



Robotic assisted surgery

Background, Situation today, Future Questions

Jonas Johannink

AG Chirurgische Technologie und Training

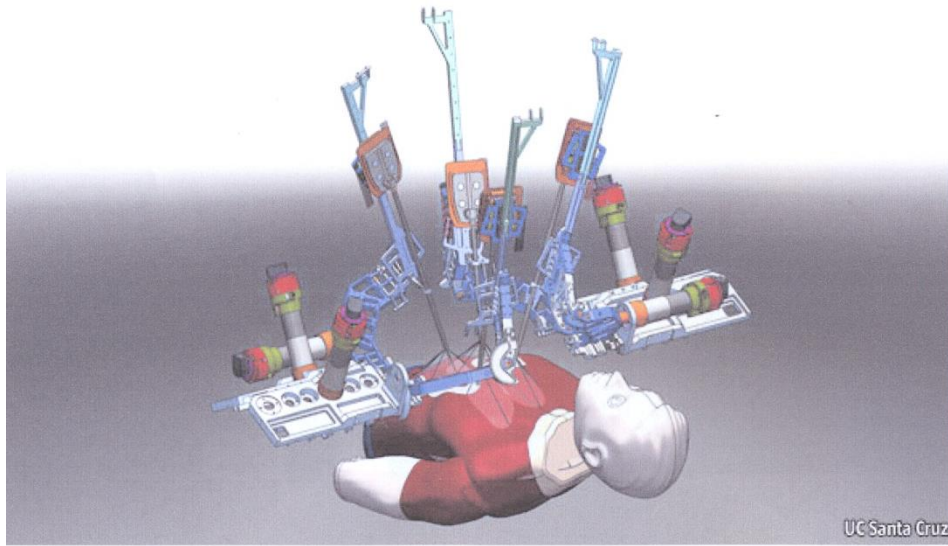
Why?

Where does the idea come from?



- Robot aided surgery on the battle field

Wish and reality



What happened in the past?

- Lots of projects
- But little Progress
- Huge Developments

project name	number of manipulating arms	joint technology	imaging technique	sterilisable?
ANUBIS [37]	2	bending	flexible endoscope	questionable
Azuma et al. [50]	2	bending	rigid endoscope	questionable
COBRASURGE [34]	2	discrete	video	no
ENDOMIA [59]	2	flexible	flexible endoscope	n/a
ENDOSAMURAI [38]	2	flexible	flexible endoscope	questionable
Harada et al. [60]	2	discrete	flexible or rigid endoscope	manipulators: yes
HVSPS [61]	2	flexible	flexible endoscope	questionable
IREP (SPORT) [35]	2	flexible	video	questionable
Low et al. [41]	2	discrete	flexible endoscope	questionable
MAGS [62]	2	discrete	video	n/a
NEUROBOT [49]	2	discrete	rigid endoscope	possibly
Park et al. [63]	2	bending	flexible endoscope	questionable
SNAILSURGEON [36]	3	discrete	not included	sterile draping
SPRINT [51]	2-4	discrete	not included	possibly
STRAS [39]	2	bending	Flexible endoscope	possibly
Suzuki et al. [40]	2	bending	flexible endoscope	questionable
Tognarelli et al. [64]	1	discrete	video	no
Toyoda [65]	2	discrete & bending	flexible endoscope	questionable
VIACATH [66]	2	discrete	flexible endoscope	questionable

Actual clinical implementations

- Cholecystectomy single Port
- leftsided Pancreatectomie
- transanal rektal resection
- onkologic Colon resection
- Bariatric Surgery

Technical developments

- Haptic Feedback
- Navigation
- Better Visualisation
- Deep learning / neuronal Networks

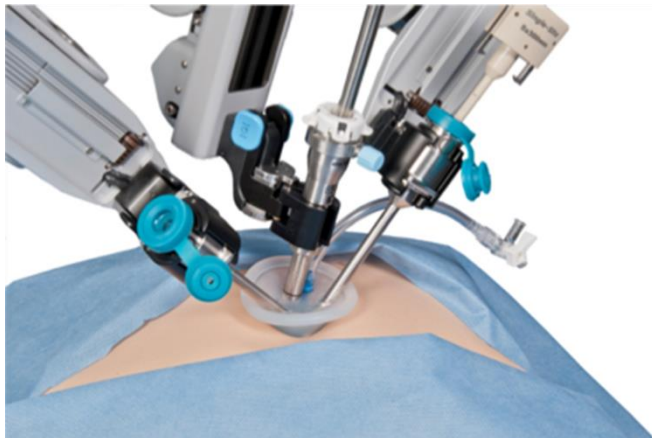
Robotic assisted single Incision Cholecystectomy

