Toward Laryngeal Tumors Detection and Medical Images Segmentation Techniques

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Outline

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- Pre-Operative Tumor Imaging
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Introduction

- Head and neck cancer is a major cause of morbidity and mortality [Szeto C. 2011];
- By leaving positive margins, the risk of local recurrence increases from 32% to 80% [Hughes O. R. 2010];
- Healthy tissue must be preserved (vocal and swallowing functions);
- Distinguish between healthy mucosa, dysplasia, and invasive carcinoma;

- PRE-OPERATIVE IMAGING: primary tumor definition (i.e. MRI, CT)

+

- REAL-TIME IMAGING: “translate” these images to the operation field

+

- SEGMENTATION ALGORITHMS: objectively assess tumor margins

Pre-Operative Imaging (1)

LARYNX – Radiological Imaging

CT and MRI are the golden standard for pre-therapeutic staging of a head and neck malignancy.

CT	*MRI*
• Wide available; relative low cost	• Lower availability; higher costs
• Short examination time; less image degradation caused by swallowing and respiration	• Long acquisition time; sensible to motion artifacts
• Superior bone detail	• Lower bone detail
• Low soft tissue contrast resolution	• Superior soft tissue resolution
• Radiation exposure	• Absence of radiation exposure
• Severe image degradation by dental fillings or other metallic objects	• Image quality not or less hampered by dental fillings
• Preferred for evaluating laryngeal, hypopharyngeal cancer and oral cavity, oropharyngeal cancer	• Preferred imaging for rarer head and neck malignancies (i.e. nasopharyngeal, sinonasal cancer)
• High quality multiplanar imaging	
• Easy extension into upper thoracic cavity or intracranial cavity	
• Needed administration of iodinated contrast agent	

Data from Hermans R. 2012

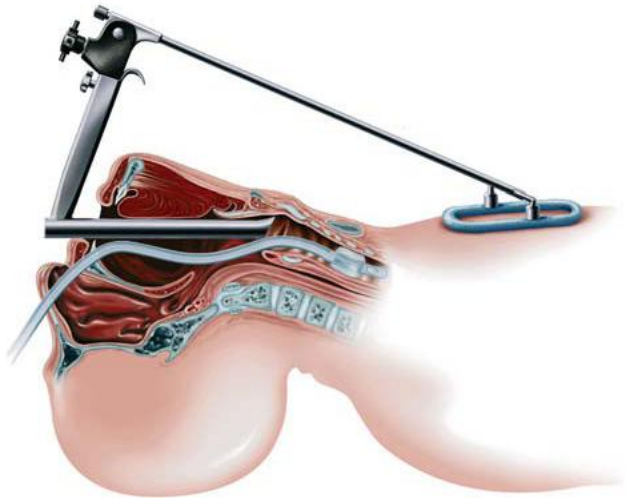
Accurate pretreatment record coupling information from radiological imaging and operative endoscopy.

Pre-Operative Imaging (2)

LARYNX – Operative Endoscopy

- Hopkins rod telescope (70° or 90°) → Larynx (i.e. vocal folds function);
- Flexible nasendoscope → Postnasal space, pharynx, larynx;
- Direct Laryngoscopy → Mucosal lesion of larynx and pharynx;
- Operating Microscope (0°, 30°, 70°, and 120° telescopes) → Larynx lesions;

Image from Hermans R. 2012



Segmentation Algorithms (1)

Thresholding	• intensity value which separates the desired classes • often used as initial step in a sequence of image processing operations
Region Growing	• extracting a region of the image that is connected based on predefined criteria • requires a seed point selected by the operator
Classifiers	• pattern recognition techniques, requiring training data as references • *maximum likelihood, Bayes*, *k-nearest-neighbor, Parzen window*
Clustering	• same function as classifiers without the use of training data • iterate between segmenting and characterizing the properties of each class
Markov Random Field Modeling	• statistical model which can be used within segmentation methods • often incorporated into clustering segmentation (maximizing the probability)
Neural Networks	•the most widely applied use in medical imaging is as a classifier •weights determined using training data; the network is used to segment new data
Deformable Models	•delineate region boundaries using closed parametric curves or surfaces that deform under the influence of internal and external forces
Atlas Guided Approaches	• the atlas is generated by compiling information on the anatomy • this atlas is then used as a reference for segmenting new images.

