



The Promise of Artificial Intelligence for Colonoscopy Quality and Documentation

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Disclosures

- Cofounder and Chief Medical Officer of Docbot, a UCI Applied Innovations and Y-Combinator Company

Colorectal Cancer 2019

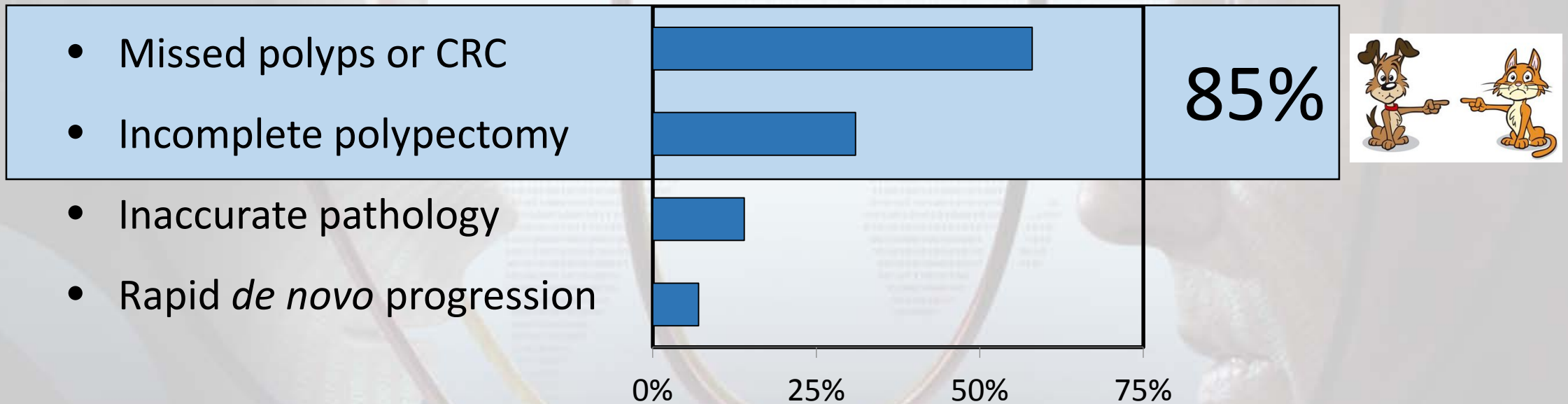
- 1:20 Americans will get CRC without screening
- Up to 90% of colorectal cancers are preventable through removal of precancerous polyps (adenomas) during colonoscopy

Zauber AG, et al. N Engl J Med. 2012; 366: 687-96

Yet...

- 5-9% of CRCs are diagnosed in patients who ARE up-to-date with recommended colonoscopy (Interval Colorectal Cancers)
- Why not better?

Four Plausible Explanations



Robertson DJ et al *Gastroenterology* 2008;134:111-112

Pabby A et al *Gastrointestinal Endoscopy* 2008; 61:385-391

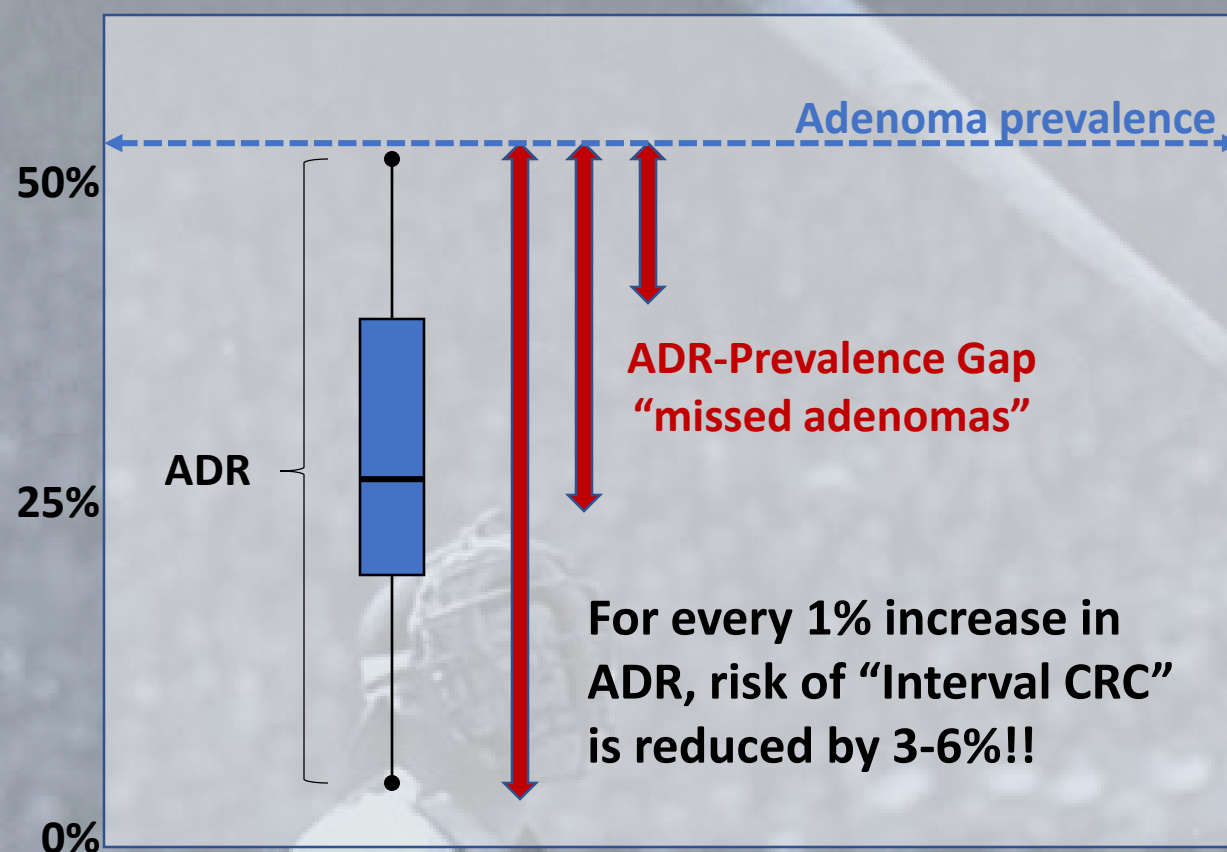
Pohl H & Robertson DJ *Clin Gastroenterol Hepatol* 2010;8:858-864

The Colonoscopist's Batting Average

Adenoma Detection Rate (ADR)

fraction of screening colonoscopies with at least one adenoma

Ted Williams
.406 in 1941



Corley DA, et al. *N Engl J Med.* 2014; 370: 1298-306
Kaminski M, et al. *Gastroenterol* 2017;153:98-105

Medicare Cares

- Key Factors Affecting ADR
 - Cecal intubation rate
 - Prep Quality
 - Withdrawal time
- Documentation and performance tied to reimbursement
 - Document ADR ($\geq 25\%$, $\geq 30\%$ for men, $\geq 20\%$ for women)
 - Photodocument two cecal landmarks ($\geq 90\%$ overall, $\geq 95\%$ screening cases)
 - Document Prep Quality ($\geq 85\%$ “adequate”)
 - Document withdrawal time (≥ 6 min)

