

# Soluciones basadas en imágenes para los problemas de salud

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# Agenda

- Breast cancer and quantitative imaging
- Pulmonary diseases
- Skin diseases
- Abdominal diseases

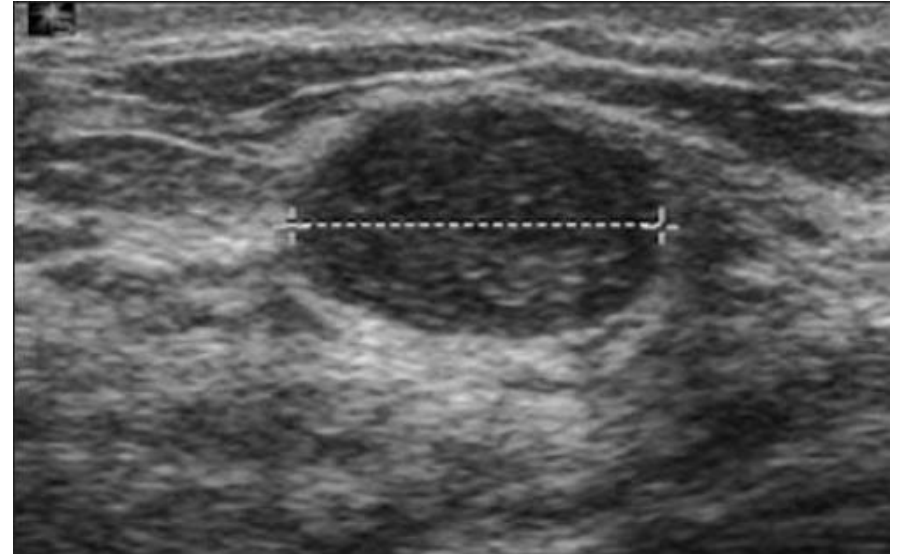
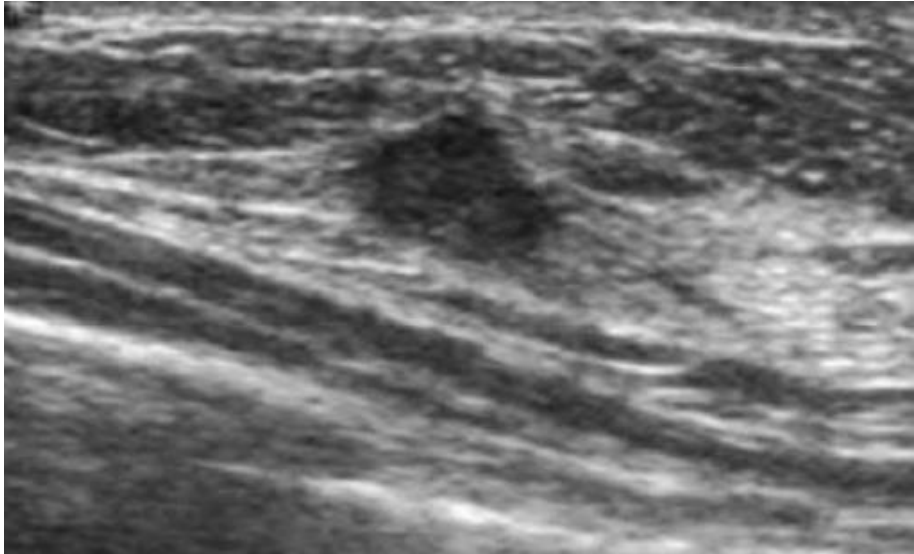
# Breast Cancer

- The 2nd most common cancer in Perú.
- On average, 90% patients are hospitalized with a tumor above stage I.
- Mamography has been widely used worldwide, presenting an 96% accuracy of detecting cancerous lesions.

## HOWEVER....

- Radiation-induced mammography, despite being regulated at low exposure levels, increase the possibility of generating breast cancer.
- Mammogram tests induce as well discomfort and pain to the patient due to the pressure exerted on the breast structure, being more severe in smaller busts.

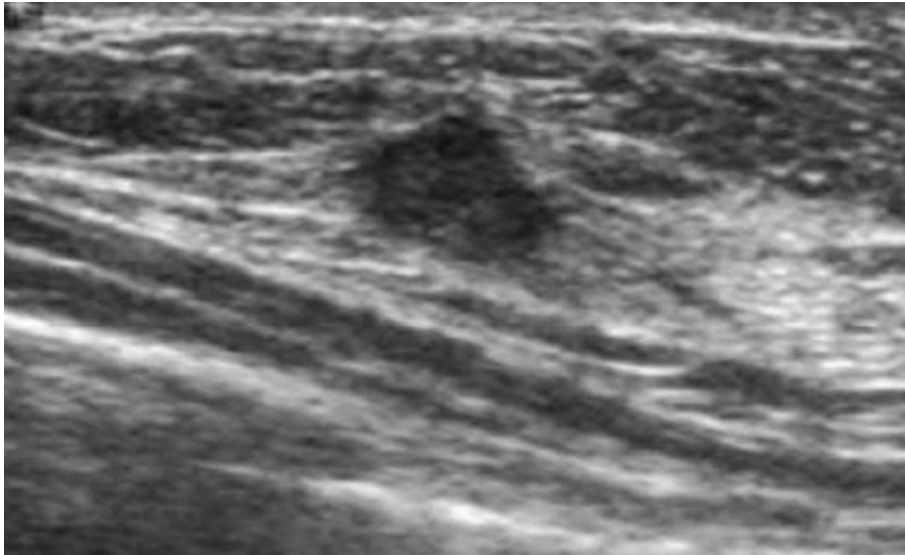
# Example of B-mode of breast images from ultrasound



