Robotic Liver Surgery

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Carolinas Medical Center

Uncompromising Excellence. Commitment to Care.

Disclosures

- Proctor, Speaker, HBP Advanced Course Director for Intuitive Surgical
- Course faculty for Ethicon, Medtronic
- No other financial interests


FIRST WORLD CONGRESS OF THE

Twelve Minutes. . . ?

- Not here to try to convince you that robotics is superior to laparoscopic
- Provide my insights into the use of robotics for liver surgery
- 11 years of experience. The hard way.

Objectives

- Discuss the “Why” of Robotics
- Literature for robotic liver surgery
- Demonstrate some technical aspects of robotic liver resections
- Present CMC experience

Why?

- Morbidity of incision vs procedure
  - Pain and physiological effect of the incision vs. "what is done on the inside"
- Approach this question with both an *open mind and a skeptical eye.*
- Try to be rational and practical, but not a *crumudgeon.*

Why?

- Truth. . . . .
- Humility. . .
- Honesty. . . .

AHPBA 2014

What percentage of your liver cases are you doing either laparoscopic or robotic?

- None at all
- Some, up to 25%
- Between 25 and 50%
- Between 50 and 75%
- Most, >75%

Approx. 80% minimal

Why Robotics?

- *Can robotics improve upon what we already do?*
  - Can it reduce operative times?
  - Can it reduce blood loss?
  - Can it reduce fistula rates?
  - Can it reduce hospital length of stays?
  - Can it reduce pain?

Why Robotics?

- *Can robotics allow us to do things we cannot do?*
  - At least not easily or very well
- *Can it help the surgeon?*
  - Reduce stress, fatigue, exc. . .
- *What about oncological outcomes?*

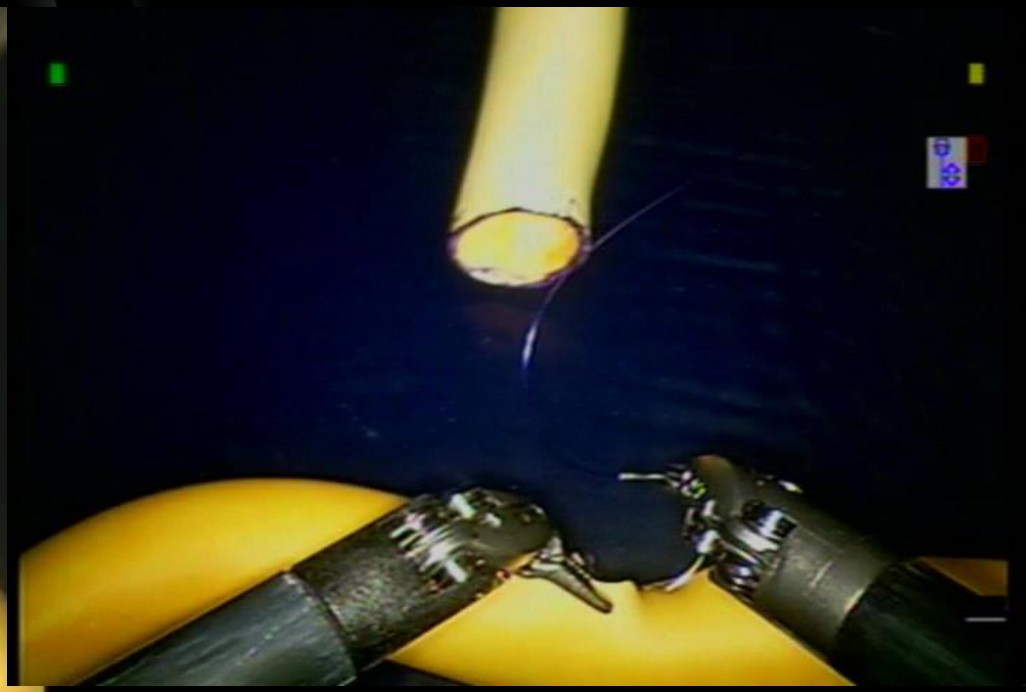
Advantages of Robotics

- 3-D binocular scope, depth perception
- 10x magnification
- Extends the limits of the human ROM
- Dampens tremors
- “fine tunes” motions, “scaling”
- Operator controls camera and 4th arm

Advantages of Robotics

- Ergonomics: may reduce surgeon stress, physical fatigue*
- May improve suturing skills**
  - Clutching mechanism
- *"May allow us to things which are simply too difficult to do with standard laparoscopy"*

Fine Suturing



Training and Education

Drivers Education

Disadvantages of Robotics

- Lack of tactile feedback
  - (visual haptics)
- Physical distance from patient
- Prohibits HALS techniques
- Hinders assistants mobility
- Multi-quadrant procedures difficult
- Cost

"But I don't need a robot to do that"

- Common refrain, often from (former) pioneers in their respective fields
- "I'm only going to use the robot for complex cases, like whipples"
- "I only dock the robot for the reconstruction"

Attitude is Everything

Current Literature

ORIGINAL ARTICLE

Totally Robotic Right Hepatectomy

Surgical Technique and Outcomes

Pier Cristoforo Giulianotti, MD; Fabio Sbrana, MD; Andrea Coratti, MD; Francesco Maria Bianco, MD; Pietro Addeo, MD; Nicolas Christian Buchs, MD; Subhashini M. Ayloo, MD; Enrico Benedetti, MD

- Single surgeon retrospective series
  - Archives Surg July 2011 volume 146 no. 7
- Two institutions, sequential time periods
- 24 (13/11) fully robotic anatomical right lobes
- Outstanding description of technique
- Outcomes compare favorably to laparoscopic series in terms of conversions, transfusion, blood loss, morbidity/mortality, and LOS

Table 3. Intraoperative and Postoperative Results Among 24 Patients

Variable	Value
Conversion to open surgery	1
Operative time, mean (SD) [range], min	337 (65) [240-480]
Intraoperative blood loss, mean (SD) [range], mL	457 (401) [100-2000]
Blood transfusion	3
Secondary procedures	
Partial diaphragmatic resection	2
Extensive adhesiolysis	2
Ventral hernia repair	1
Mortality	0
Morbidity	
Transitory liver failure	2
Pleural effusion	1
Bile leak	1
Fluid collection	1
Deep venous thrombosis	1
Postoperative hospital length of stay, mean (SD), d	9.0 (3.0)
Italy	11.0 (5.0)
US	5.5 (2.0)

Robotic liver resection: technique and results of 30 consecutive procedures

Gi Hong Choi · Sung Hoon Choi · Sung Hoon Kim · Ho Kyoung Hwang · Chang Moo Kang · Jin Sub Choi · Woo Jung Lee

Received: 3 October 2011 / Accepted: 11 January 2012 / Published online: 4 February 2012

- Single surgeon/institution series
  - Surg Endo 2012, 26(2247-2258).
- 30 consecutive liver resections
- *Surgeon began with liver resections*
- Demonstrate typical learning curve

Table 3 Type of resection and perioperative outcomes

Type of resection	No.	Mean operative time (min)	Mean blood loss (ml)	Transfusion	Conversion
Wedge resection	4	226 (120–330)	199 (95–300)	0	0
Segmentectomy (segment 4b and partial segment 5)	2	534 (420–648)	138 (100–175)	0	0
Left lateral sectionectomy	4	451 (322–660)	216 (100–250)	1	0
Left hepatectomy	14	518 (315–763)	328 (150–900)	1	1
Right hepatectomy	6	724 (648–812)	629 (100–1500)	2	1
Total	30	507	343	4 (13.3%)	2 (6.6%)

