospital
  - About 60 cases of Robotic radical prostatectomy done for 1 year
- If we assumed the public robotic system can handle about the same (or slightly higher) case load as that of the private hospital
  - 160 cases = ~3 robotic systems

Better usage of resources

- Other examples in HK
  - Transplant Surgery
  - Vascular surgery
  - Trauma centre
- Robotic prostatectomy
  - an ultra-major surgery
  - better to be concentrated in certain centres

Better usage of resources

- Concentrate in certain centres for the procedure
  - Increase case load → Better usage of resources
  - Improve performance → shorter operation time, hospital stay → less cost
  - Better training opportunities – rotation of staffs
- → Benefit our patients and our health care systems

Justification of Usage

- More cases → cheaper cost
  →Using Robot for all surgery?

Technique Development vs Real Benefits

Availability vs Unjustified Usage

The Evidences

	OpRP	LapRP	RoRP
• Good clinical outcomes			
– Complications	↓	↑	↑↑
– Oncological	↓	↔	↑
– Functional	↔	↔	↑
• Learning curve	↔	↓	↑

Review of evidences

Formulate clinical guidelines for justification of usages

Conclusion

- Robotic Assisted procedure
  - No doubt in improving the quality of care of our patients
  - No doubt in increasing the financial burden to the health care system
- A careful balance of the indications, clinical evidences, resources/patients allocation is crucial to maximize the cost-effectiveness of the procedure

Thank You