Segmentation Algorithms (2)

Few works in literature about the application of *segmentation algorithms* to *head and neck lesions*.

Zaidi et al. comparative methods for PET image segmentation in [illegible] the stochastic expectation-maximization (SEM) approach, fuzzy clustering-based segmentation (FCBS), and the spatial wavelet-based algorithm (SWBA). MRVE = mean relative volume errors;

[illegible] automatically generated.

[illegible] with respect to manual segmentation.

Authors	Target Lesion	Imaging Method	Algorithm Used	Results
Zhou et al. 2006	NPC	MRI	SVM	PM = 79±7%
Ritthipravat et al. 2010	NPC	CT	Region Growing	PM = 85.03% PM* = 29.26%
Zaidi et al. 2012	PSCC	PET	Thresholding (5) Active Contour SEM FCBS SWBA	MRVE = 100-400% MRVE = 27.20% MRVE = -31.88% MRVE = 35.58% MRVE = -5.94%
Ingle and Kwon 2009	Whole Larynx	MRI	SVM k-means	OAM = 93% OAM = 94%

Real-Time Imaging (1)

The introduction of real-time imaging technologies into the operating room has the potential of traversing the gap between radiology and surgery, resulting in intra-operative image-guided surgery.

Currently in routine use

- Optical Imaging Techniques:
  - Autofluorescence
  - Contact Endoscopy
- Narrow-Band Imaging

To be validated for Larynx

- Optical Imaging Techniques:
  - Confocal Endomicroscopy
- Color-Coded Surgery

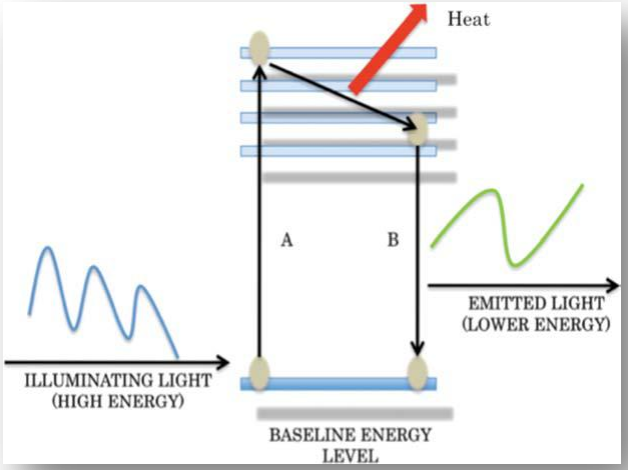
Real-Time Imaging (2)

Autofluorescence Endoscopy

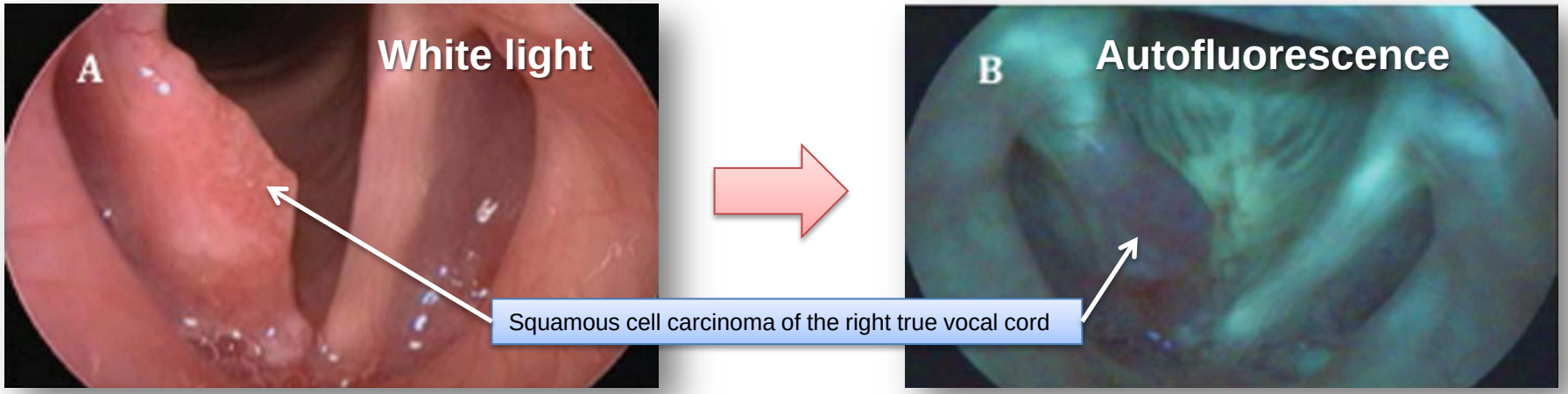
Autofluorescence is a property of few molecules, called fluorophores, which are present at different concentrations in healthy and neoplastic laryngeal mucosa.