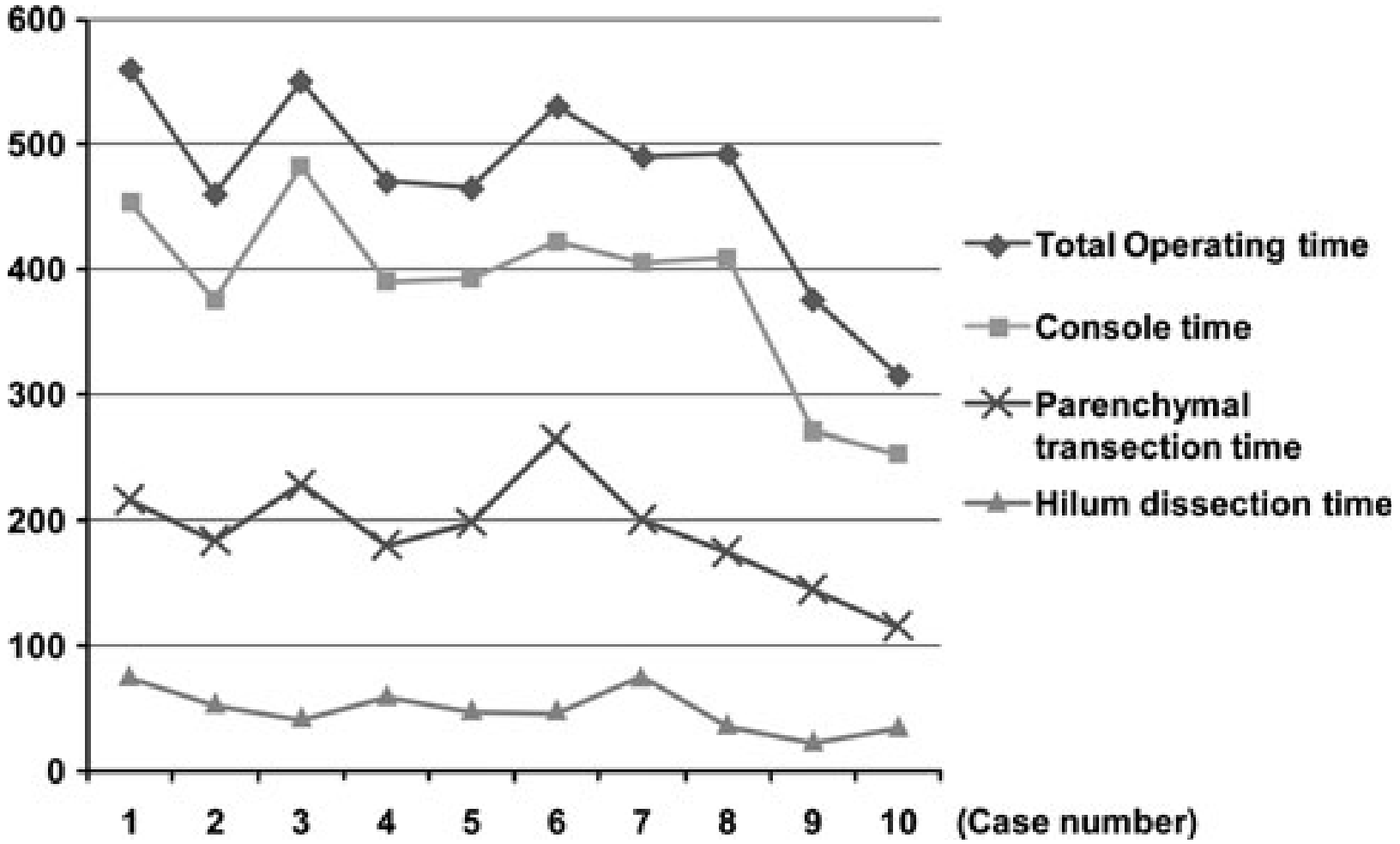


Fig. 5 The operation time according to each procedure in left hepatectomy

Robotic Versus Laparoscopic Hepatectomy

A Matched Comparison

Allan Tsung, MD, David A. Geller, MD,* Daniel C. Sukato, BA,* Shirin Sabbaghian, MD,† Samer Tohme, MD,* Jennifer Steel, PhD,* Wallis Marsh, MD,* Srinevas K. Reddy, MD,‡ and David L. Bartlett, MD†*

- Retrospective review cohort study
  - Annals of Surgery, March 2014 (e-published)
- 1:2 case match using demographics, comorbidities, performance status and extent of resection (57:114)
- Major hepatectomies compared
- In robotic group, patients were divided into early vs late groups

TABLE 1. Comparison of Robotic Versus Laparoscopic Groups: Demographic and Preoperative Parameters

	Robotic ($n = 57$)	Laparoscopic ($n = 114$)	Overall P
Cirrhosis, No. (%)	3 (5)	6 (5)	1.00
Steatohepatitis, No. (%)	5 (9)	10 (9)	1.00
Extent of resection			1.00
Major	21	42	
Minor	36	72	
ASA			0.41
1	0	1	
2	8	24	
3	42	75	
4	7	8	
Diagnosis			0.82
Benign	19	36	
HCC	7	18	
CRC	21	36	
Others	10	24	
Age, mean (SD), y	58.35 ± 14.6	58.72 ± 15.8	0.88
Male, No. (%)	24 (42)	47 (41)	0.91
BMI, mean (SD), kg/m^2			0.11
Underweight (<18.5)	1	1	
Normal (18.5–24.9)	15	45	
Overweight (25–29.9)	19	41	
Obese (>30.0)	22	25	
No. lesions*	1 (1–2)	1 (1–2)	0.26
Largest tumor size,* cm	3.15 (2.05–5.00)	3.50 (2.0–6.0)	0.55
Tumor type			0.82
Malignant, No. (%)	40 (70)	78 (68)	
Benign, No. (%)	17 (30)	36 (32)	
All	57	114	
Laparoscopic resection type			
Pure lap, No. (%)	53 (93.0)	55 (49.1)	<0.001
Hand-assisted lap	0	31	
Hybrid	0	16	
Converted to open	4 (7)	10 (8.8)	0.67

*Reported as median (IQR).

TABLE 3. Comparison of Major Robotic Versus Laparoscopic Groups: Demographic and Preoperative Parameters

	Robotic ($n = 21$)	Laparoscopic ($n = 42$)	Overall P
Cirrhosis, No. (%)	1 (5)	2 (5)	1.00
Steatohepatitis, No. (%)	4 (19)	8 (19)	1.00
ASA			0.53
1	0	1	
2	5	12	
3	12	20	
4	4	3	
Diagnosis			0.96
Benign	9	18	
HCC	4	6	
CRC	5	11	
Others	3	7	
Age, mean (SD)	59.90 ± 14.8	53.29 ± 17.5	0.14
Male, No. (%)	11 (52)	15 (36)	0.21
BMI, mean (SD), kg/m^2			0.64
Underweight (<18.5)	0	1	
Normal (18.5–24.9)	6	15	
Overweight (25–29.9)	9	19	
Obese (>30.0)	6	7	
No. lesions*	1 (1–2)	1 (1–2)	0.17
Largest tumor size,* cm	3.7 (2.45–5)	5.4 (2.5–8.0)	*0.021*
Tumor type			0.15
Malignant, No. (%)	15 (71)	22 (52)	
Benign, No. (%)	6 (29)	20 (48)	
All	21	42	
Laparoscopic resection type			
Pure lap, No. (%)	17 (81)	3 (7.1)	<0.001
Hand-assisted lap	0	18	
Hybrid	0	14	
Converted to open	4 (19)	7 (16.7)	0.67

*Reported as median (IQR).

TABLE 6. Comparison of Robotic and Laparoscopic Groups: Operative and Postoperative Parameters