- No difference in clinical outcome
- Score Quality of Life (BIQ+PSQ):
 - Better cosmesis
 - Improved body picture

Follow-up visit	RSSC	MPLC	<i>P</i> value
2-Week follow-up, <i>n</i>	77	52	
Question 1, mean score $\pm$ SD (95% CI)	8.27 $\pm$ 2 (5.27–5.74)	7.21 $\pm$ 2.13 (5.86–6.87)	0.004
Questions 5, mean score $\pm$ SD (95% CI)	7.75 $\pm$ 2.71 (7.14–8.37)	6.6 $\pm$ 2.41 (5.92–7.27)	0.014
6-Week follow-up, <i>n</i>	67	45	
Questions 1, mean score $\pm$ SD (95% CI)	8.84 $\pm$ 1.62 (8.44–9.23)	8.13 $\pm$ 1.9 (7.56–8.7)	0.038
Questions 5, mean score $\pm$ SD (95% CI)	8.94 $\pm$ 1.56 (8.56–9.32)	8.24 $\pm$ 1.82 (7.7–8.79)	0.032
3-Month follow-up, <i>n</i>	66	48	
Questions 1, mean score $\pm$ SD (95% CI)	9.23 $\pm$ 1.12 (8.95–9.5)	8.06 $\pm$ 1.88 (7.52–8.61)	0.0003
Questions 5, mean score $\pm$ SD (95% CI)	9.42 $\pm$ 1.12 (9.15–9.7)	8.15 $\pm$ 1.83 (7.61–8.68)	<0.0001

Statistically significant *P* values are given in bold

RSSC robotic single-site cholecystectomy, MPLC multiport laparoscopic cholecystectomy; SD standard deviation of the mean, 95% CI 95% confidence interval of the mean



Kudsi, O. Y., A. Castellanos, S. Kaza, J. McCarty, E. Dickens, D. Martin, F. M. Tiesenga, K. Konstantinidis, P. Hirides, S. Mehendale and A. Gonzalez (2016). "Cosmesis, patient satisfaction, and quality of life after da Vinci Single-Site cholecystectomy and multiport laparoscopic cholecystectomy: short-term results from a prospective, multicenter, randomized, controlled trial." Surgical Endoscopy: 1-9.

Left sided pancreatic resection

- Safe Performance
- Shorter operation time
- But reduced rate of splenectomies (less complex?)

Outcome Parameter	LDP (N = 94)	RADP (N = 30)	P
Procedure duration (mean ± SD) (min)	372 ± 141	293 ± 93	<0.01
Planned splenectomy	77 (82)	28 (93%)	0.157
Estimated blood loss (mL)	150 (100, 300)	150 (100, 300)	0.688
Frequency of blood transfusion (%)	12 (13)	3 (10%)	1.00
Average units transfused	2.25 ± 1.36	2.33 ± 0.58	0.921
Median estimated blood loss (mL) in upper quartile (>75th percentile for blood loss)	550 (400, 650)	375 (300, 550)	<0.05
Converted to open	15 (16)	0 (0%)	<0.05
Postoperative admission to intensive care unit	31 (33)	7 (23)	0.370
Pancreatic fistula	39 (41)	14 (46)	0.676
International Study Group of Pancreatic Fistula grade A	23 (24)	6 (20)	NS
International Study Group of Pancreatic Fistula grade B	11 (12)	4 (13)	NS
International Study Group of Pancreatic Fistula grade C	5 (5)	4 (13)	NS
90-day morbidity			0.658
Minor (Clavien 1/2)†	47 (50)	14 (46)	
Major (Clavien 3/4)†	13 (14)	6 (20)	
Length of stay (d)	7.1 ± 4.0	6.1 ± 1.7	0.183
90-day readmission	22 (23)	11 (37)	0.162
30-day mortality	1 (1.1)	0 (0%)	1.0

Normally distributed values are expressed as mean ± SD or n (%); otherwise: median (25th, 75th percentile) as IQR. Boldface represents statistically significant values.

†Clavien classification of surgical complications.¹⁶

Robot-Assisted Minimally Invasive Distal Pancreatectomy Is Superior to the Laparoscopic Technique.