**Which one is malignant (if any)?**

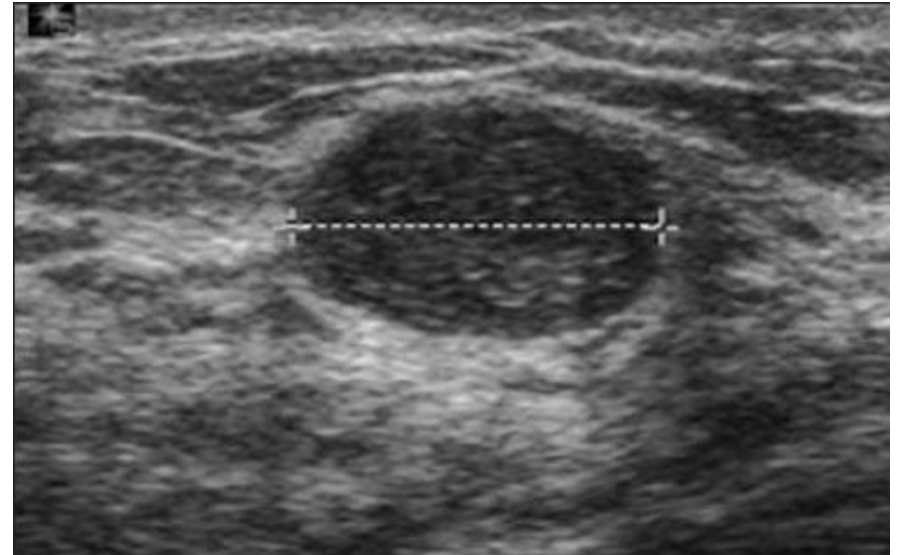
**Constantini et al., JUM, 2006;25:649-659**

# Example of B-mode of breast images from ultrasound



**Irregular hypoechoic mass with  
angular margins and no posterior  
acoustic features (BI-RADS - 5)**

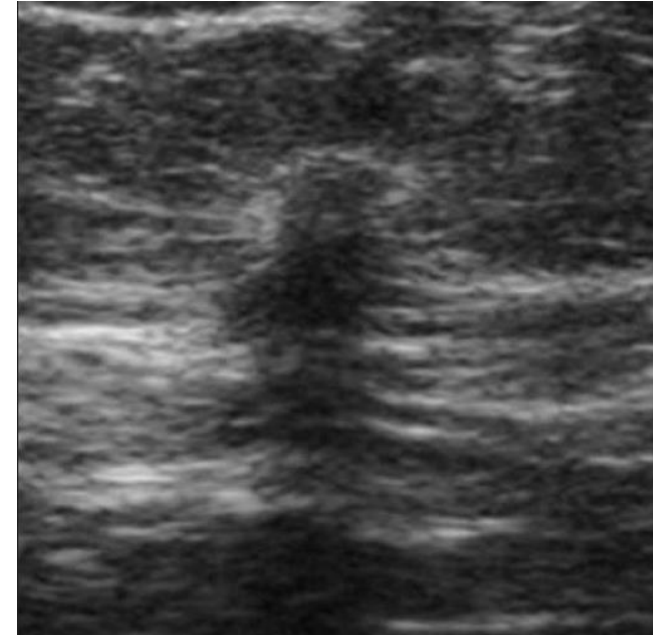
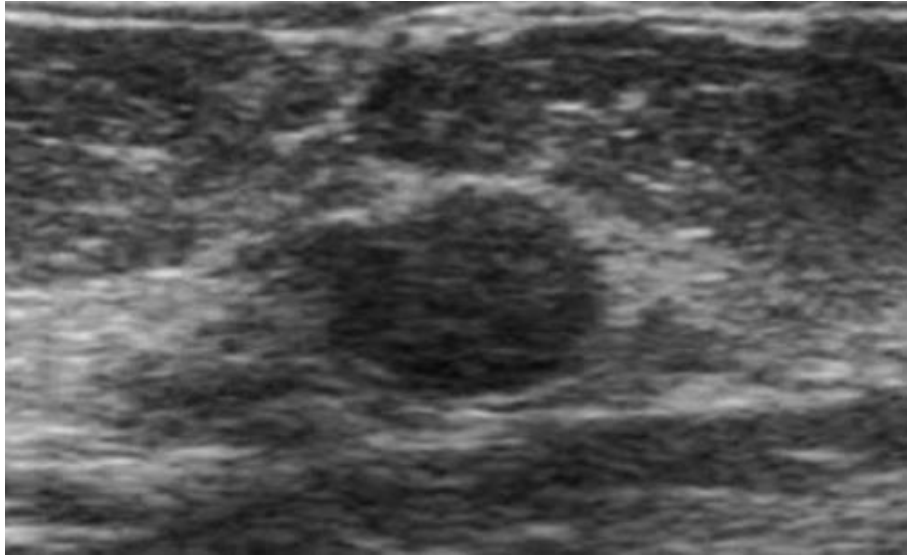
**IDC**



**Hypoechoic mass with  
circumscribed margins (BI-  
RADS - 3)**

**Fibroadenoma**

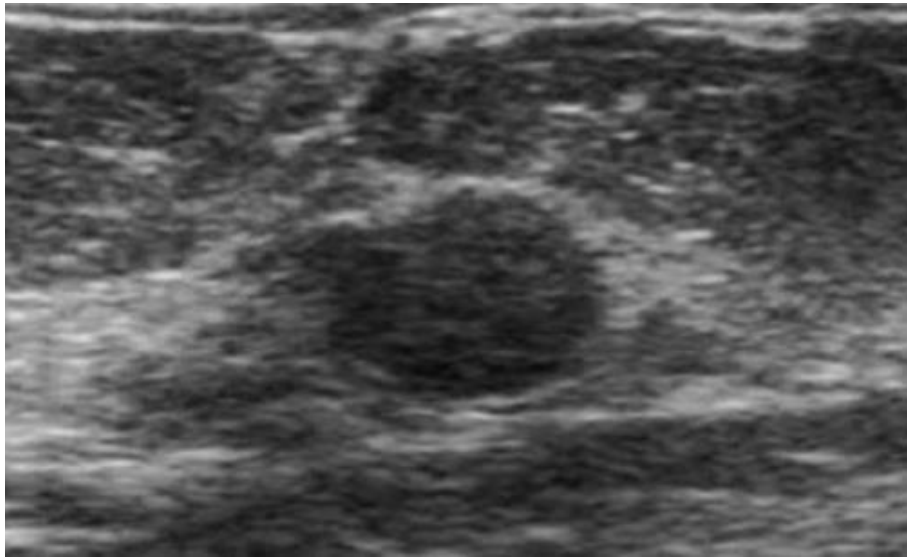
# Example of B-mode of breast images from ultrasound