Limitations:

- the light does not penetrate the diseased epithelium;
- scar tissue, necrosis, and inflammation can unpredictably alter mucosal fluorescence.



Figures from Hughes O. R. 2010



Real-Time Imaging (3)

Contact Endoscopy

- Cellular detail in vivo (methylene blue (MB) is applied to stain nucleic acids);
- Magnifying endoscope placed in direct contact with the mucosal surface;
- Images at 60x or 150x magnification;
- Neoplastic cells and blood vessels (from angiogenic processes) are stained by MB.
- Histological interpretations in vivo.

Applications [Szeto C. 2011]:

- Mucosal lesions:
  - dysplasia, hyperplasya, carcinoma, papilloma,…
- Specificity = 81-100%;
- Sensitivity = 79-100% ;
- Accuracy = 88-94%

Limitation:

- Cannot give clear images of cells beyond the most superficial layers of the epithelium.

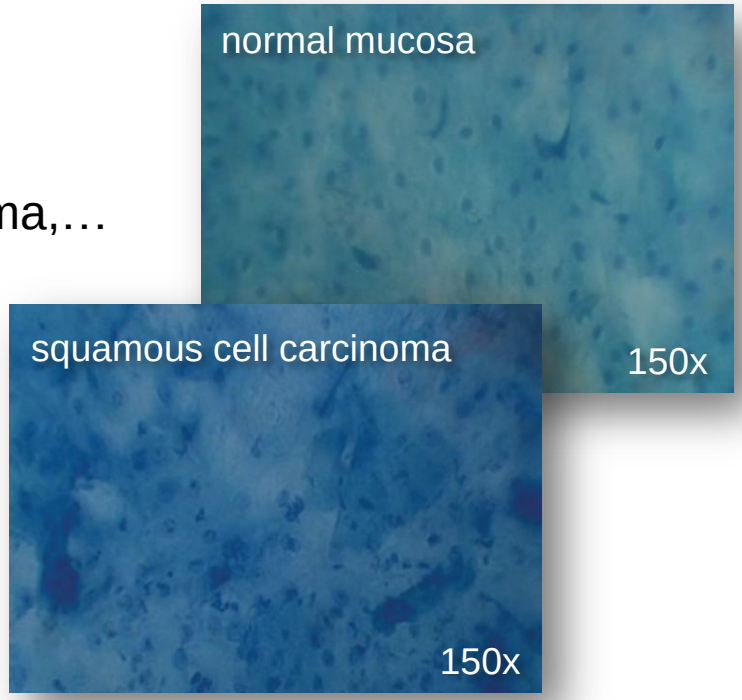


Figure from Szeto C. 2011

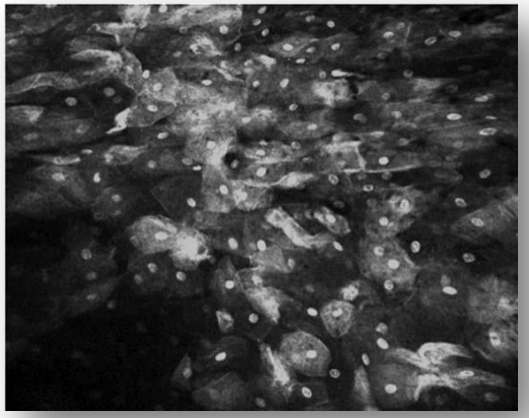
Real-Time Imaging (4)