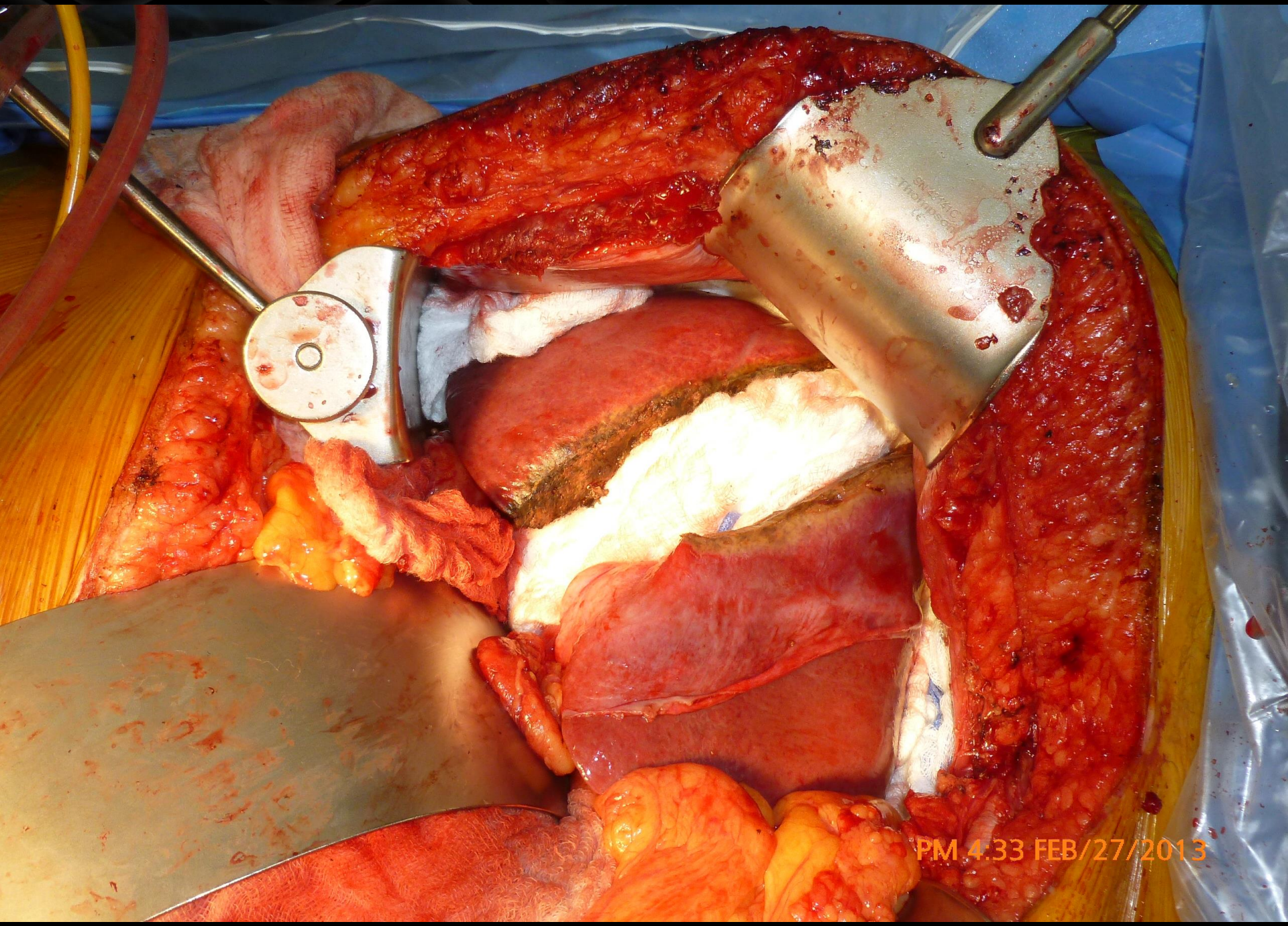
	Robotic ($n = 57$)	Laparoscopic ($n = 114$)	Overall P
EBL, median (IQR) mL	200 (50–337.5)	100 (50–350)	0.097
Transfusion rate, No. (%)	2 (3.8)	7 (7.4)	0.372
Room time, median (IQR), min	342 (264–453)	261.5 (199.5–333)	*<0.001*
OR time, median (IQR), min	253 (180–355)	198.5 (137.75–261.5)	*0.001*
Complication rate, No. (%)	11 (19.3)	29 (26)	0.34
Major complication rate, No. (%)	1 (1.8)	1 (0.9)	0.624
Postoperative peak bilirubin	1.15 (0.7–1.7)	1.2 (0.8–1.6)	0.895
Postoperative ICU, No. (%)	11 (19)	8 (8.5)	0.053
LOS, median (IQR), days	4.0 (3.0–5.5)	4.0 (3.0–5.0)	0.10
30-d mortality, No. (%)	0 (0)	1 (0.9)	0.478
90-d mortality, No. (%)	0 (0)	2 (1.8)	0.314
R0 negative margin, No. (%)	40 (95)	98 (92)	0.44

TABLE 8. Comparison of Major Robotic and Laparoscopic Groups: Operative and Postoperative Parameters

	Robotic ($n = 21$)	Laparoscopic ($n = 42$)	Overall P
EBL, median (IQR), mL	200 (87.5–450)	300 (100–650)	0.527
Transfusion rate, No. (%)	1 (5.6)	6 (18.8)	0.197
Room time, median (IQR), min	452 (352–547)	348.5 (299–413)	0.003
OR time, median (IQR), min	330 (265–453.5)	280.5 (226–332.75)	0.036
Complication rate, No. (%)	5 (24)	13 (32)	0.517
Major complication rate, No. (%)	1 (4.8)	0 (0)	0.159
Postoperative peak bilirubin	1.4 (1.05–3.3)	1.4 (0.9–2.6)	0.734
Postoperative ICU, No. (%)	5 (24)	3 (7)	0.061
LOS, median (IQR), d	5 (4–10)	4.5 (4–6)	0.489
30-d mortality, No. (%)	0 (0)	0 (0)	1.00
90-d mortality, No. (%)	0 (0)	0 (0)	1.00
R0 negative margin, No. (%)	14 (100)	38 (93)	0.30

Overall robotic approach allowed for an increased percentage of major hepatectomies to be performed in purely minimally invasive fashion (81% vs 7.1% P<0.05)

Why all the fuss about an incision?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Can’t we do a better job?