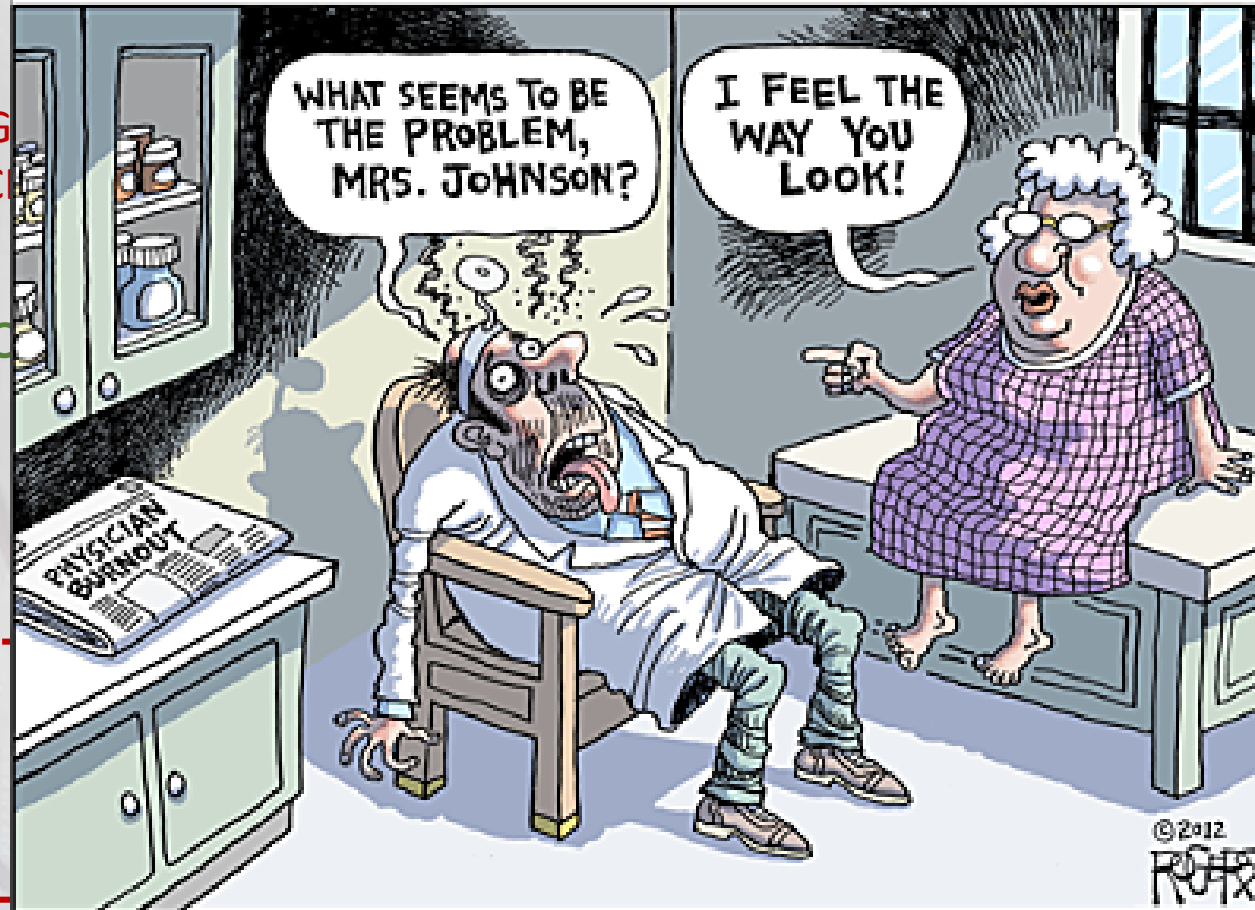
<https://www.asge.org/home/practice-support/macra-resource-center>

QUALITY INDICATORS FOR GI ENDOSCOPIC PROCEDURES, *Gastrointest Endoscopy* 81:31-53

There's got to be an easier way!

SECOND OPINION

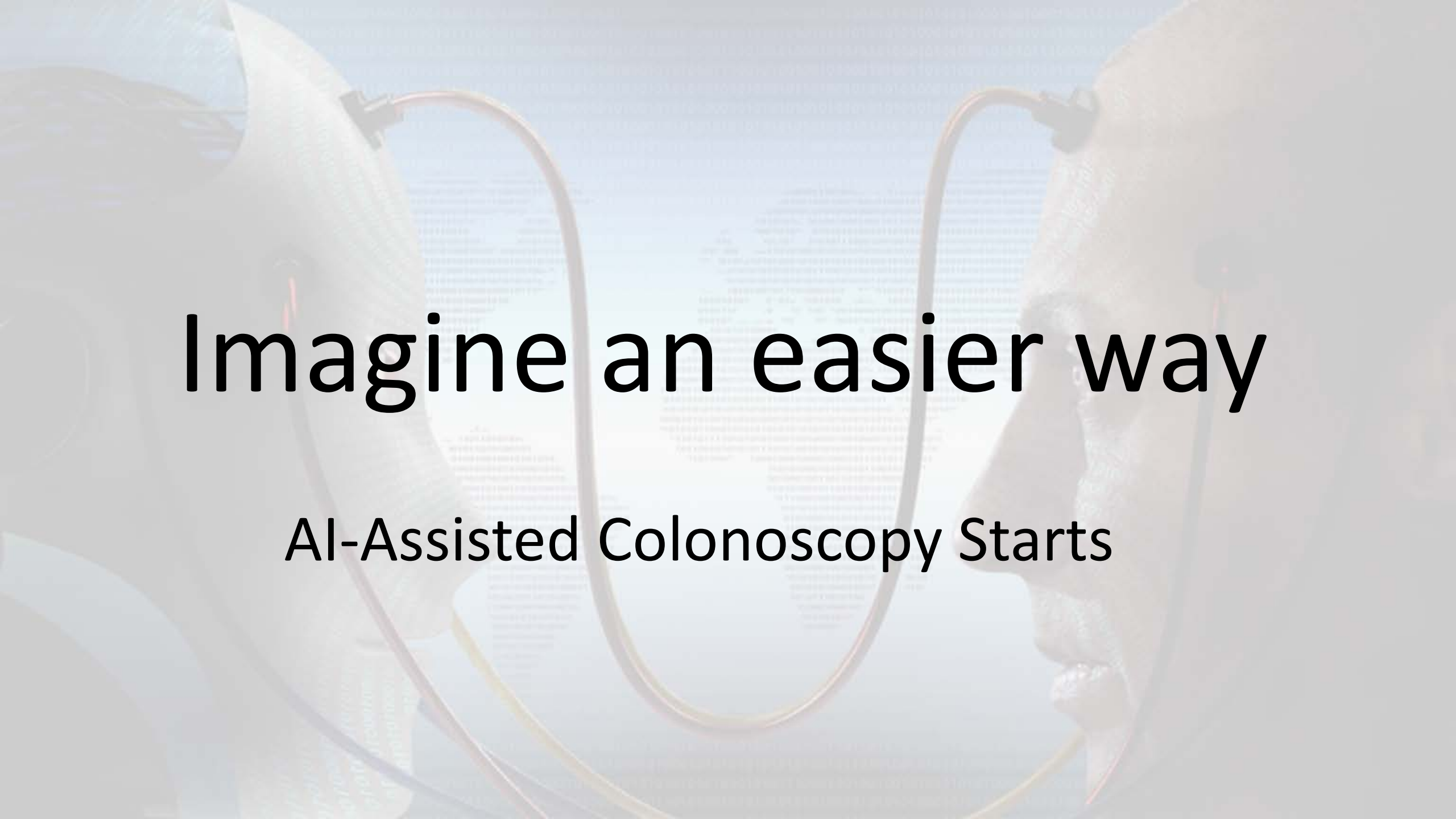
BY ROB ROGERS





“Progress doesn’t come from early risers — progress is made by lazy men looking for easier ways to do things.”