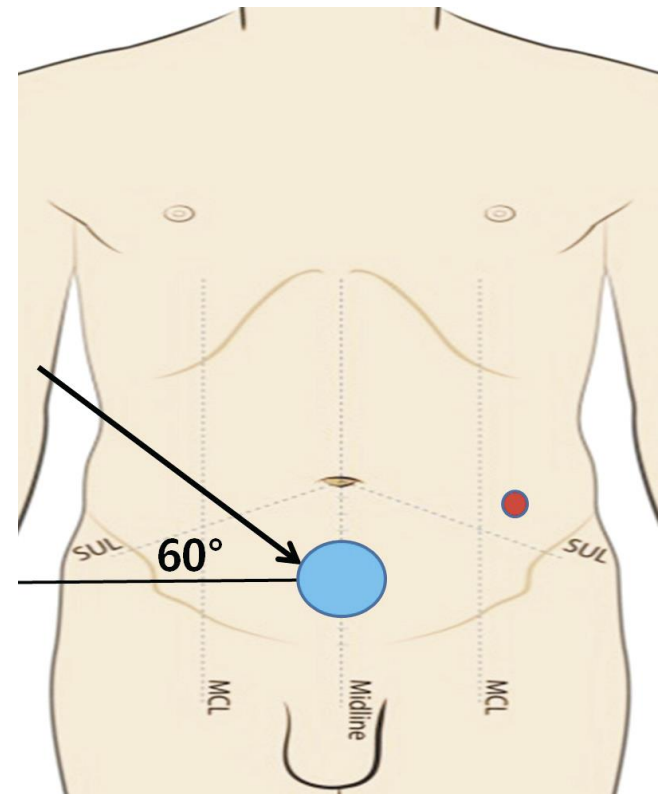
Daouadi, Mustapha; Zureikat, Amer; Zenati, Mazen; MD, MPH; Choudry, Haroon; Tsung, Alan; Bartlett, David; Hughes, Steven; Lee, Ken; Moser, A; Zeh, Herbert

Annals of Surgery. 257(1):128-132, January 2013.

DOI:
10.1097/SLA.0b013e31825fff08

Oncologic right hemicolectomy

- CME safe and successful
- Central vascular ligation



Bae, S. U., W. K. Jeong and S. K. Baek (2016). "Single-port plus an additional port robotic complete mesocolic excision and intracorporeal anastomosis using a robotic stapler for right-sided colon cancer." *Ann Surg Treat Res* **91**(4): 212-217.

Further use cases

- Transanal rectal resection R- TAMIS
 - Case Report 58 year old patient
- Bariatric surgery
 - Successful Gastric sleeve
- Hernia inguinalis both sides

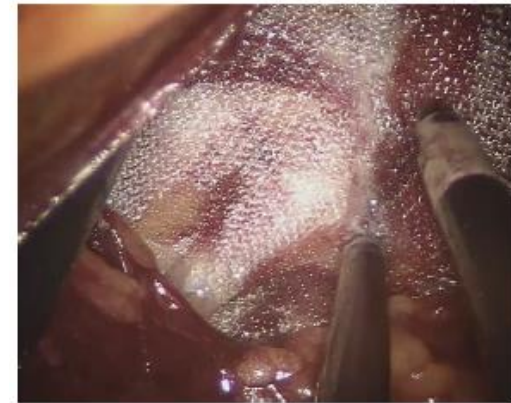


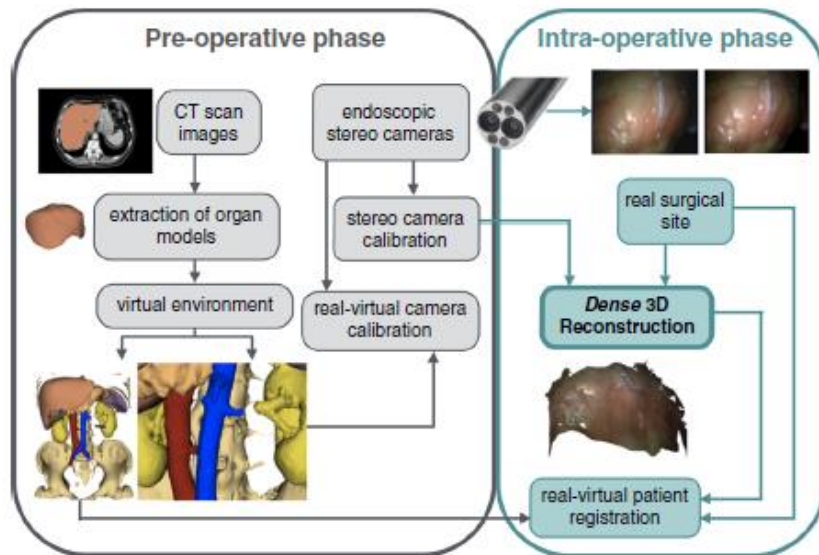
Table 2 Intraoperative and postoperative outcomes