UNDER ARMOUR

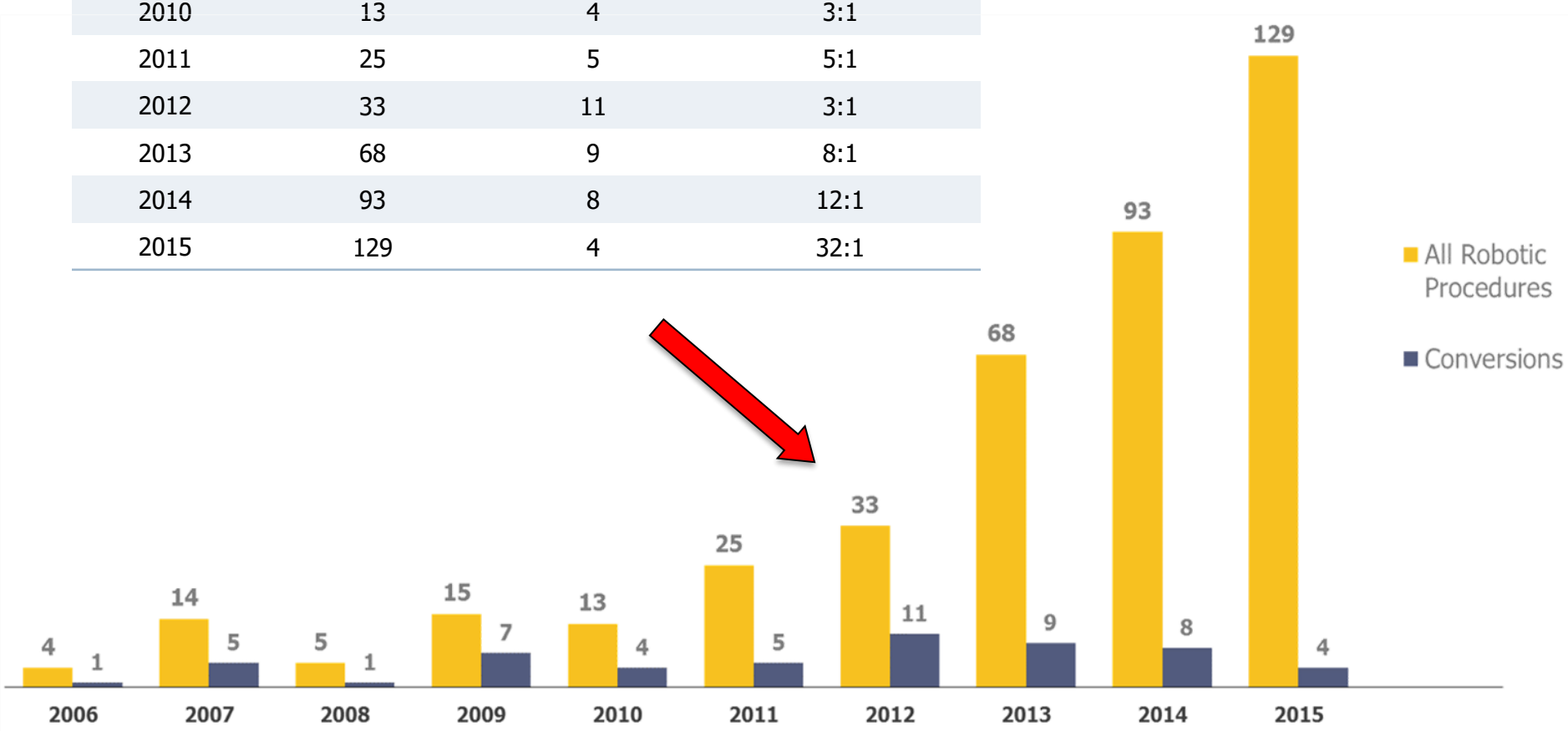
Carolinas Medical Center

Charlotte, North Carolina

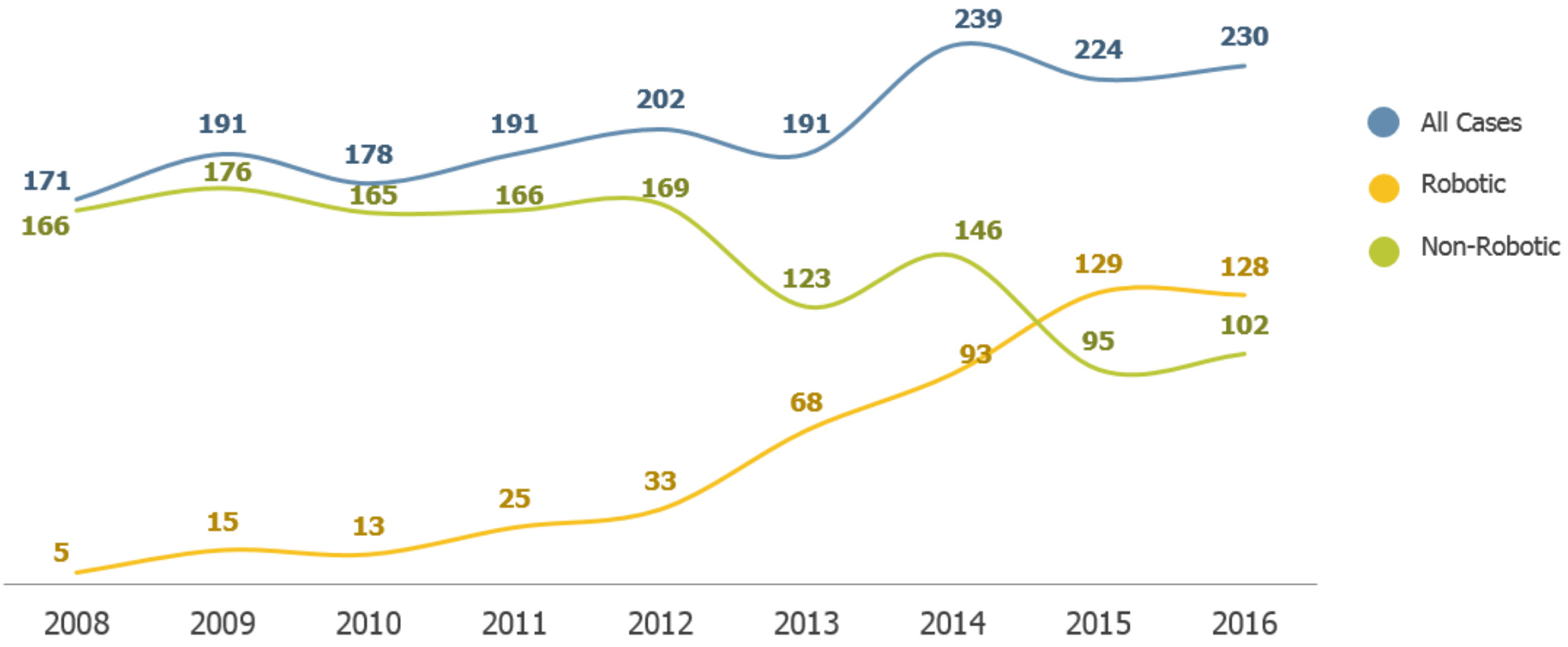

INTUITIVE
SURGICAL

Procedures and Conversions

Year	Procedures	Conversions	Ratio Procedures to Conversions
2006	4	1	4:1
2007	14	5	3:1
2008	5	1	5:1
2009	15	7	2:1
2010	13	4	3:1
2011	25	5	5:1
2012	33	11	3:1
2013	68	9	8:1
2014	93	8	12:1
2015	129	4	32:1



All Cases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2008
2009
2010
2011
2012
2013
2014
2015
2016
All Cases
Robotic
Non-Robotic

Background

(how I got started on all this)

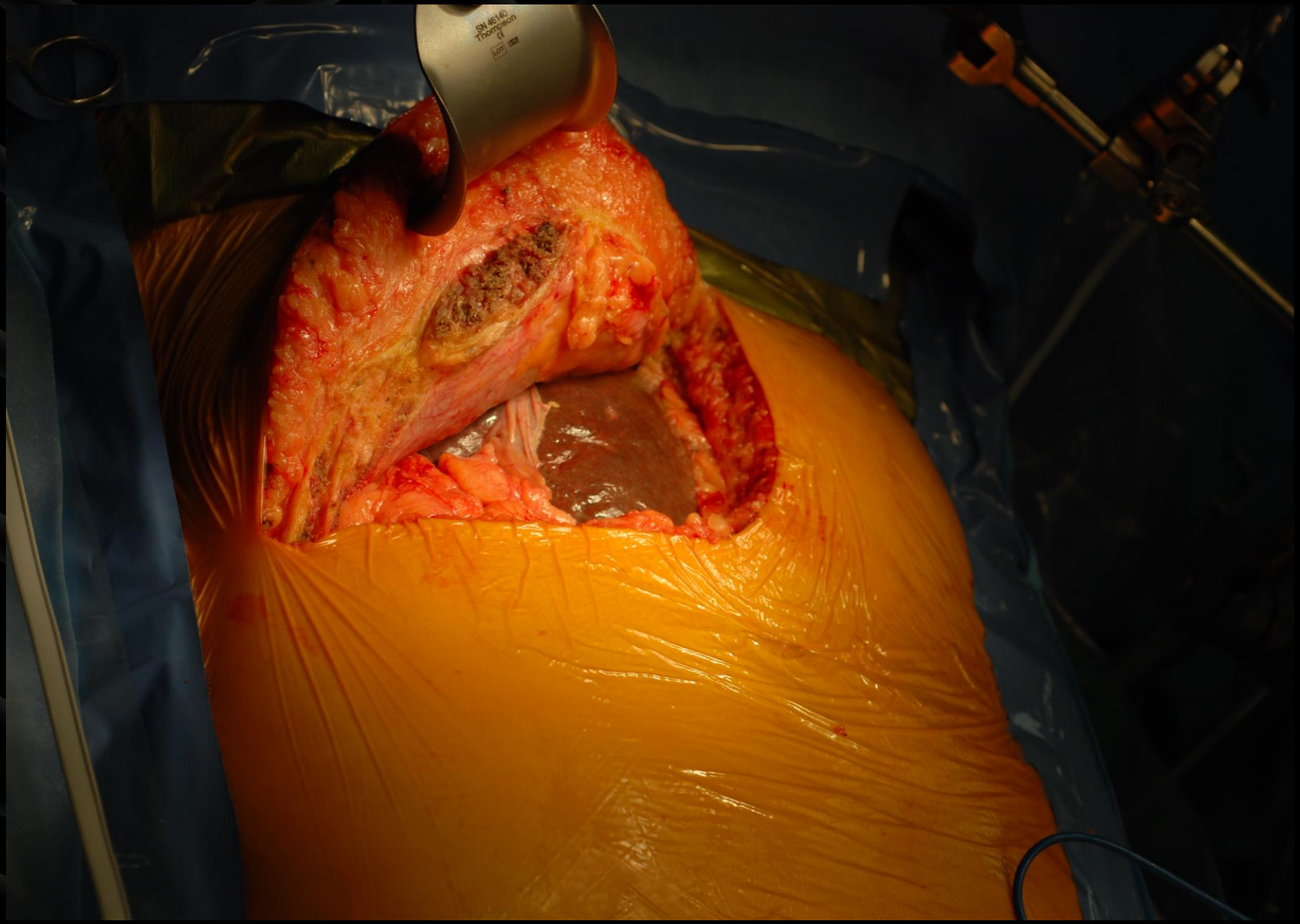
- AHPBA 2005, Cincinnati course
- First Lap left lateral hepatectomy performed at McGill Peter Metrakos
- March 2006, first robotic case, UNC-CH
- Simultaneously and gradually began developing both lap and robotic cases
- AHPBA 2008
- Summer 2012, full robotic formal hepatectomies and whipples

Learning Curves

- Open, Lap, Robotic learning curves running simultaneously. . .but with synergy
- Optimal training programs and pathways shorten the process

Progression?