**Which one is malignant (if any)?**

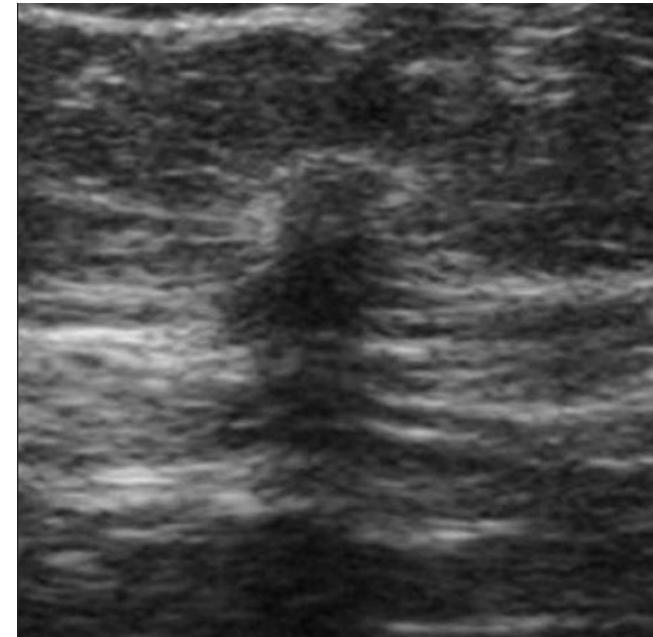
**Constantini et al., JUM, 2006;25:649-659**