Confocal Endomicroscopy

- Allows tumors to be examined in 3D in vivo;
- Sufficient magnification to see histologic detail;
- Moving the focal plane through the tissue:
  - can see cells at different depths;
  - no lose image resolution;
  - “virtual biopsy” vs “real biopsy” (i.e. vocal cord permanent damage)
- Acriflavine hydrochloride stains cell nuclei;
- Gastrointestinal tract application*: reduced number of colon biopsies (-50%);
- Formal trials of confocal endomicroscopy in the larynx are awaited

Human supraglottis captured in vivo

Figure from Goetz M. 2010

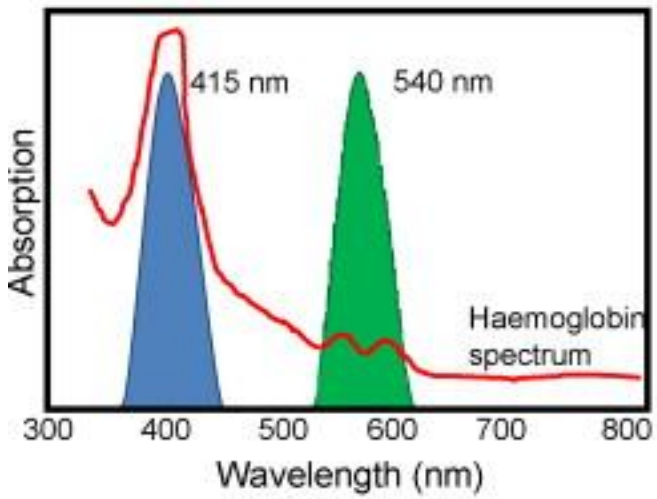


Figures from Hughes O. R. 2010

Real-Time Imaging (5)

Narrow-Band Imaging (NBI) (1)

- Depth of light penetration increases with wavelength;
- Tissue is illuminated with light centred around 415 nm (blue) and 540 nm (green), which are both absorbed by haemoglobin more strongly than by other tissue;
- The blue light enhances the superficial capillary network;
- The green light enhances the visibility of deeper vessels.



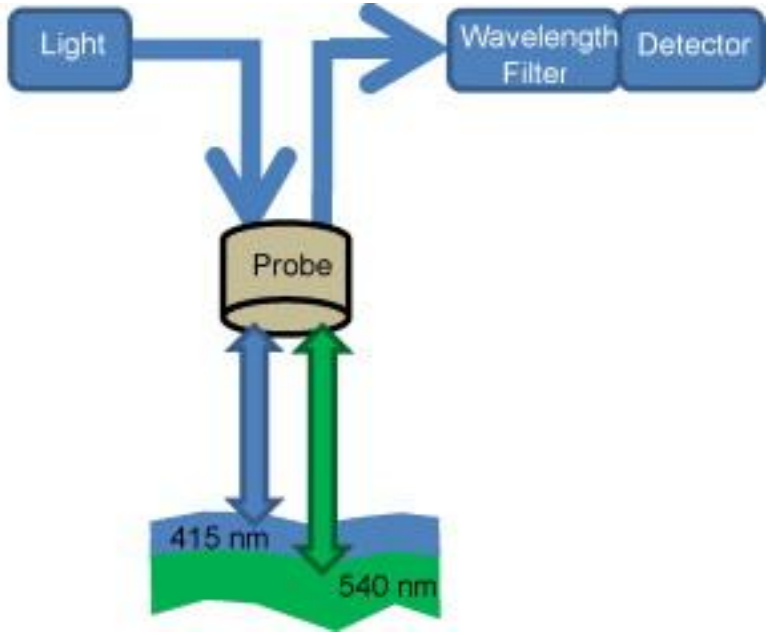
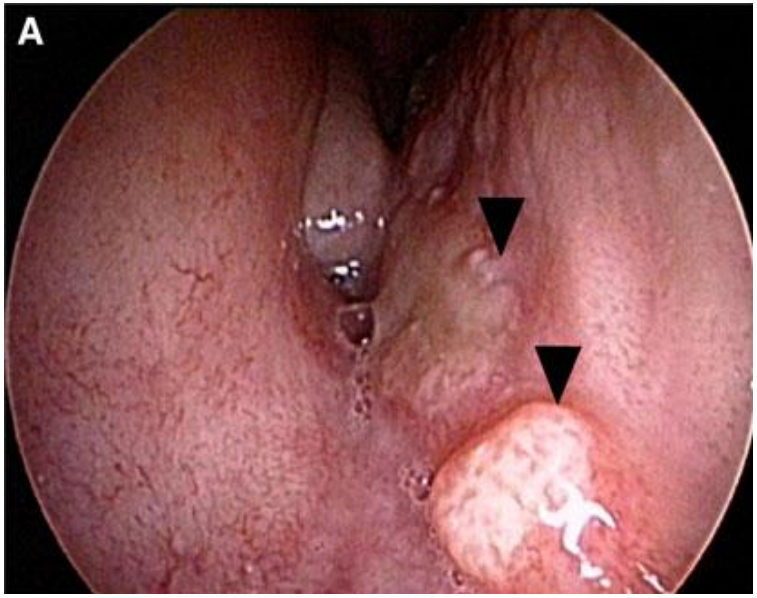