Benjamin Franklin

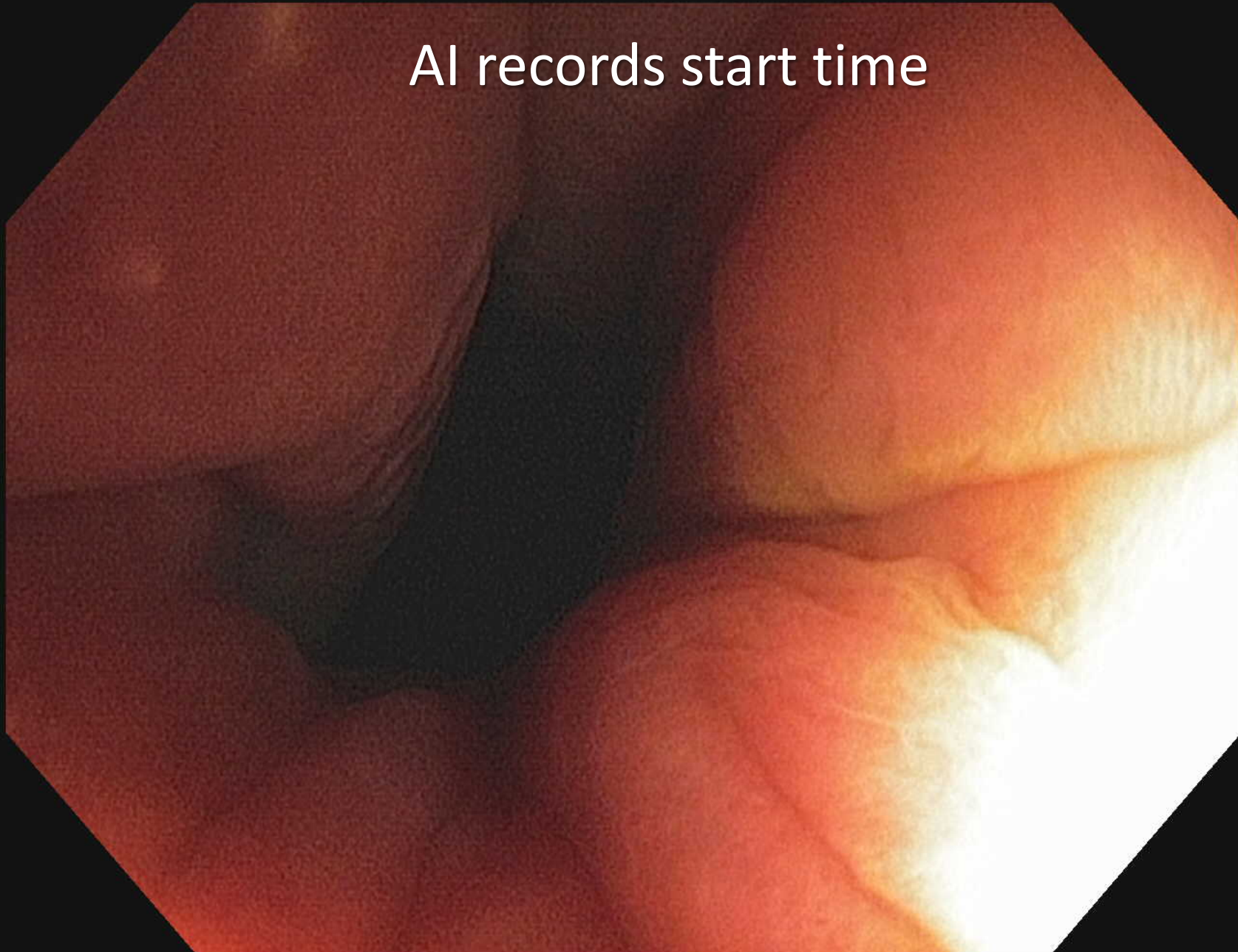


Imagine an easier way

AI-Assisted Colonoscopy Starts

3

AI records start time



Start Time: 09:23:04

AI challenges to improve prep



Start Time: 09:23:04

1

AI challenges to improve prep

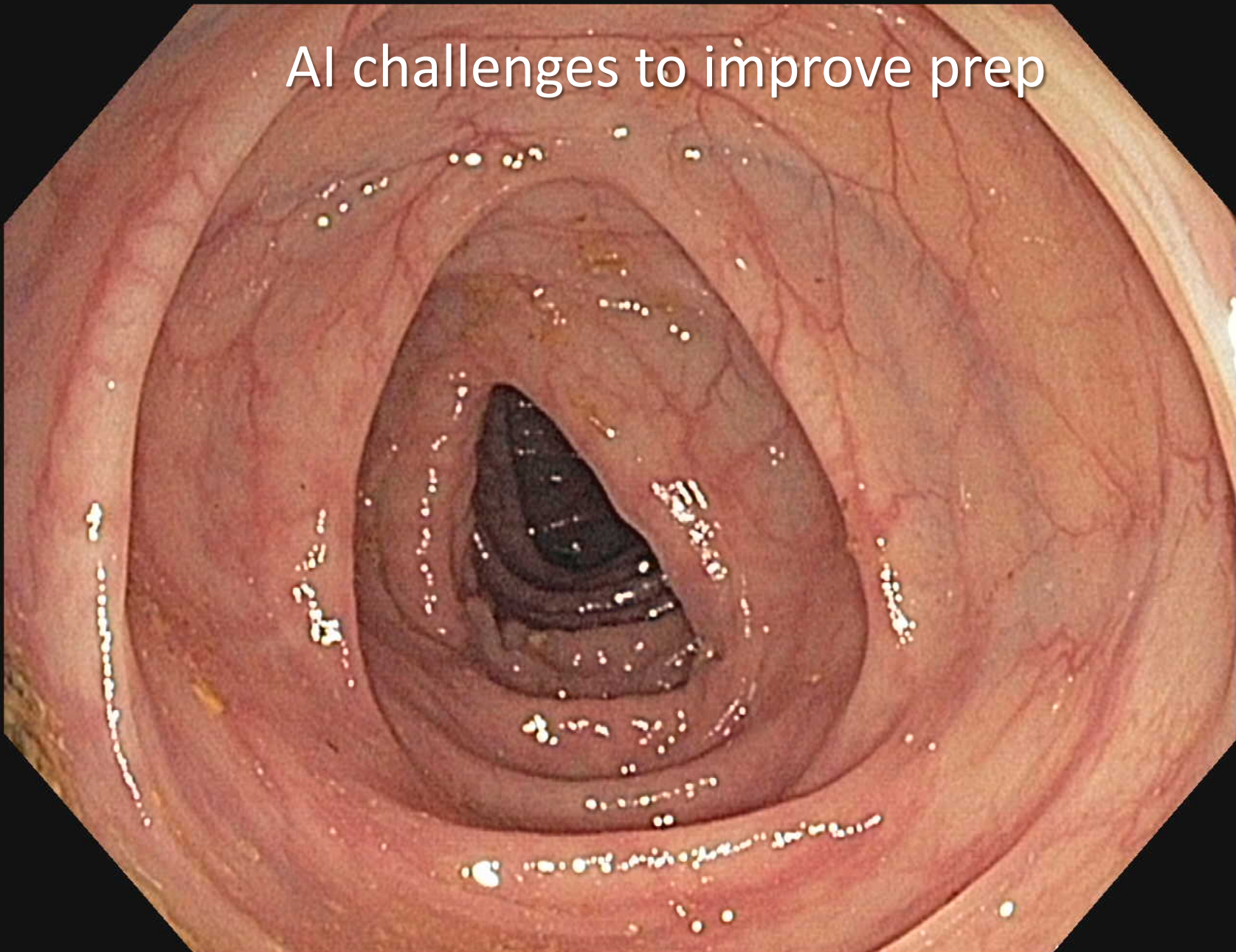


2

Start Time: 09:23:04

3

AI challenges to improve prep



Start Time: 09:23:04

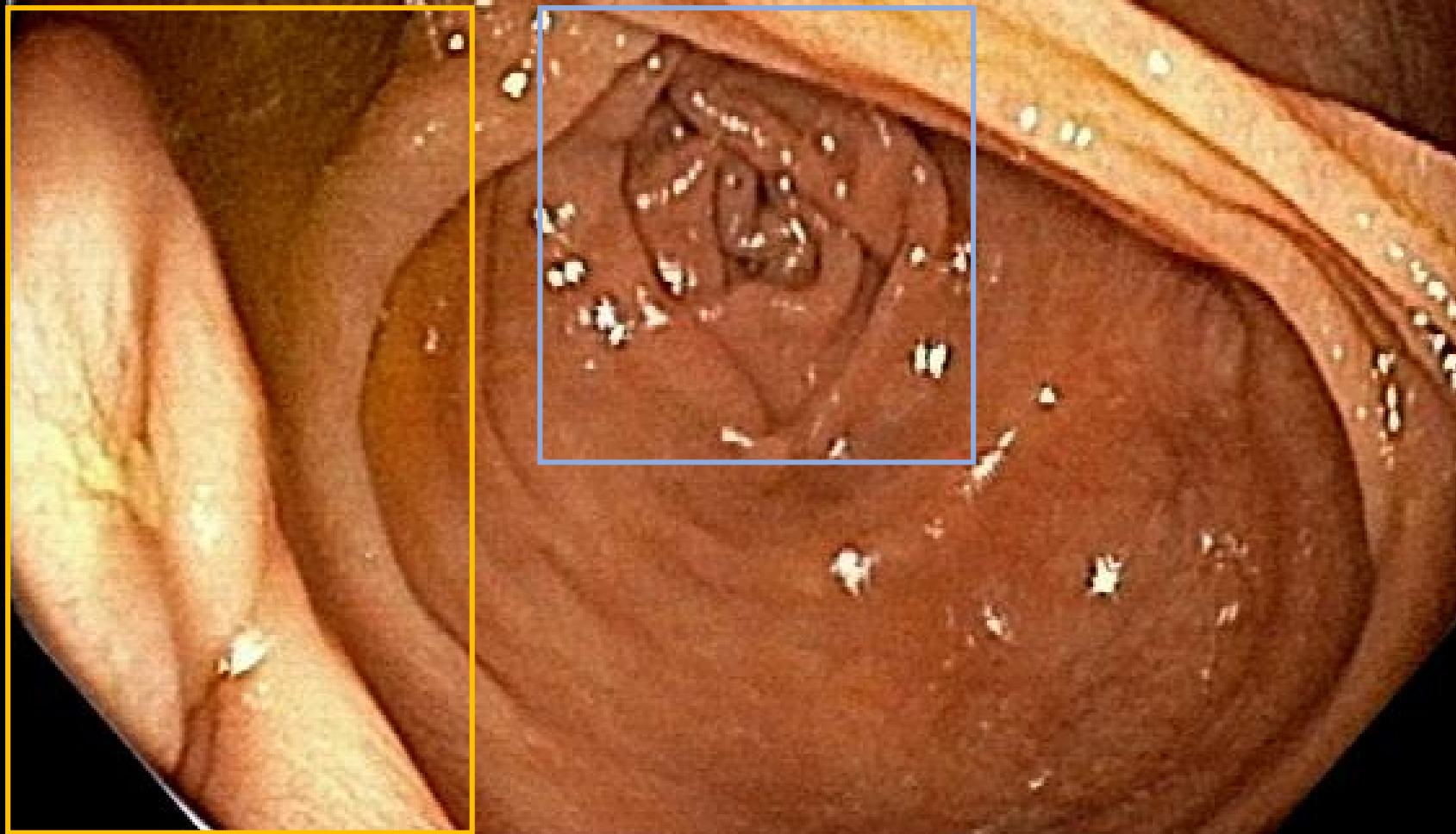
3

AI identifies landmarks, marks times (Cecum)