# Example of B-mode of breast images from ultrasound



**Hypoechoic mass with angular  
margins and no posterior  
acoustic features (BI-RADS - 4)**

**Medullary Carcinoma**

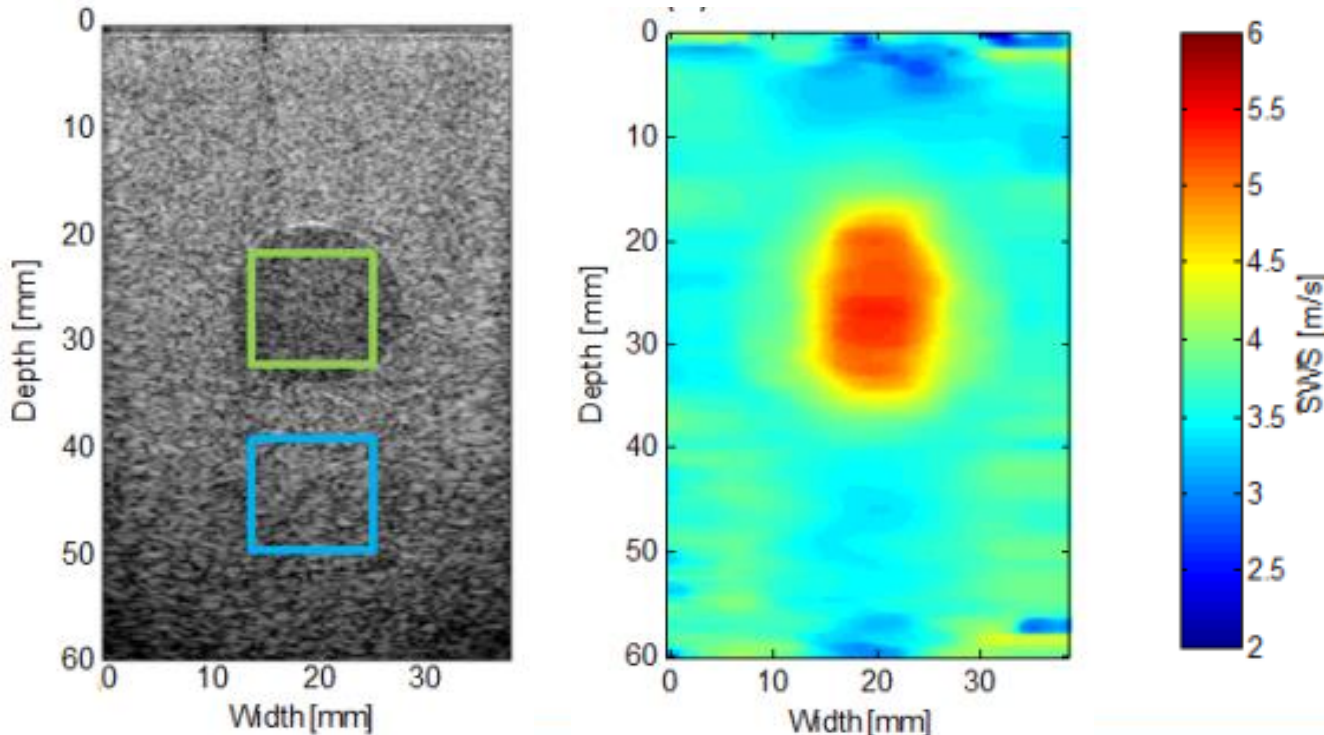


**Irregular hypoechoic mass with  
spiculated margins and echogenic  
halo (BI-RADS - 5)**

**Benign Sclerotic Lesion**

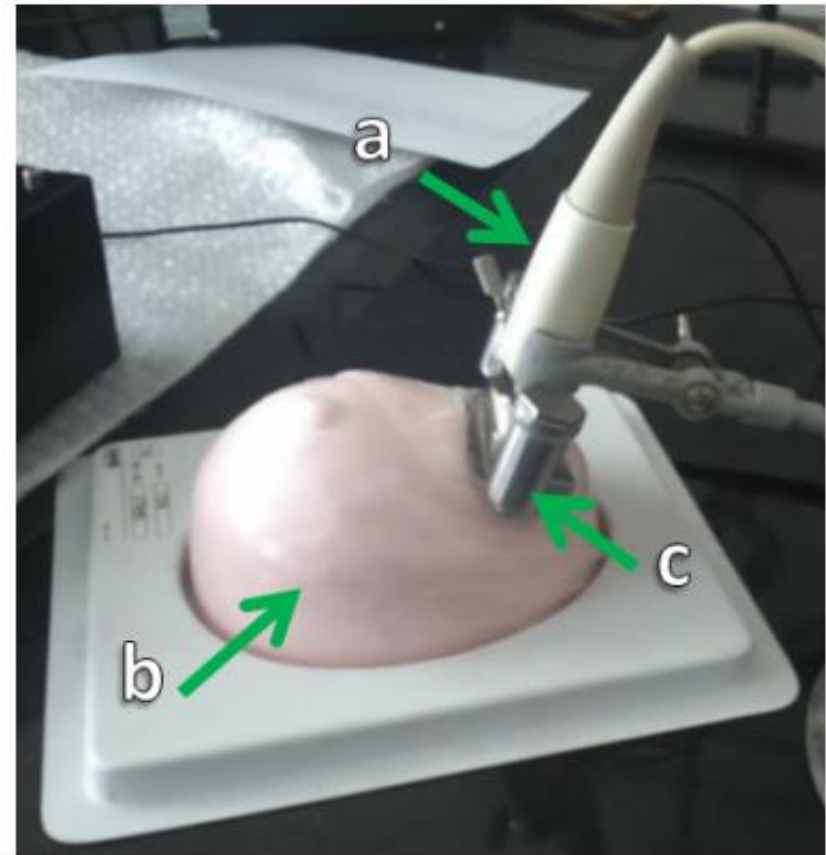
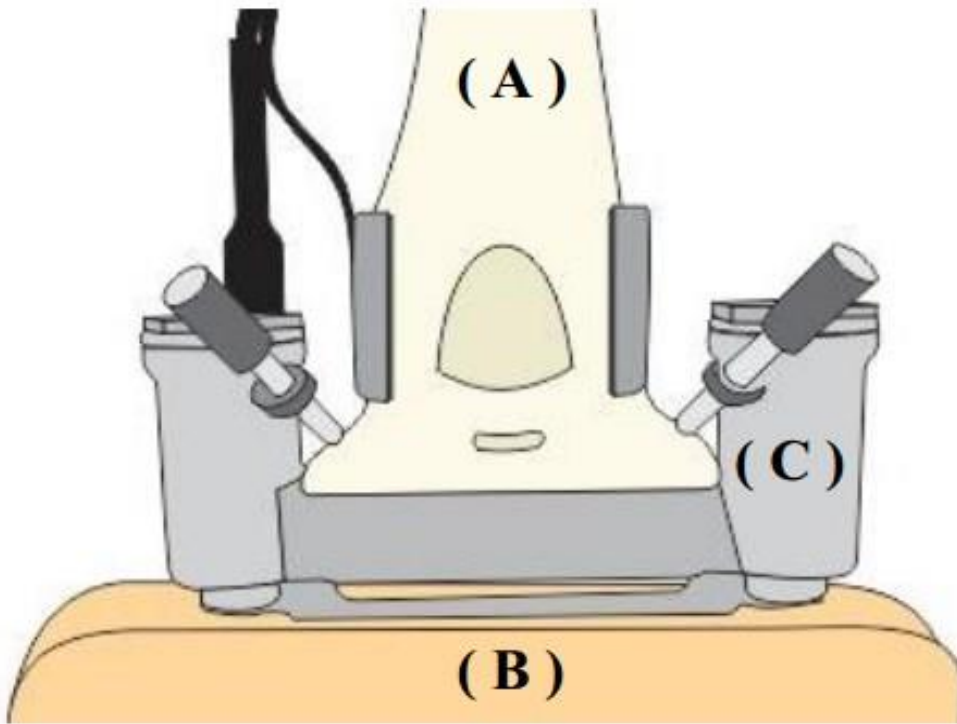
# Breast cancer diagnosis by elastography

- Ultrasound uses non-ionizing radiation, which is safer than mamography.
- Elastography is an ultrasound modality that assesses the stiffness of a region by analyzing the tissue response to a mechanical excitation.