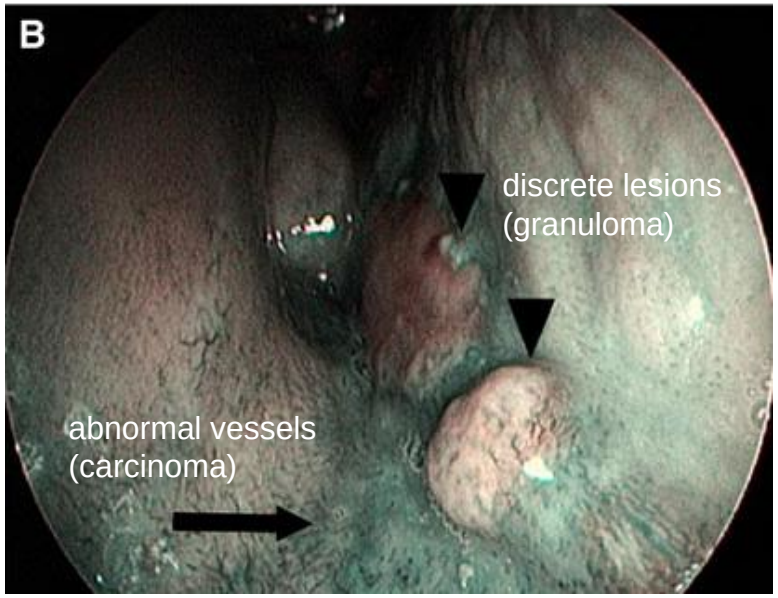
Figure from Cauberg E. 2009

Real-Time Imaging (6)

Narrow-Band Imaging (NBI) (2)

- Specific neoangiogenic patterns → premalignant or neoplasic lesions [Peretti 2011]:
  - darker areas in a context of green-blue normal mucosa;
  - scattered thick dark spots;
  - increased microvascular density;
  - winding vessels (intraepithelial papillary capillary loops);
- Definition of the histopathologic nature of the lesion.