- Open to Lap
- Open to hybrid
- Open to HALS
- Open to robotic
- Lap to robotic
- *I don't profess to know which way is best.*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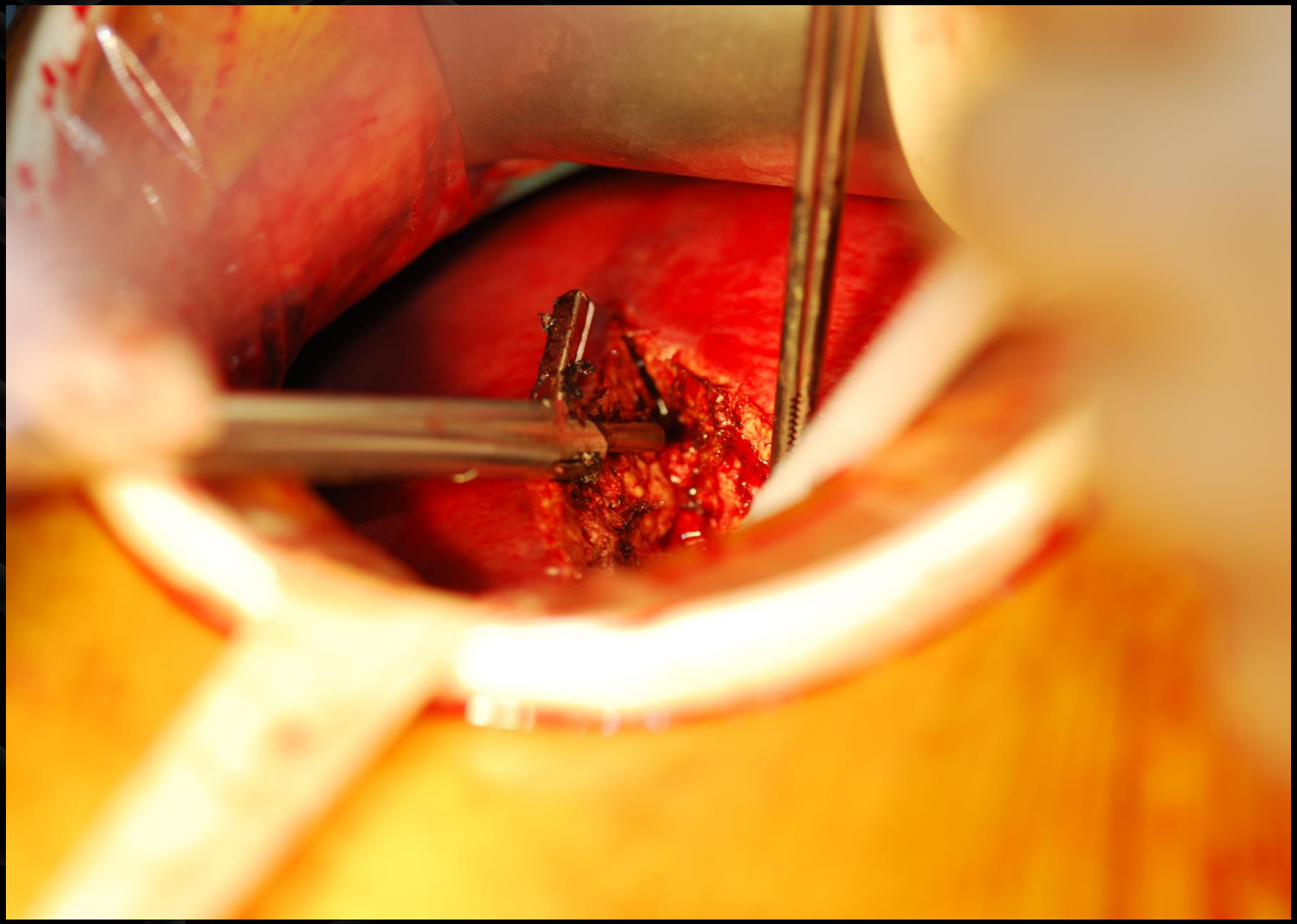