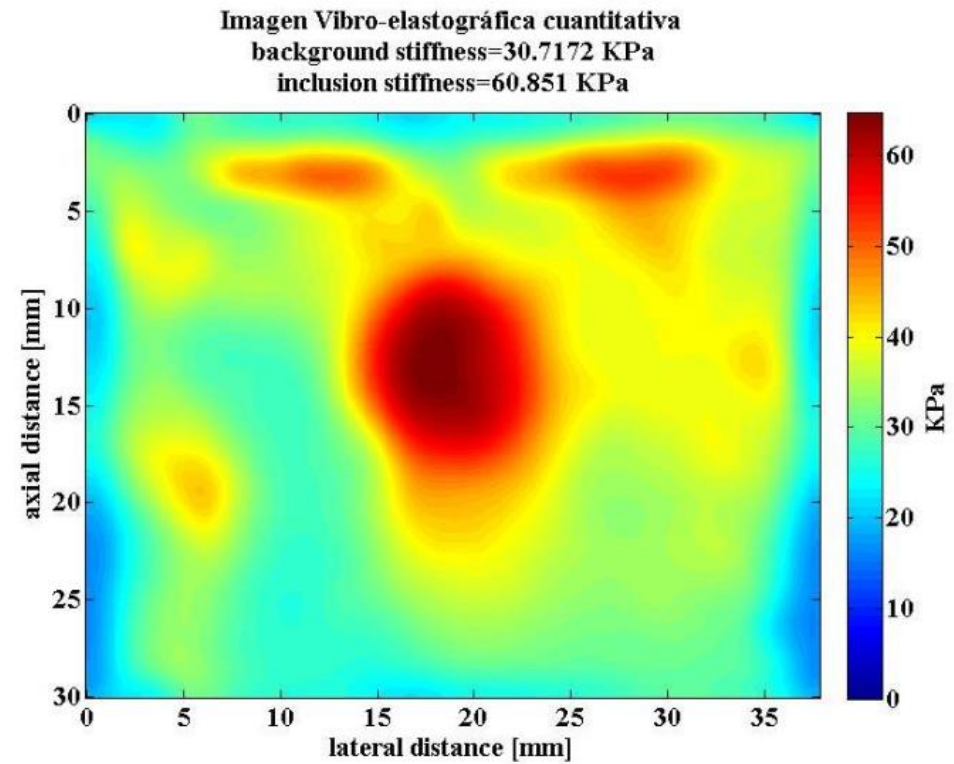
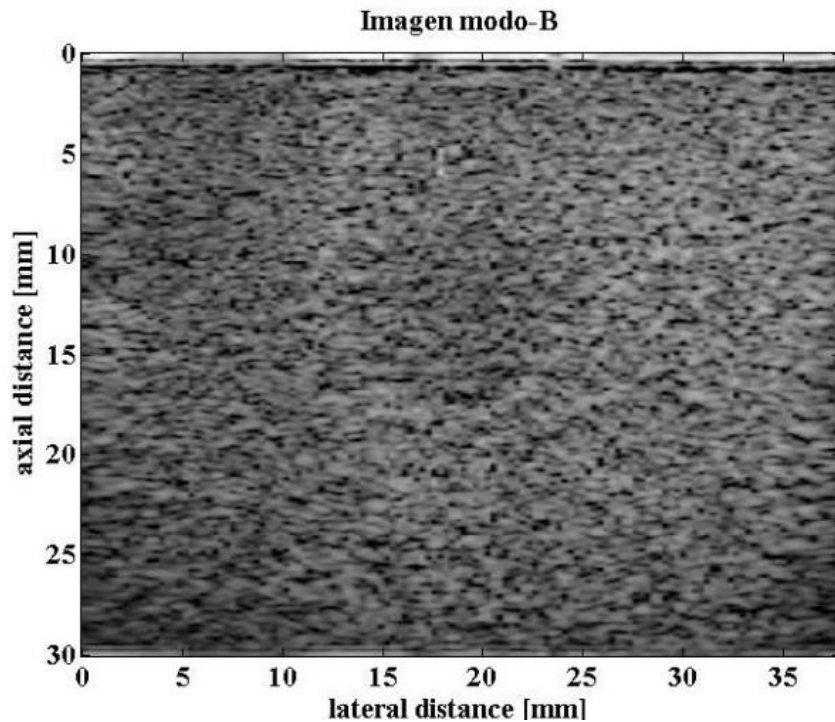
# Breast cancer diagnosis by elastography

- A portable module can be attached to the ultrasound probe to induce a mechanical external vibration into the examined organ.

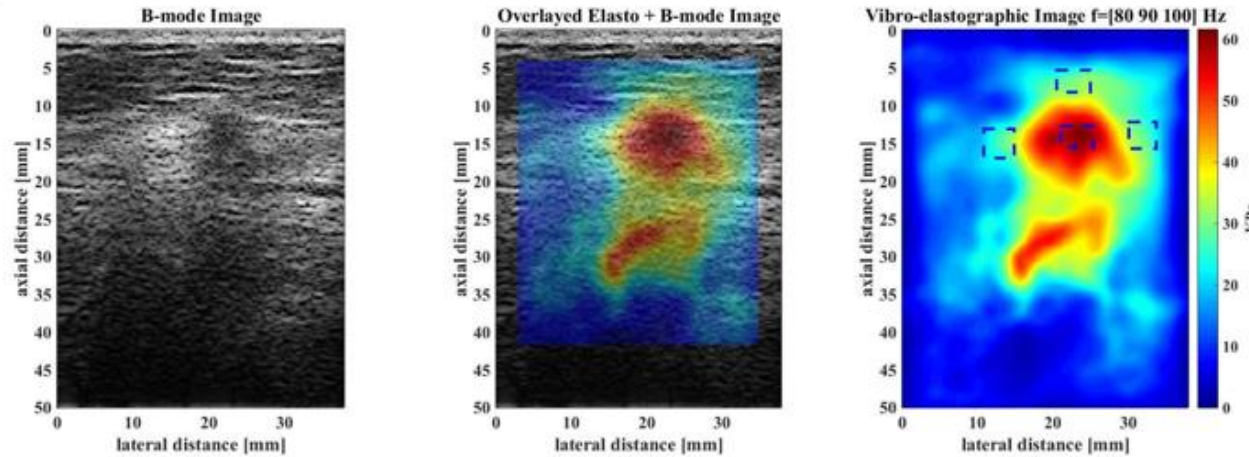


# Breast cancer diagnosis by elastography

- An elasticity image is reconstructed, providing additional information that positively affects the accuracy of the diagnosis.

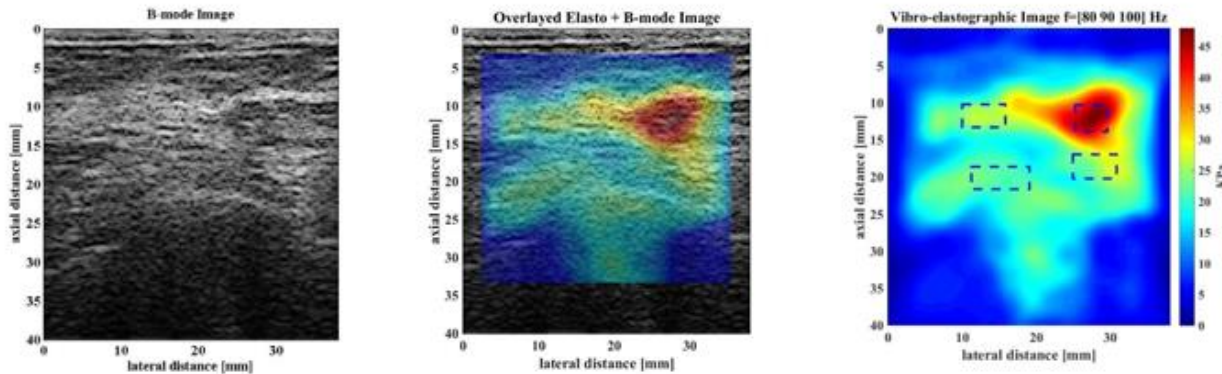


# Breast cancer diagnosis by elastography



(a)