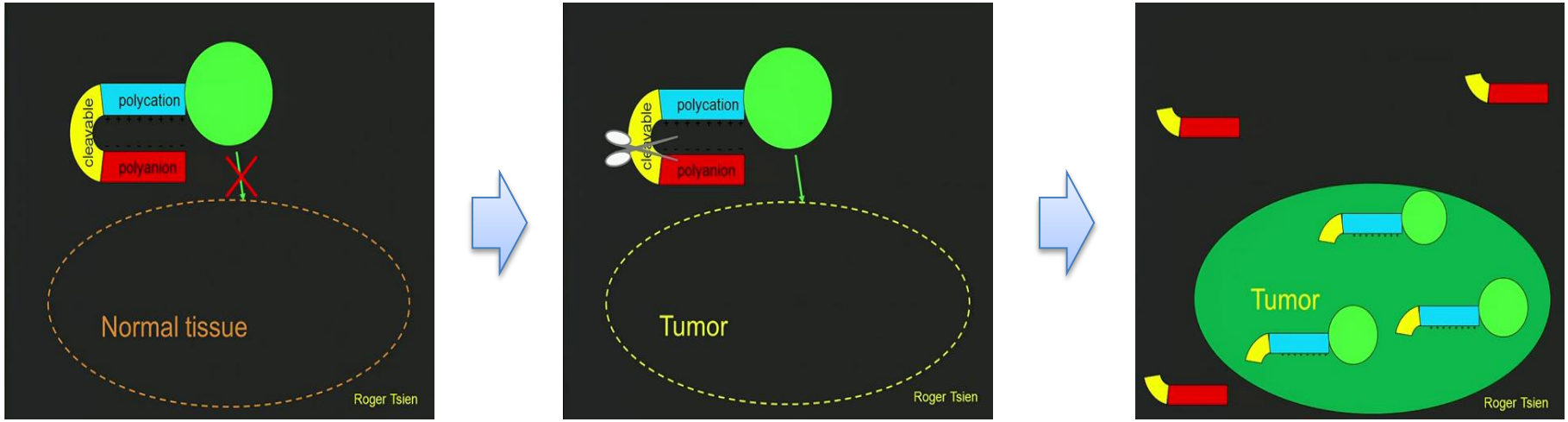


Figures from Peretti G. *2010*

Real-Time Imaging (7)

Color-Coded Surgery (1)

- Nguyen Q.T. and Tsien R. [Nguyen Q.T. 2010];
- Visualize tumors during surgery using activable cell-penetrating peptides (ACPPs);
- POLYCATION (very sticky) + DYER + POLYANION (non stick)+ CLEAVABLE PART;
- Molecular scissors (i.e. protease enzymes that tumor makes);
- The tumor labels itself and it gets fluorescent;

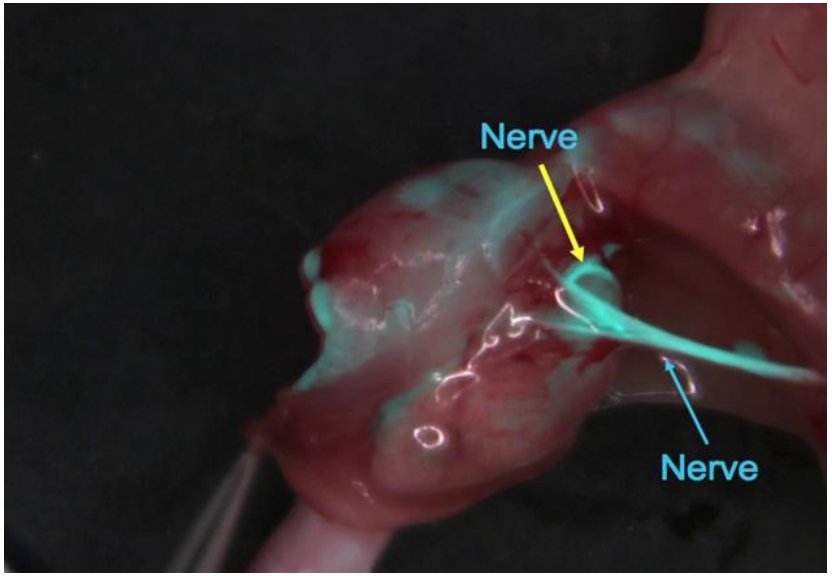


Figures from http://www.ted.com/talks/quyen_nguyen_color_coded_surgery.html

Real-Time Imaging (8)

Color-Coded Surgery (2)

- The fluorescent light can go through tissues; this works for metastatic lymph nodes;
- It is visible on a MRI;
- Molecules that were specifically labeling nerves;
- Prepare for eventual human clinical trials.