Patient	Op. time (min)	Console time (min)	Intraop complications	Post operative hospital stay (hours)	Post op. complications	Post op pain (VAS score 1–10) at discharge	Post op pain (VAS score 1–10) 7 days after surgery
W.A.	155	105	None	21	None	3	2
M.D.	86	63	None	18	None	3	1
C.A.	55	42	None	22	None	2	2

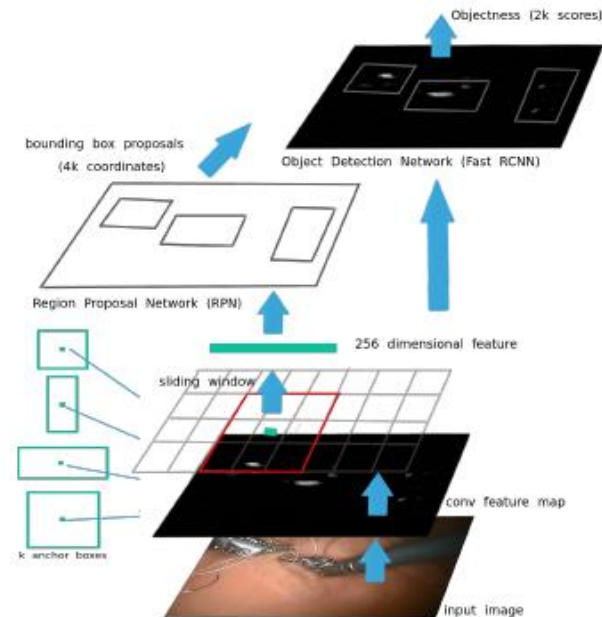
Cestari, A., A. C. Galli, M. N. Sangalli, M. Zanoni, M. Ferrari and G. Roviato (2016). "Totally extraperitoneal (TEP) bilateral hernioplasty using the Single Site(R) robotic da Vinci platform (DV-SS TEP): description of the technique and preliminary results." Hernia.

Navigation and Deep Learning

- Analysis of instruments and pictures
- combination with preoperative radiology data



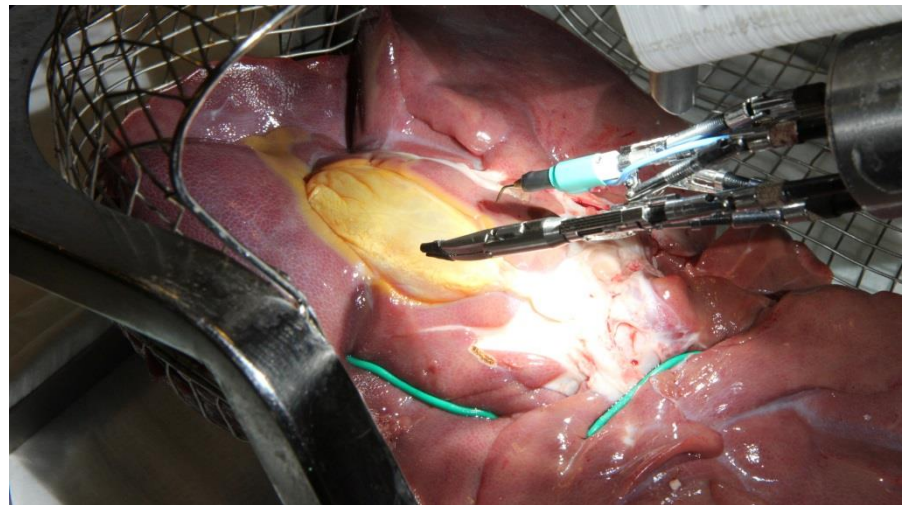
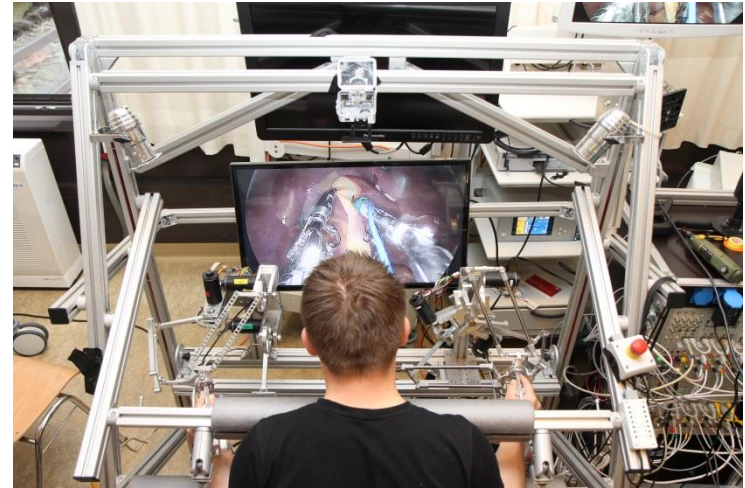
Penza, V., J. Ortiz, L. S. Mattos, A. Forgione and E. De Momi (2016). "Dense soft tissue 3D reconstruction refined with super-pixel segmentation for robotic abdominal surgery." *Int J Comput Assist Radiol Surg* **11**(2): 197-206.