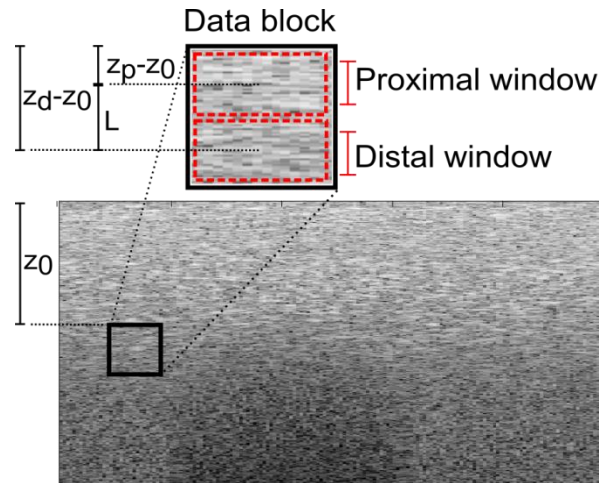
Example of elastographic images of a cancerous (top, shear modulus = 60 KPa) and a benign (bottom, shear modulus = 40 Kpa) tumor.



(b)

# Ultrasonic attenuation imaging

- Quantitative ultrasound estimation (e.g. attenuation coefficient) -> spectral log difference technique.



- $y(f)$ : Spectral ratio: proximal and distal window.
- $f$ : Useful frequency range (i.e. -15 dB).
- $\beta$ : Attenuation coefficient slope.
- $c$ : Log-ratio of backscatter coefficients.

$$y(f) = 4(z_p - z_d)\beta f + c.$$

- Regularized spectral log difference (RSLD) technique

$$\begin{bmatrix} (y_{1,1})_1 \\ \dots \\ (y_{1,1})_v \\ \dots \\ (y_{m,n})_1 \\ \dots \\ (y_{m,n})_v \end{bmatrix} = \begin{bmatrix} 4Lf_1 & \dots & 0 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 4Lf_v & \dots & 0 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & \dots & 4Lf_1 & 0 & \dots & 1 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & \dots & 4Lf_v & 0 & \dots & 1 \end{bmatrix} \times \begin{bmatrix} \beta_{1,1} \\ \dots \\ \beta_{m,n} \\ c_{1,1} \\ \dots \\ c_{m,n} \end{bmatrix} \Rightarrow Y(F) = F \begin{bmatrix} B \\ C \end{bmatrix} \Rightarrow \min_{B,C} \left\{ \left\| Y - F \begin{bmatrix} B \\ C \end{bmatrix} \right\|_2^2 + \mu(\text{TV}(B) + \text{TV}(C)) \right\}$$

- TV: Total variation function of a 2D map.

# Breast cancer diagnosis by QUS

- Attenuation estimation using the RSLD technique.

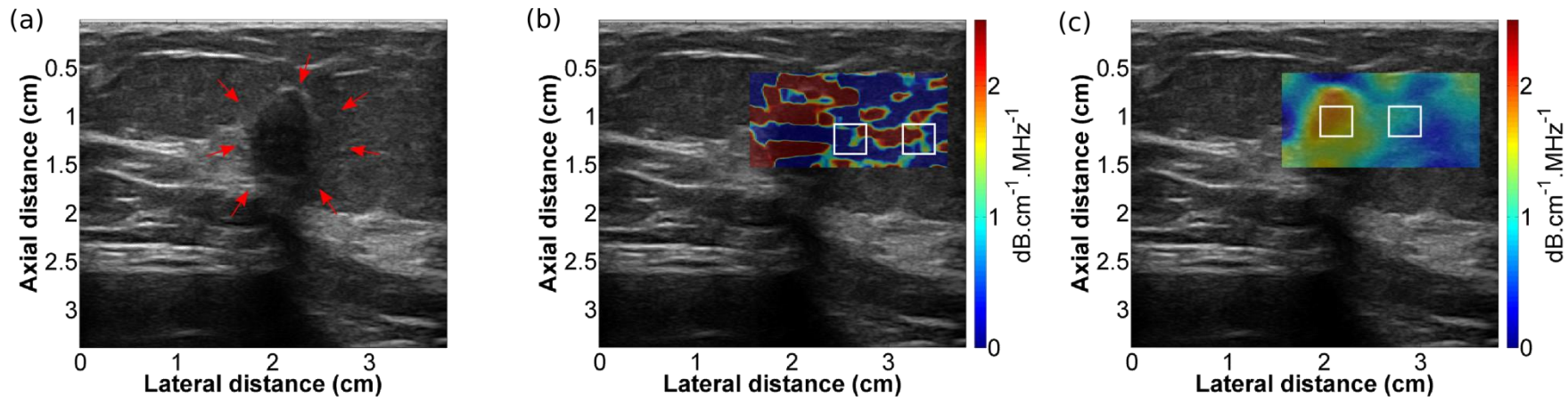


Fig. B-mode image for *in vivo* breast tissue (a) and ACS maps when using the SLD (b) and RSLD (c) techniques for data block sizes of  $10\lambda \times 10\lambda$ . The arrows and solid lines outline the tumor and regions for the calculation of performance metrics, respectively.

Table: Attenuation coefficient estimation by using the RSLD technique of *in vivo* breast tissue.

Breast	Data block size ( $\lambda$ )	Mean $\pm$ SD ( $\text{db.cm}^{-1}.\text{MHz}^{-1}$ )	
		SLD	RSLD
Tumor	$10 \times 10$	$1.26 \pm 3.48$	$1.71 \pm 0.11$
Normal tissue	$10 \times 10$	$0.61 \pm 2.73$	$0.9 \pm 0.14$

# Pneumonia Detection and Diagnosis

- The respiratory disease with the highest pediatric mortality rate accounting for 15% of all deaths of children under 5 years old worldwide.
- The diagnosis of pneumonia is commonly made by clinical criteria with support from ancillary studies and also laboratory findings.