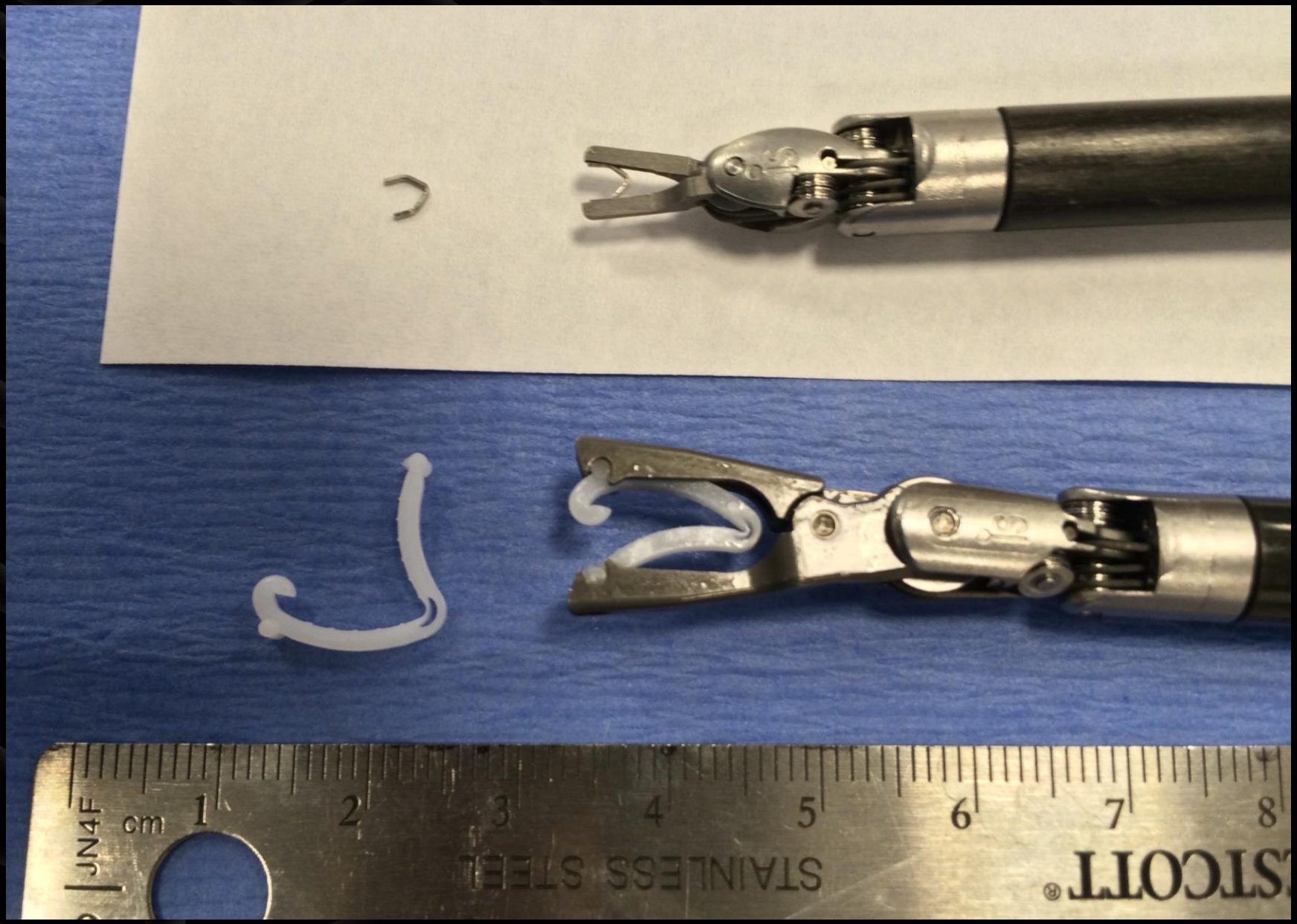
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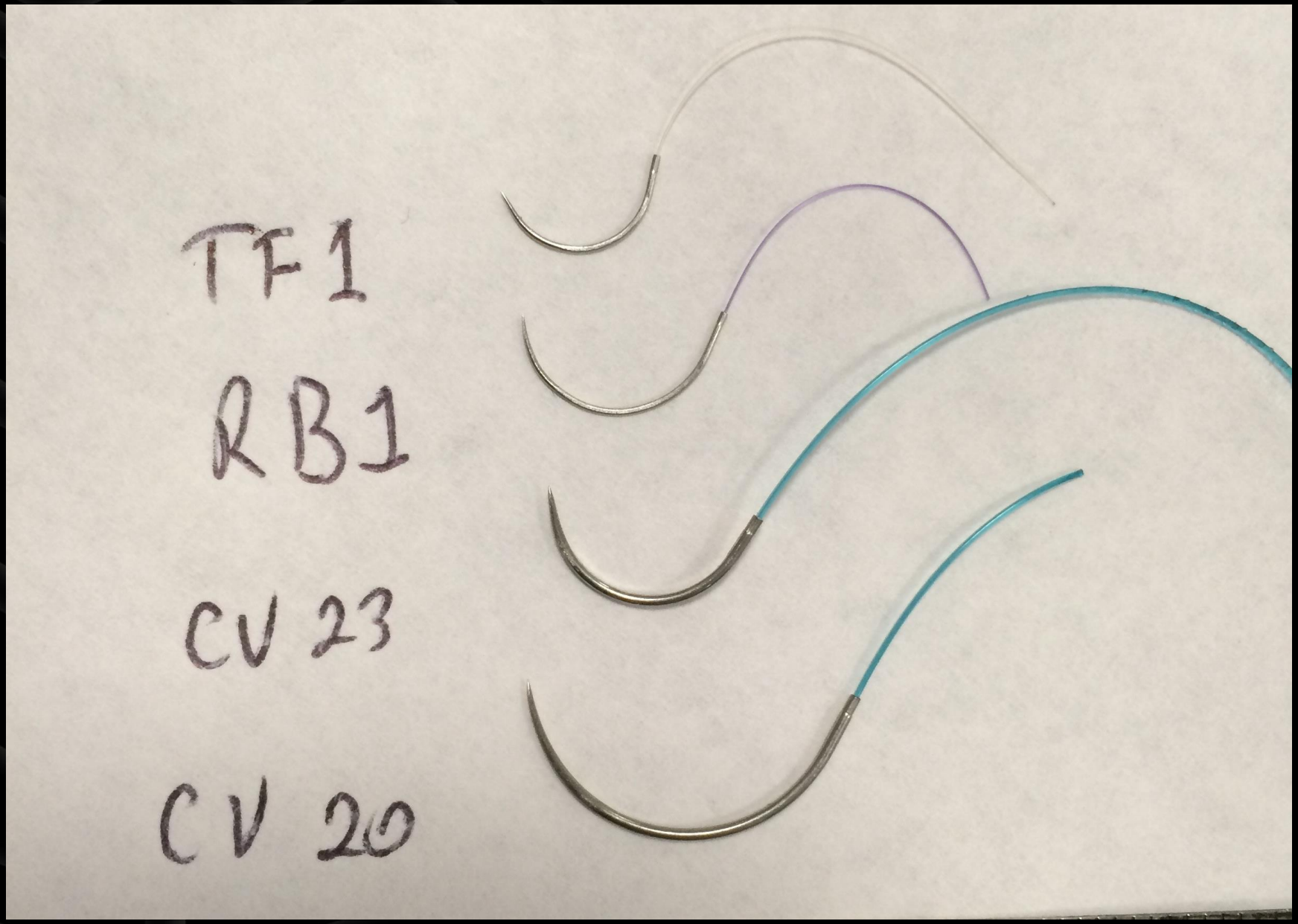
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Robotic liver techniques