ICV 0.98

AO 0.99

Cecum 1.0

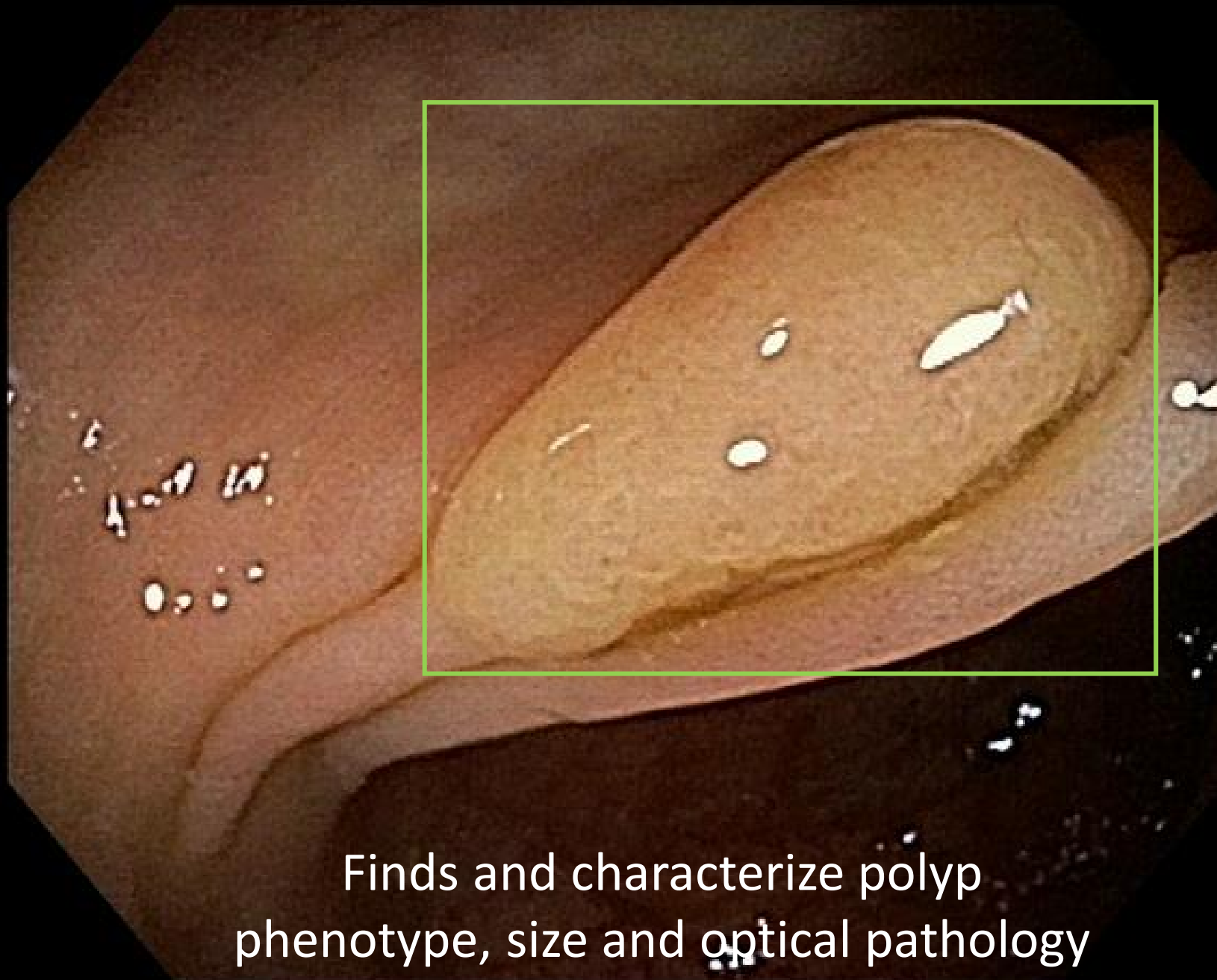


Start Time: 09:23:04

Cecal Time: 09:26:38

IT: 00:03:34

3



SP 0.98
12mm
Is

Finds and characterize polyp
phenotype, size and optical pathology

Start Time: 09:23:04
Cecal Time: 09:26:38
IT: 00:03:34

3

AI identifies tools