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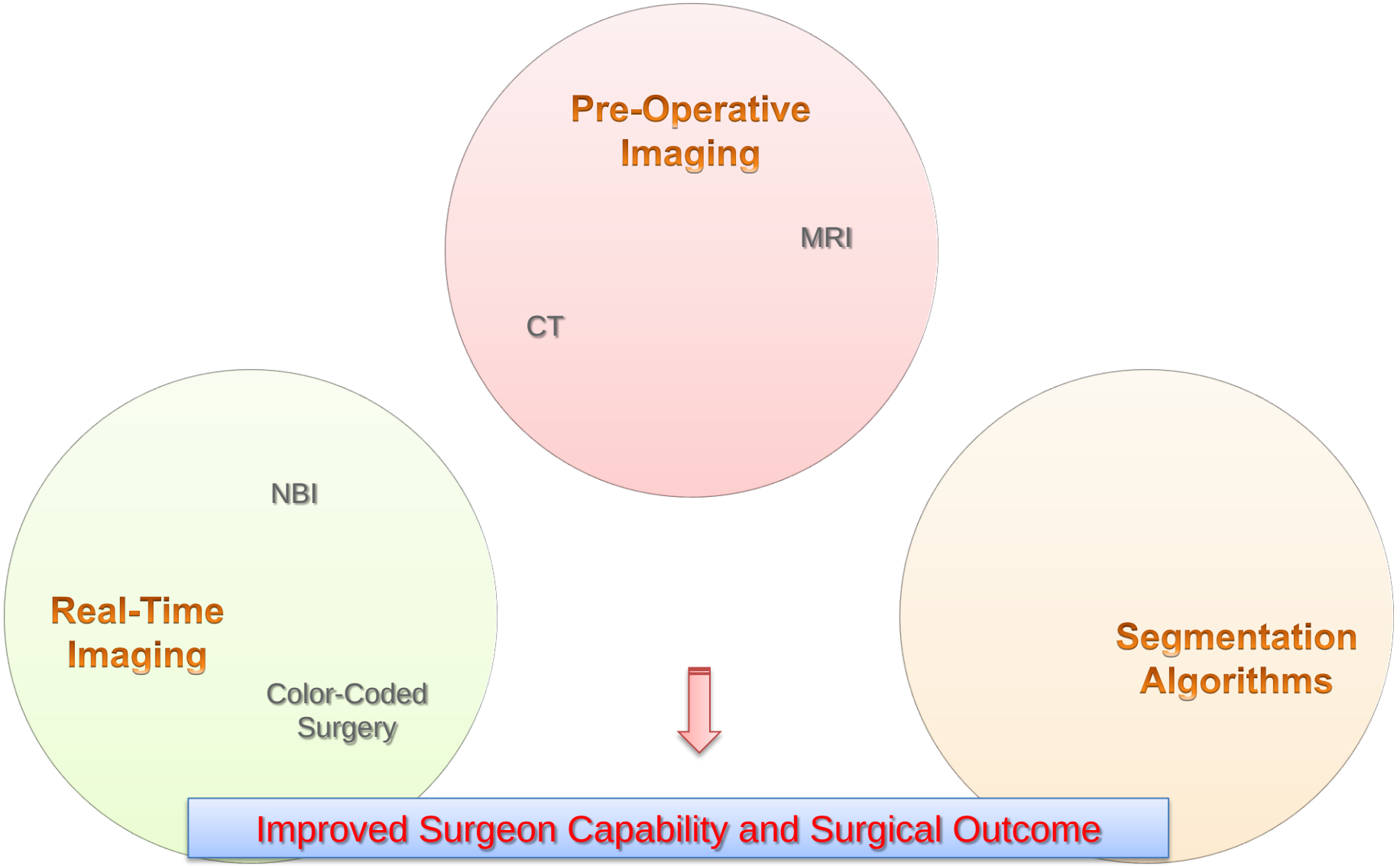
Conclusions & FW



THANK YOU!

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