Portal Dissection Left Hepatectomy

Parenchymal Transection Left Hepatectomy

Robotic Right Hepatic Artery

Robotic right lobectomy

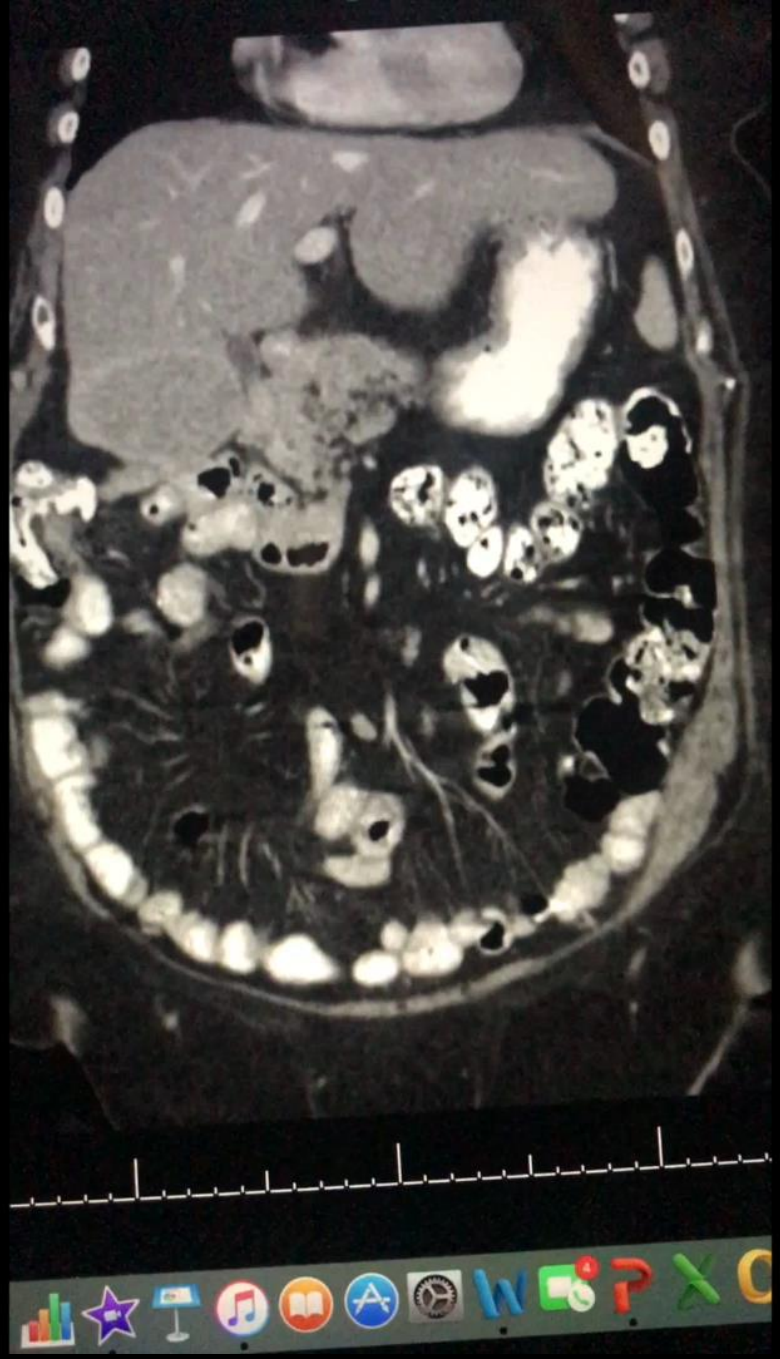
Robotic right lobectomy

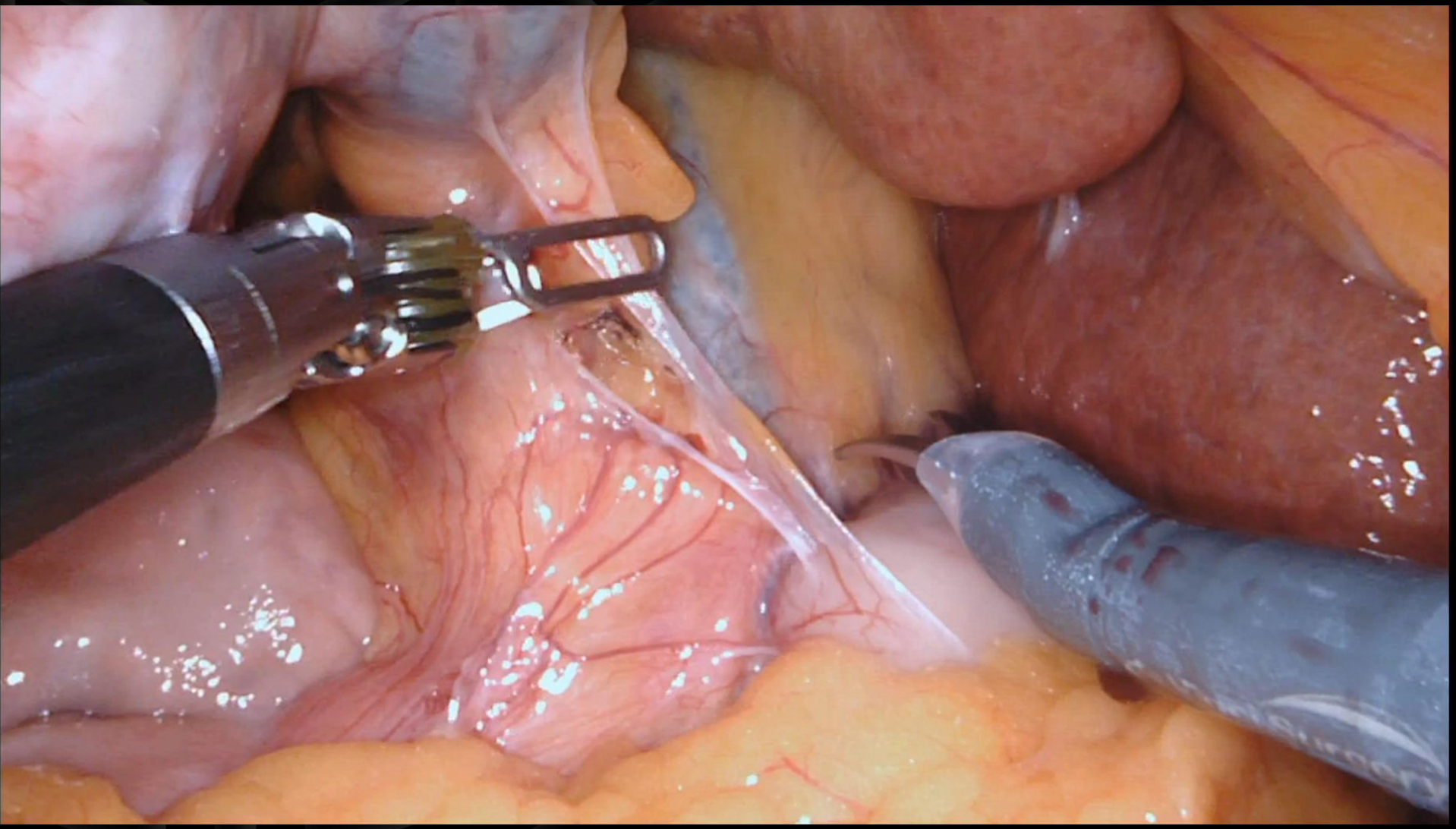
Robotic right lobectomy

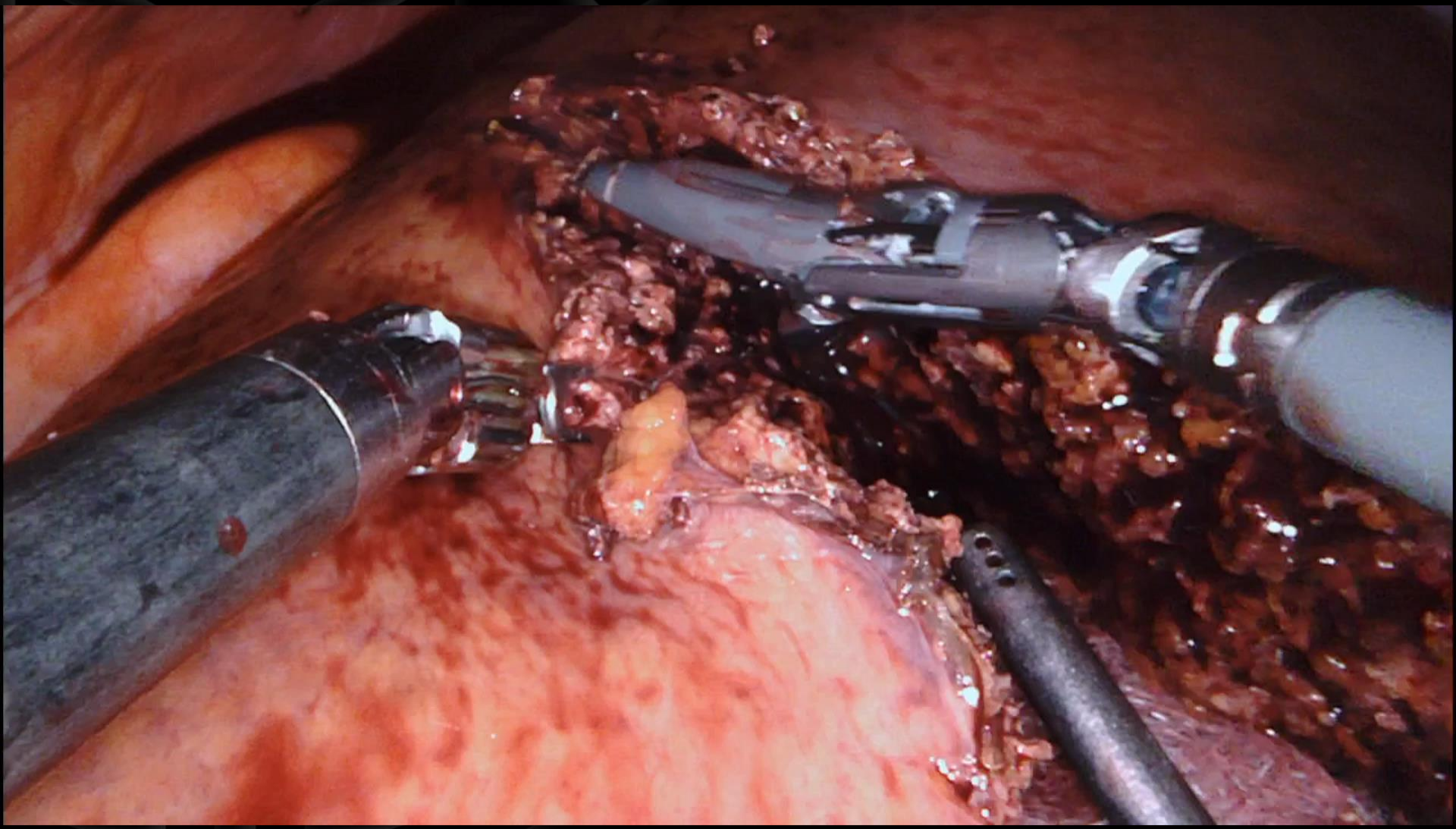
Evolution of Technique

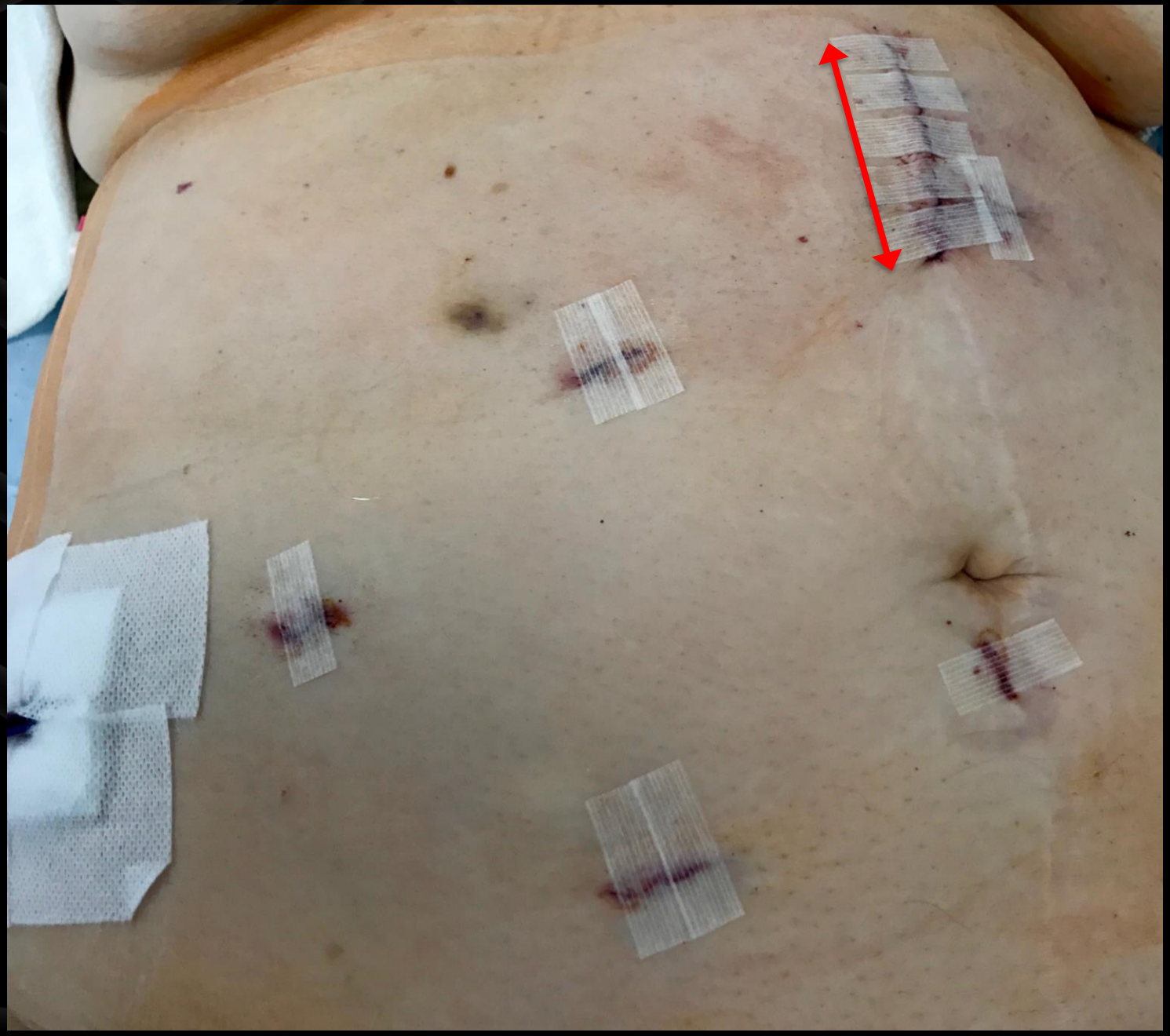
- Robotics 2006-2017, >500 HPB cases
- Lap Liver Surgery 2005-2012
- Robotic Liver Suregry 2012-2017

- Elimination of the staplers
- Elimination of additional energy devices









Robotic vs Laparoscopic Major Liver Resection:

A Review of the Literature and a Cost-benefit Analysis from a Single High-volume Center

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Objectives

- Considerable debate exists regarding outcomes and cost-effectiveness of robot-assisted versus laparoscopic approaches to hepatectomy
- The goals of this study were to review published data, and compare them to cost-benefit analyses for major hepatectomy performed at a single, high-volume HPB surgery center

Methods

- Comprehensive literature review of minimally invasive robotic-assisted and laparoscopic hepatectomy (2008 to 2016)

- Retrospective analysis (2008-2016) of identical parameters for patients at our center undergoing a major (≥3 segments) laparoscopic of robotic-assisted hepatectomy

Patient demographics and operative characteristics for single-center experience with robotic and laparoscopic liver resections, 2008–2016

Parameters	Robotic (n = 57)	Laparoscopic (n = 124)	p value
Gender (male)	37 (64.9)	70 (56.5)	.282
Age, mean (SD)	58.1 (15.7)	53.1 (15.6)	.029*
Resection			.059
Left	20 (35.1)	23 (18.6)	
Partial	17 (29.8)	51 (41.1)	
Right	20 (35.1)	50 (40.3)	
Diagnosis, No. (%)			.034*
Benign	8 (14.0)	34 (27.4)	
Hemangioma	4 (7.0)	15 (12.1)	
Adenoma	3 (5.3)	9 (7.3)	
Liver Metastasis	24 (42.1)	35 (28.2)	
Hepatocellular Carcinoma	4 (7.0)	17 (13.7)	
Cholangiocarcinoma	7 (12.3)	7 (5.7)	
Gallbladder Cancer	2 (3.5)	0	
Other	5 (8.8)	7 (5.7)	
Margin Status, No. (%)			
Negative	30 (85.7)	58 (79.5)	.433
Positive	5 (14.3)	15 (20.6)	
EBL, median (range), mL	250 (125–600)	400 (150–750)	.299
Operative time, median (range), min	194 (152–255)	204 (149–280)	.614

Abbreviation: SD, standard deviation; EBL, estimated blood loss.