Exacto Snare 0.99

SP 0.80

3mm

Is

Start Time: 09:23:04

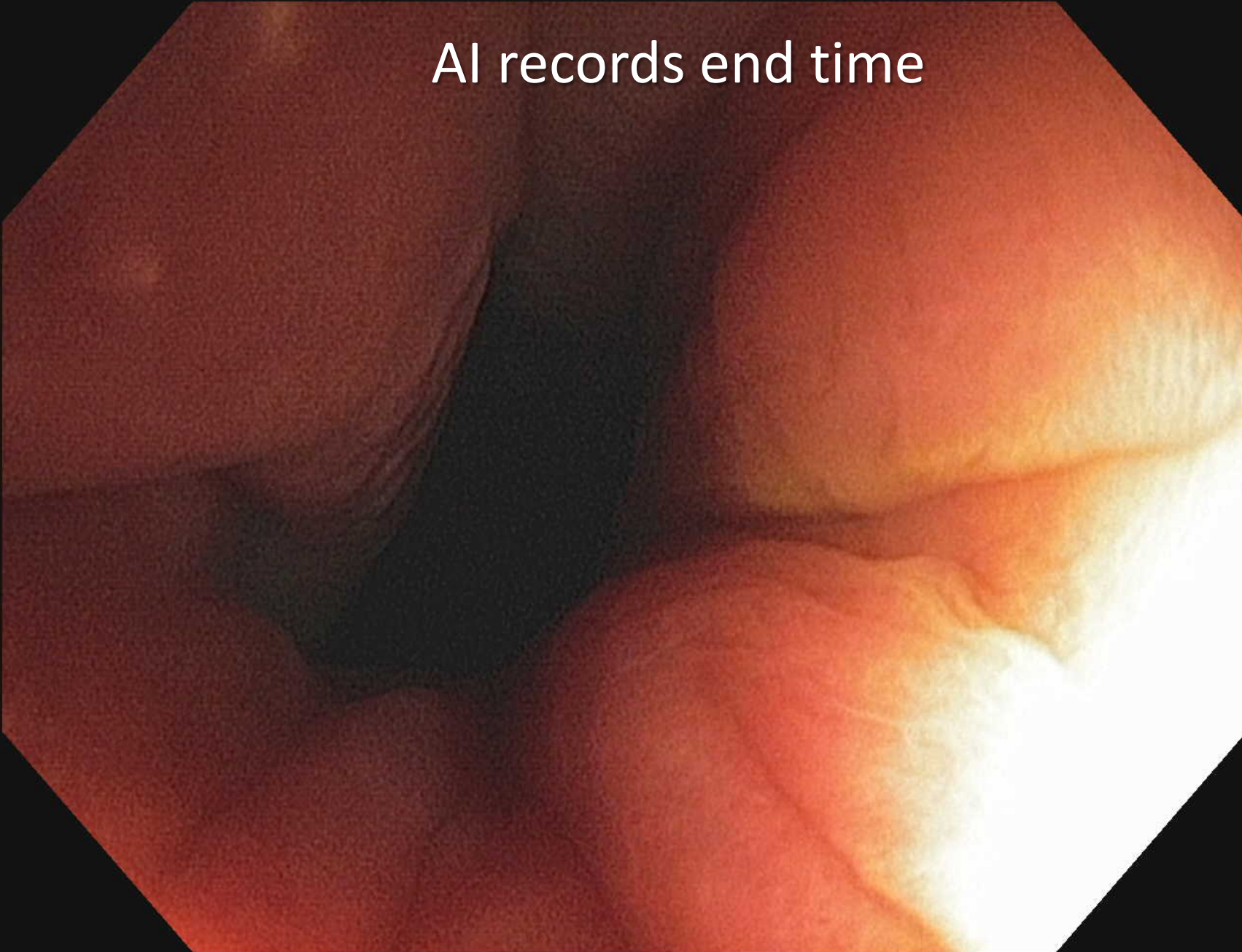
Cecal Time: 09:26:38

IT: 00:03:34

3

AI records end time

Last Anal Image

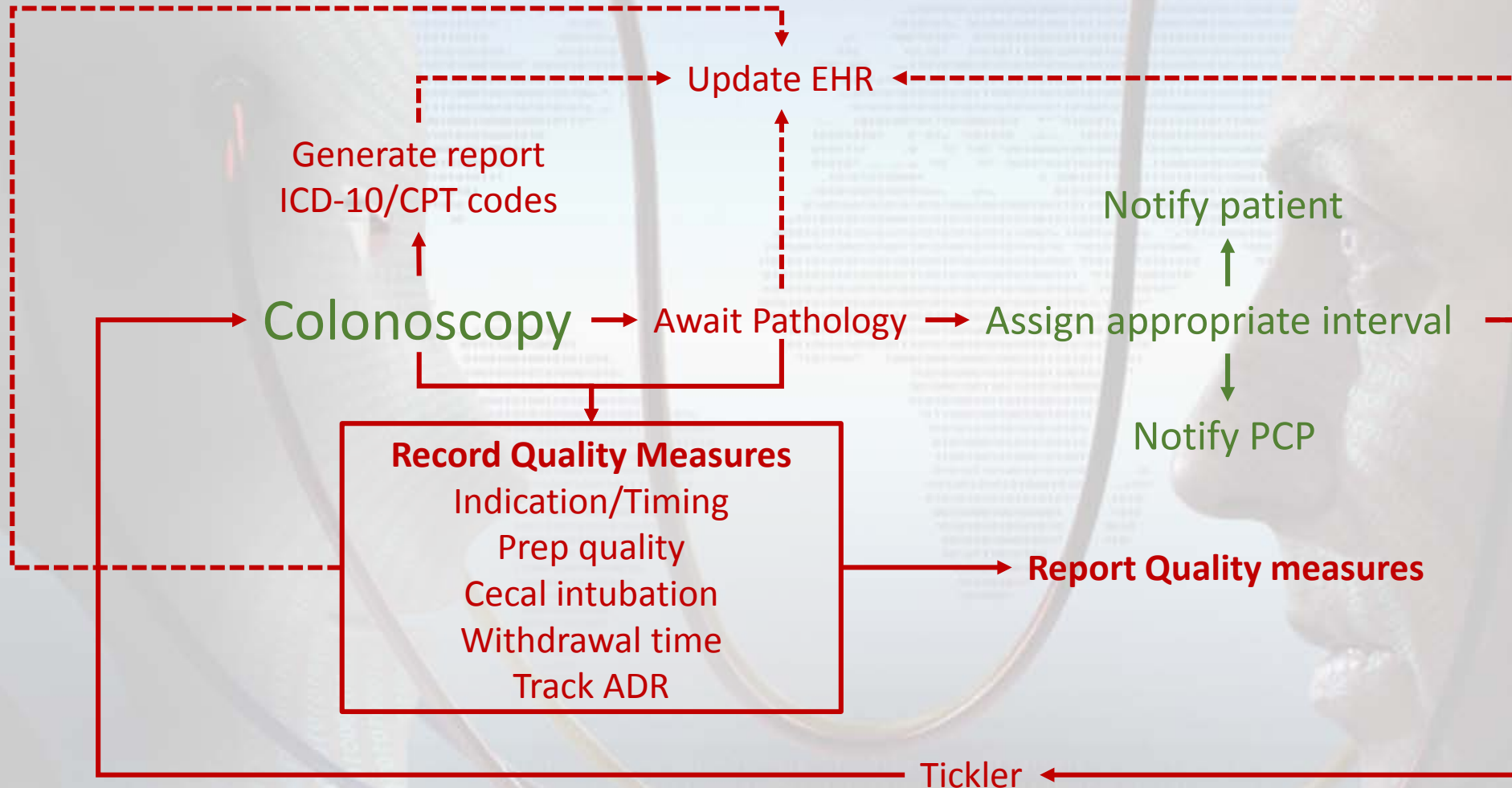


Start Time: 09:23:04
Cecal Time: 09:26:38
End Time: 09:39:13
IT: 00:03:34
WT: 00:12:35