Sarikaya, D., J. Corso and K. Guru (2017). "Detection and Localization of Robotic Tools in Robot-Assisted Surgery Videos Using Deep Neural Networks for Region Proposal and Detection." *IEEE Trans Med Imaging*.

Flexmin System

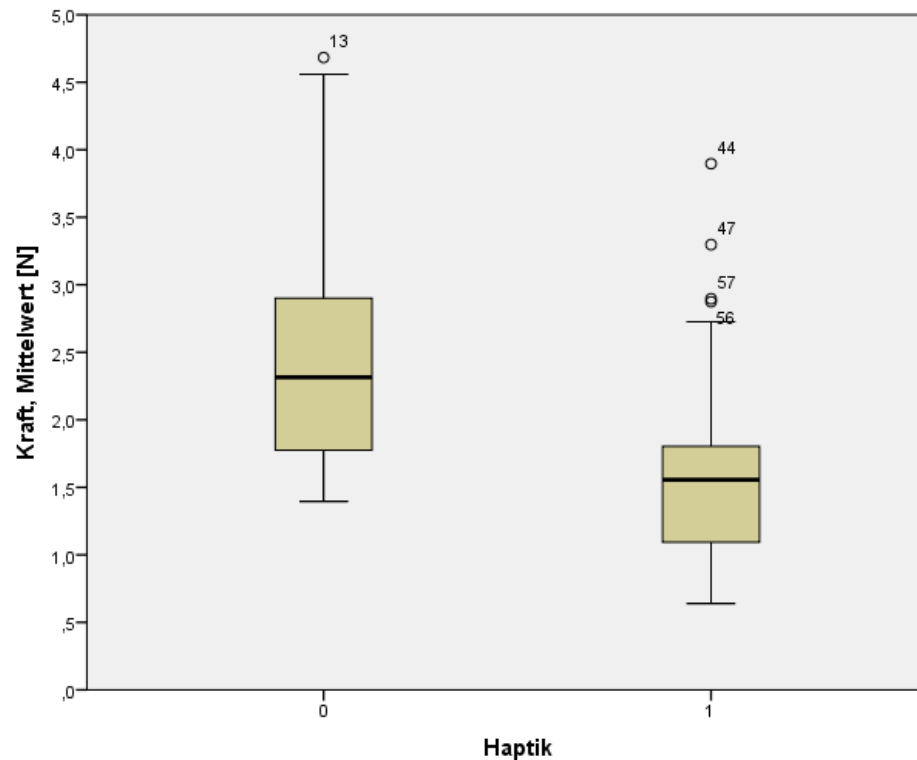
- Master Slave Unit
- Single Incision OP
- Indications:
 - Rectal surgery
 - Cholezystektomy
 - Hernia inguinalis
- Integration haptic Feedback



Study haptic Feedback

- 11 Participants
- Task:
 - Draw a circle
- Analysis of force
- Favors haptic Feedback

Boxplots mit vs. ohne Haptik



Mittelwerte der Druckkräfte ohne (links) und mit (rechts) haptisches Kraftgefühl an der Bedienkonsole.

n = 11 Probanden à 6 Durchgänge à 3 Kreise gezeichnet (198 Kreise)

Unterschied signifikant ($p = 0,002$)

Replacement of open Surgery

- Development:
 - Replacement for the option to feel:
 - Navigation
 - haptic Feedback
 - More sensors
 - Same options as normal surgery:
 - Performance of complex operations
 - Use of standard equipment
 - Energy Based Devices
 - Stapler
- Assistance of artificial intelligence

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Vielen Dank
für Ihre Aufmerksamkeit!