## HOWEVER...

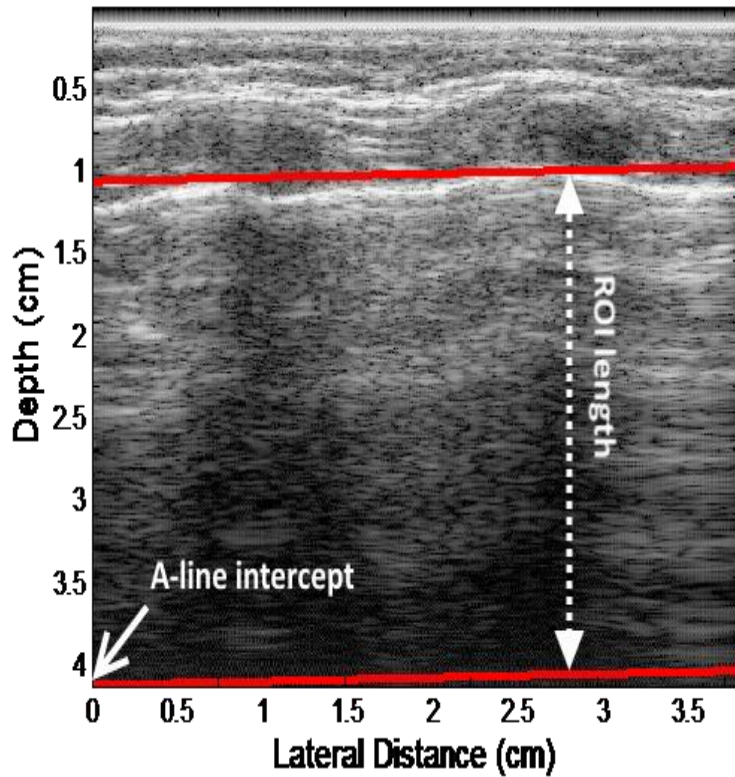
- Radiography is also used but involves ionizing radiation.
- Lung ultrasound is a promising alternative for chest imaging; but interpretation is subjective and requires adequate training.



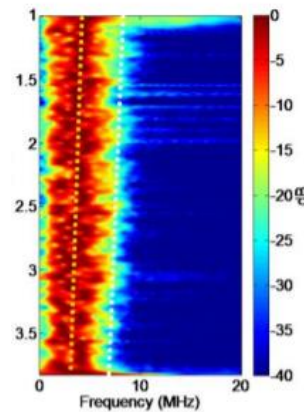
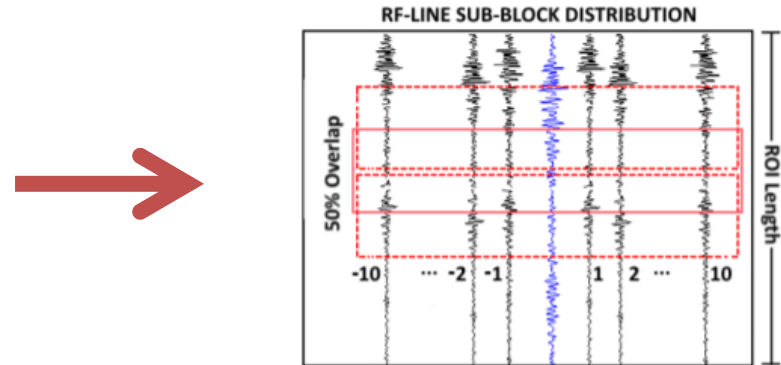
Acquisition setup for childrens with pneumonia in “Hospital Nacional de Puno”, Perú

# Pneumonia Detection and Diagnosis

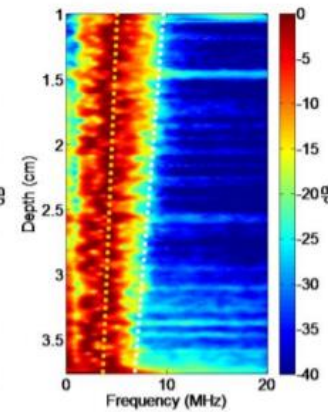
Algorithm detection based on RF data spectral features



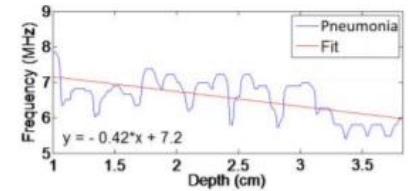
B-mode image



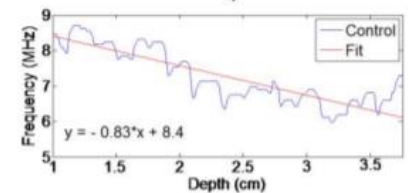
a)



b)