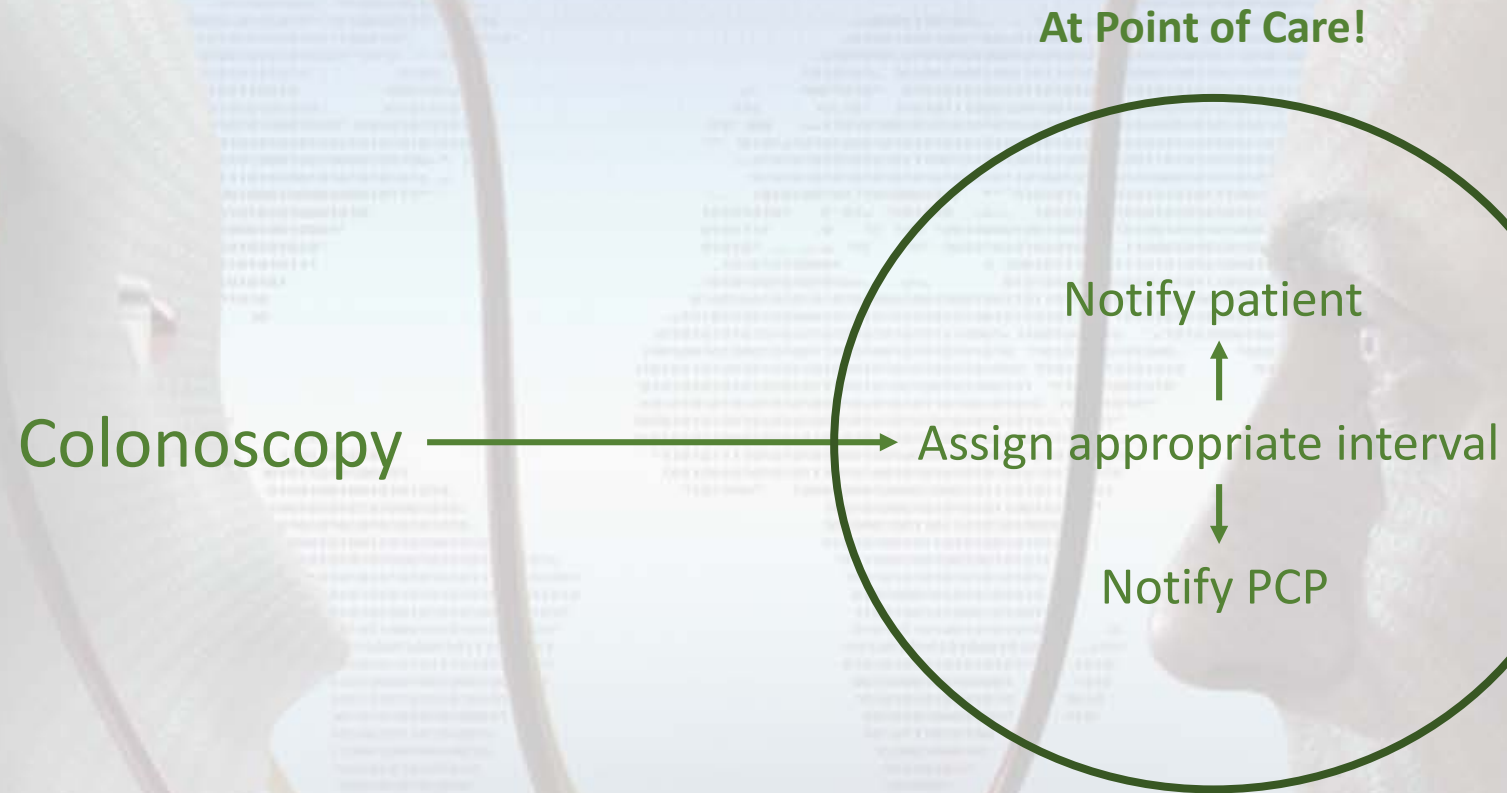
Imagine Easy!

- **Colonoscopy is complete**
- **AI has recorded all quality metrics:** including cecal intubation, withdrawal time, prep quality, number, sizes, predicted pathology, and removal technique/tools for all polyps.
- **AI auto-records ADR**
- **AI completes colonoscopy report**
 - auto-labelled images, including cecum
 - accurate ICD-10 and CPT codes
 - guideline recommendations
- **You simply review, edit, embellish and sign.**
- **Your changes educate the AI.** AI continuously learns and improves!

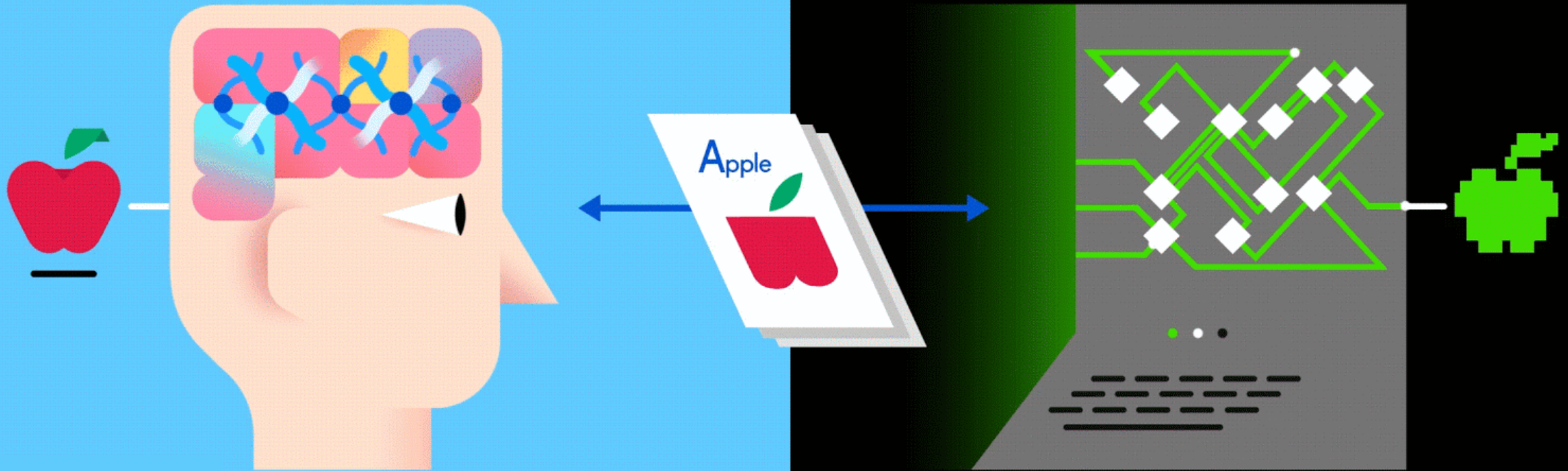
Imagine Easy!



Imagine Easy!



AI Terminology



Convolutional Neural Networks, a subset of Deep Learning
Great for Pattern Recognition (e.g., Facial Recognition)