Postoperative outcomes and complications for single-center experience with robotic and laparoscopic liver resections, 2008–2016

Parameters	Robotic (n = 57)	Laparoscopic (n = 124)	p value
Complications, No. (%)	16 (28.1)	41 (33.1)	.502
≤90-day readmission, No., (%)	4 (7.0)	34 (27.4)	.002*
Postoperative ICU, No. (%)	25 (46.3)	76 (61.3)	.041*
LOS, median (range), days	4 (3-5)	5 (3-6)	.126
Clavien-Dindo Grade of complications			.058
I	0	9 (34.6)	
II	5 (50.0)	8 (30.8)	
III-a	0	4 (15.4)	
III-b	1 (10.0)	1 (3.9)	
IV-a	2 (20.0)	3 (11.5)	
IV-b	0	1 (3.9)	
V	2 (20.0)	0	

Abbreviation: ICU, intensive care unit; LOS, length of stay.

- Patients undergoing robotic vs laparoscopic major hepatectomy were:
  - Older (58.1 ± 15.7 versus 53.1 ± 15.6 years, respectively; $p<0.05$)
  - Went to the ICU post-operatively less often (46.3% versus 61.3%, respectively; $p<0.05$)
  - Readmitted less often within 90 days (7.0% versus 27.4%, respectively; $p<0.01$)

- No significant differences were found between the two approaches for blood loss/transfusion volume, operative times, and total length of stay

Mean direct supply cost [1]

- No significant difference between the robot-assisted versus laparoscopic approach ($p>0.05$):
  - Robot-assisted: $4,720
  - Laparoscopic: $4,514

Mean direct cost [2]

- Statistically significantly difference between the robot-assisted versus laparoscopic approach ($p<0.05$)
  - Robot-assisted: $5,179
  - Laparoscopic: $6,284

(1) Mean direct supply cost = cost of supplies (2013 – 2016)
(2) Mean direct cost = cost of supplies, OR time and staffing (subgroup 2014 – 2015)

Comparative Costs

- Prograsp $220
- Scissors $320
- Bipolar $270
- Vessel sealer $595
- Needle driver $220
- Clip applier (20) $280
- Drapes $208
- Trocars(2) $80
- Trocars (5) $200
- Ligasure $450-850
- Stapler handle $200
- Stapler reloads $325

Comparative Costs

- Habib 4x $2000
- Aquamentis $1500
- MWA antennae $1500
- Hemostatic agents:

- The use of multiple disposeable energy devices and endoscopic staplers balances out the uses of robotic instruments.

Summary

- Robotics may enable the dissemination of HIS liver surgery to a greater percentage of surgeons
- Robotics may enable even expert surgeons to surpass his/her own limitations. . . .the “ceiling”
- Robotics can be done in a safe and cost neutral fashion

Thank You