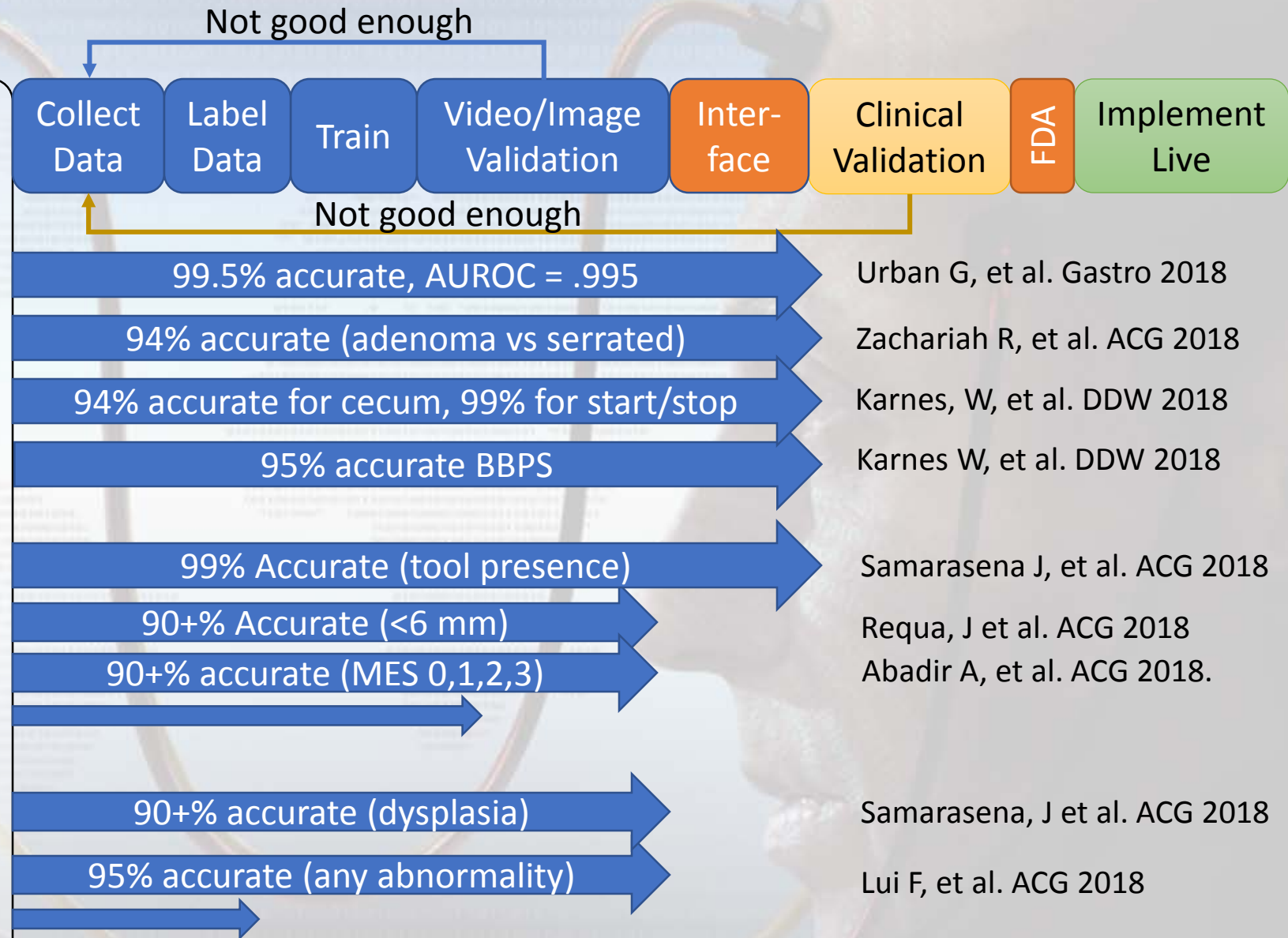
How is it done?

- The “hard” part – produce an algorithm
 - Ask a clinically relevant question
 - Access or create a **large, accurately** annotated/segmented database with your specific task in mind
 - Recruit the assistance of an AI expert to train and validate against the database
- The “hardest” parts – **implementation and clinical validation**
 - User interface must be real-time, non-distracting, reliable, low-maintenance, and low cost
 - Hardware-agnostic – works with any system (Olympus, Pentax, Fujinon)
 - Integration with current IT infrastructure, endowriter and EHR
 - Clinical validation across populations, endoscopists and systems
 - FDA clearance (when affecting clinical decision-making)

Where are we?

Imagine

- Polyp detection
- Polyp optical pathology
- Landmark recognition
- Prep quantification
- Other findings/features
 - Tools
 - Polyp size/morphology
 - IBD (inflammation scoring)
 - Diverticulosis
- Other Procedures
 - EGD (Barrett's, dysplasia)
 - Capsule Endoscopy
 - EUS (Pancreatic lesions)



Key Players:

- Polyp Detection
 - Image/Video Validation
 - Tripathi, et al. DDW 2018, Urban, et al. Gastroenterol 2018. - UCI/Docbot
 - Wang, et al. ACG 2017, Nat Biomed Eng. 2018; 2: 741-8. – Wision, China
 - Misawa M, et al. Gastroenterol. 2018; 154: 2027-9 e3. – Japan University
- Polyp Pathology
 - Image/Video Validation
 - Zachariah, et al. ACG 2018 – UCI/Docbot
 - Byrne M et al - Gut 2017 - AI4GI, Vancouver
 - Mori, et al. Ann Intern Med 2018; 169: 357-66 - Japan University
 - Chen P, et al. Gastroenterol. 2018; 154: 568-75 – Taiwan National Defense Medical Center
- Colonoscopy Documentation
 - Image/Video Validation
 - Karnes W, Samarasena J, Requa J – DDW 2018, ACG 2018 – UCI/Docbot

Thus far, no live prospective clinical studies!

Video Validation of Polyp Detection

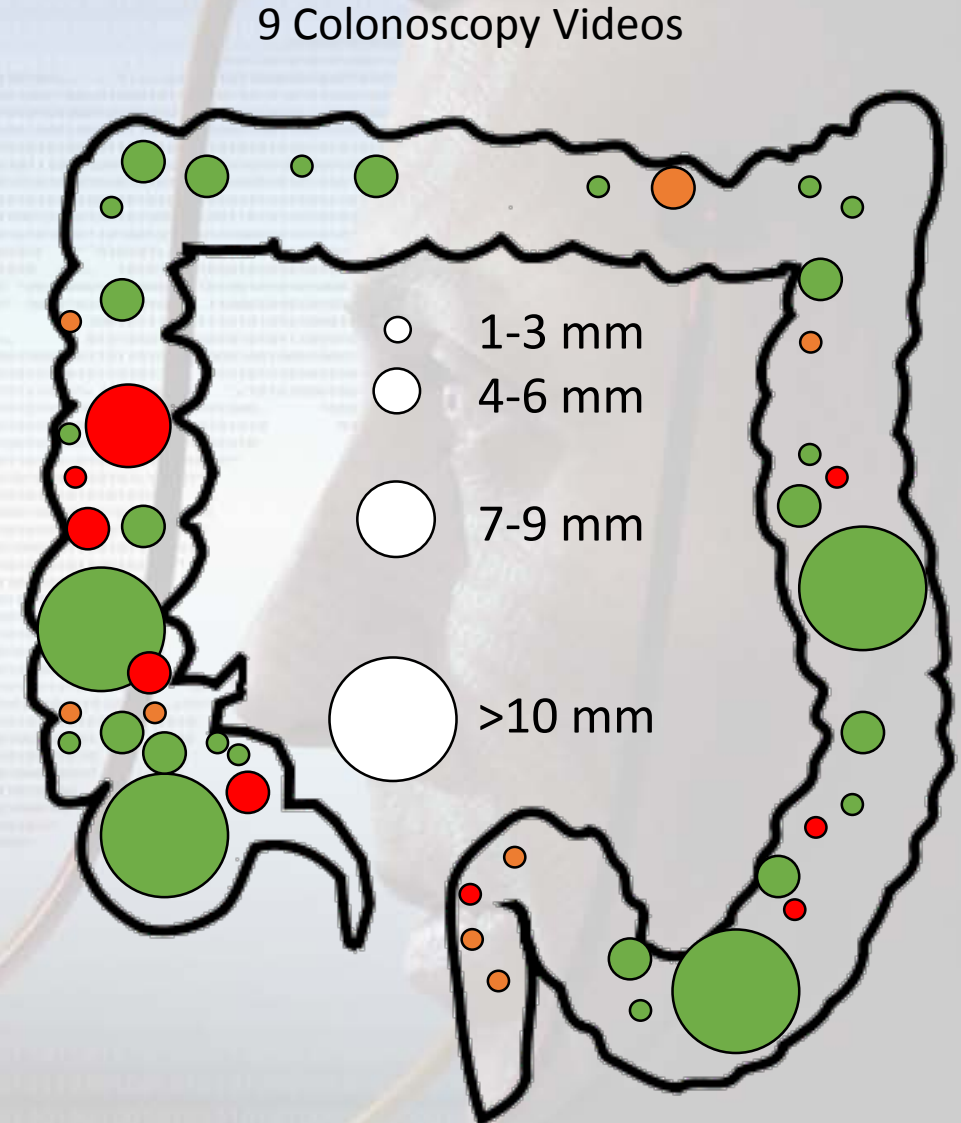
- 28 polyps removed
- $28 + 8 = 36$ polyps found on video review
- $36 + 9 = 45$ polyps found with AI assistance

AI did not miss any polyps identified by reviewers

Of the 9 additional polyps found with AI assistance:

- Confidence HIGH for 3 polyps
- Confidence LOW for 6 polyps

Urban G, et al. Gastroenterology. 2018; 155: 1069-78.



AI for Polyp Pathology

- 80+% of polyps are diminutive ($\leq 5\text{mm}$) and “almost never” advanced lesions
- Potential savings of \$1 billion in pathology costs/year in US if we can reliably diagnose diminutive polyps *in situ* as established by PIVI*
 - “**Diagnose and Leave**” diminutive rectosigmoid polyps
 - requires negative predictive value for adenomas is $>90\%$
 - “**Resect and Discard**” diminutive polyps proximal to the rectosigmoid
 - requires $>90\%$ concordance for recommended surveillance interval
- Automated ADR – no need to track and calculate ADR after waiting for pathology
- Appropriate surveillance interval can be provided to patient at point-of-care

**American Society for Gastrointestinal Endoscopy (ASGE) "Preservation and Incorporation of Valuable Endoscopic Innovations" (PIVI): Rex DK, Kahi C, O'Brien M et al Gastrointestinal Endosc 2011;73: 419-22*

Can AI achieve PIVI thresholds?

- “Diagnose and leave” – no resection, no path
 - Applies to diminutive (≤ 5 mm) non-neoplastic rectosigmoid polyps
 - Requires NPV for adenomas of $>90\%$

| | | TPath | |
|-------------|----------|---------|-------------|
| | | Adenoma | Not Adenoma |
| OPath | Adenoma | 107 | 38 |
| | Serrated | 12 | 434 |
| Sensitivity | | 0.90 | |
| Specificity | | 0.92 | |
| PPV | | 0.74 | |
| NPV | | 0.97 | |
| Accuracy | | 0.92 | |

Zachariah R, et al. ACG 2018 Plenary

Can AI achieve PIVI thresholds?

- “Resect and Discard” – no path
 - Applies to diminutive polyps proximal to rectosigmoid
 - Requires >90% concordance in surveillance interval recommendation

| Entire Colon (All polyps <6mm) | | | | | | | | | | | | | | | |
|--------------------------------|---------------------------------|------|------|-----|-----|-----|-----------|----------------------------------|-----|-----|------|------|------|--------|---------------|
| | OPath shortens interval (years) | | | | | | Unchanged | Opath lengthens interval (years) | | | | | | Totals | % Concordance |
| Indications | 10→1 | 10→3 | 10→5 | 5→1 | 5→3 | 3→1 | | 1→3 | 3→5 | 1→5 | 5→10 | 3→10 | 1→10 | | |
| Screening* | 0 | 2 | 92 | 0 | 56 | 1 | 1223 | 1 | 3 | 0 | 3 | 0 | 0 | 1347 | 90.8% |
| Surveillance** | 0 | 0 | 0 | 0 | 40 | 1 | 1110 | 0 | 1 | 0 | 0 | 0 | 0 | 1152 | 96.4% |
| Totals | 0 | 2 | 92 | 0 | 96 | 2 | 2333 | 1 | 4 | 0 | 3 | 0 | 0 | 2499 | 93.4% |

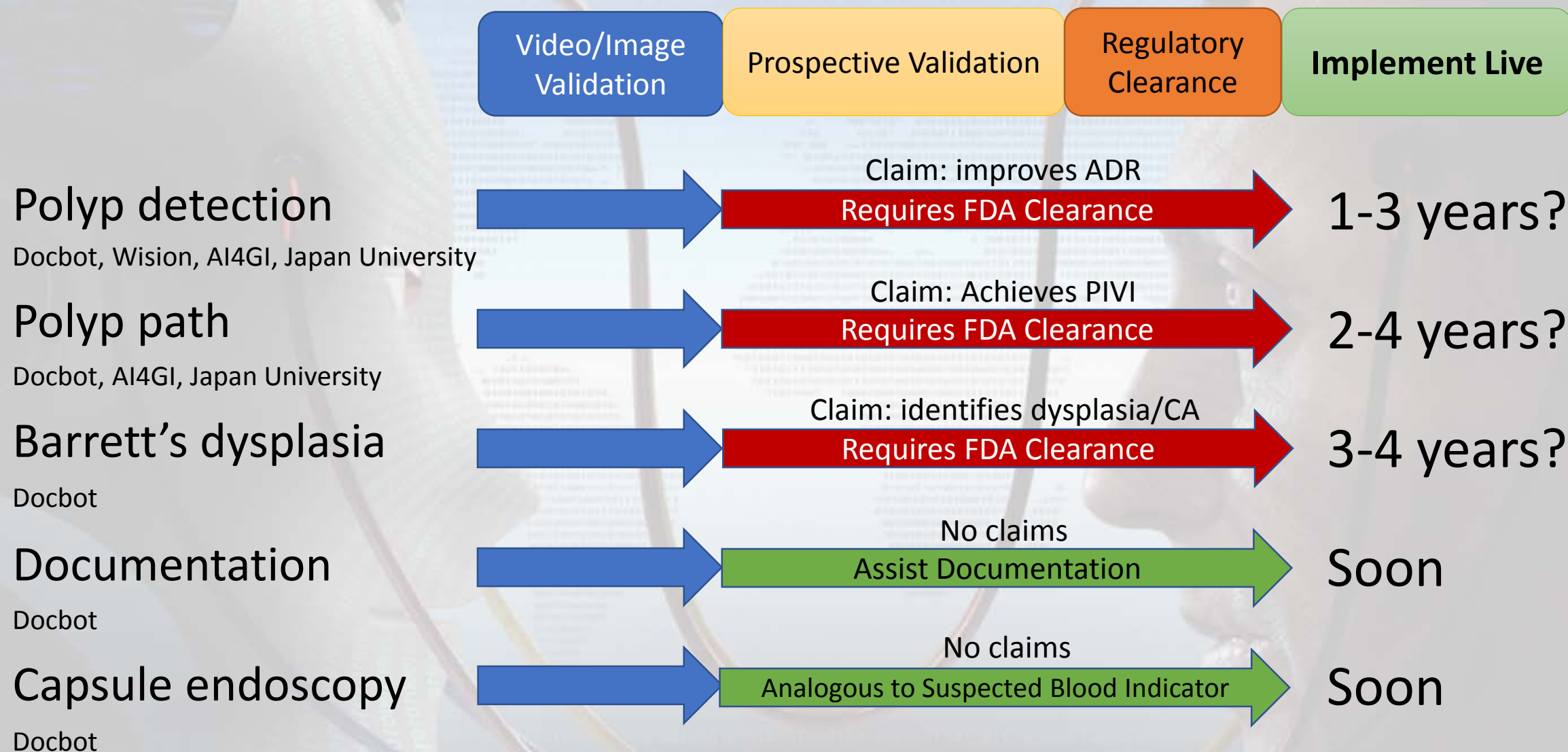
Most discordance due to normal tissue and lymphoid aggregates predicted to be serrated polyps in the right colon

Zachariah R, et al. ACG 2018 Plenary

Multiple AIs on Video



Remains Pre-Clinical but Soon to Emerge



The Future

- Real-time multi-AI feedback during colonoscopy
- Real-time quality data collection, documentation and reporting
- Improved ADR?
- “Diagnose and Leave”?
- “Resect and Discard”?
- Diagnose and target dysplasia in Barretts?
- AI-assisted capsule endoscopy “reads”
- More to come!



Acknowledgements

- UCI Chao Comprehensive Digestive Disease Center
- Data collection and annotation team:
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 - Fellows
 - Residents
 - Medical Students
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