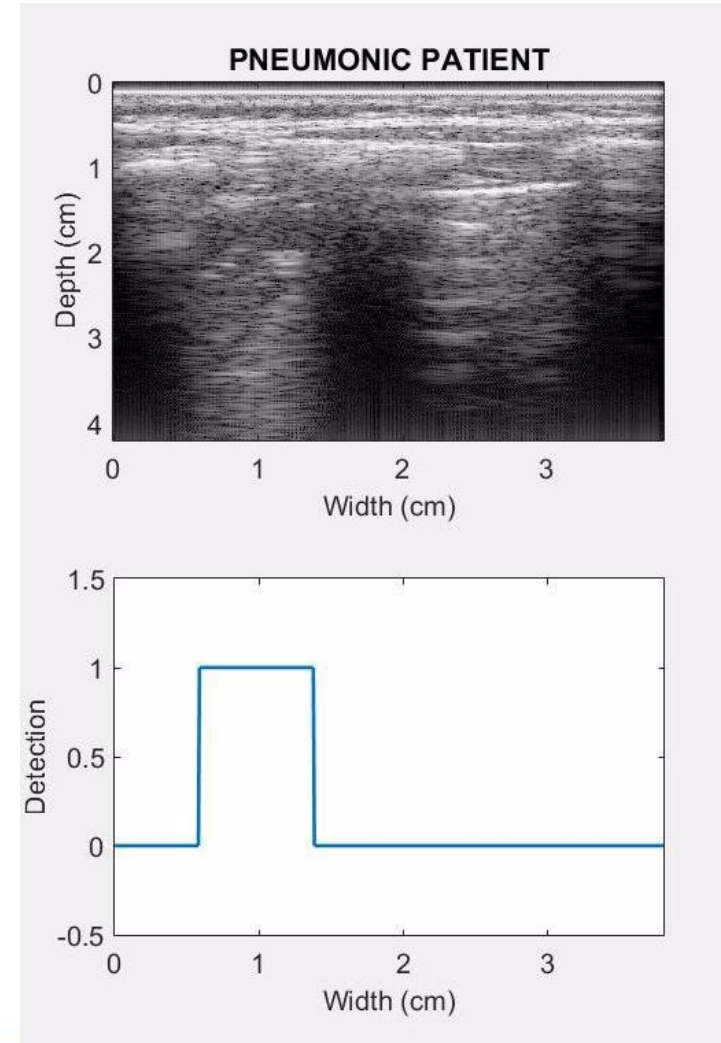
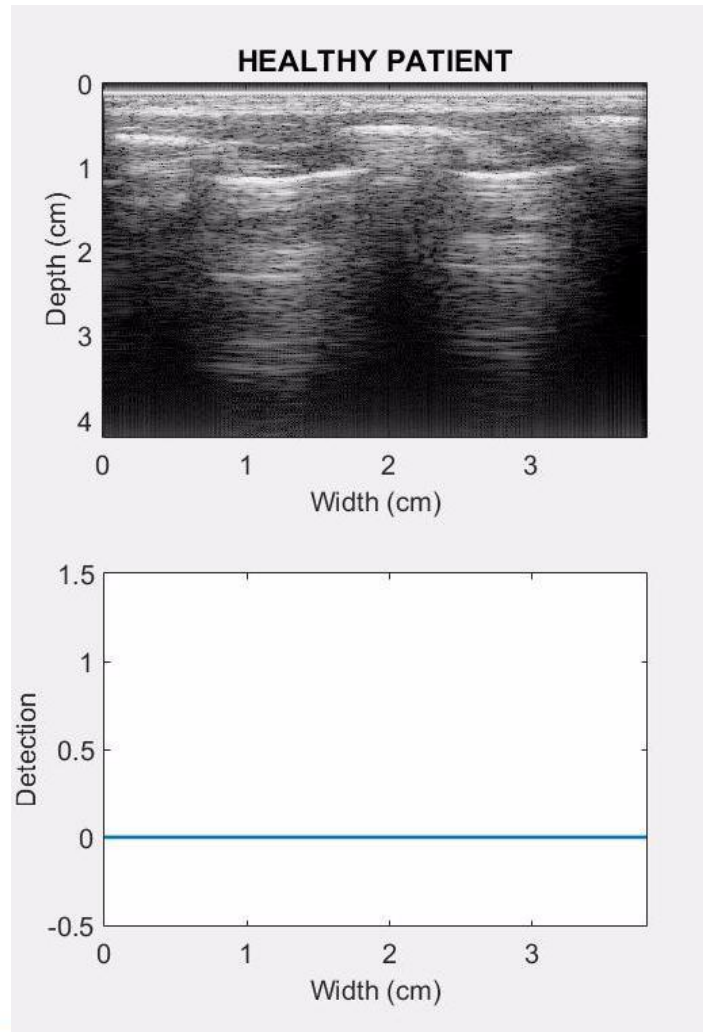


c)



d)

# Pneumonia Detection and Diagnosis



# Tuberculosis

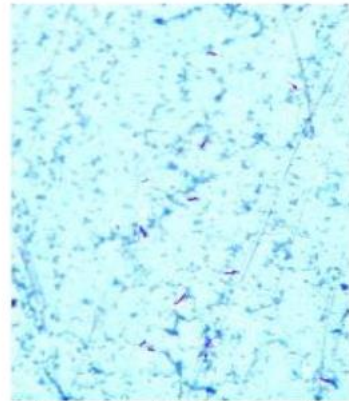
- *Mycobacterium tuberculosis*: high morbidity and mortality worldwide (20K cases of tuberculosis diagnosed in Peru, 2014)
- Sputum smear bacilloscopy is the most used test for diagnosis of tuberculosis.

## HOWEVER....

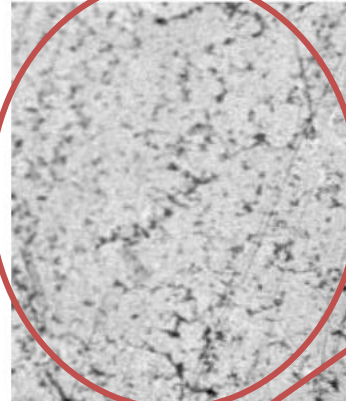
- The World Health Organization (WHO), advice that a technician should not analyze more than 20 samples per day.
- Due to the increasing number of respiratory symptomatic patients annually, computational digital image processing algorithms that allow automated visual analysis of samples and generate a reliable report of bacilli concentration are required.

# Image segmentation of TBC samples

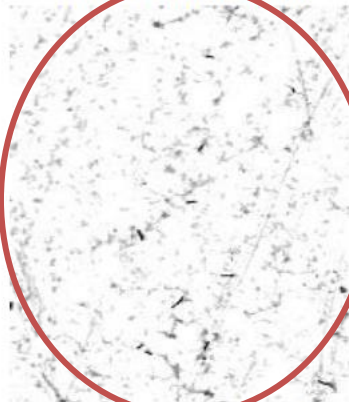
RGB component enhancement



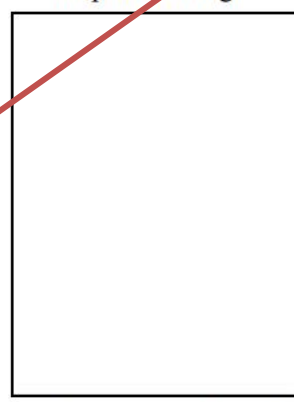
(a) Original ZN image with contrast enhancement



(b) Component "R" of the improved image.



(c) Component "G" of the improved image.



(d) Component "B" of the improved image.

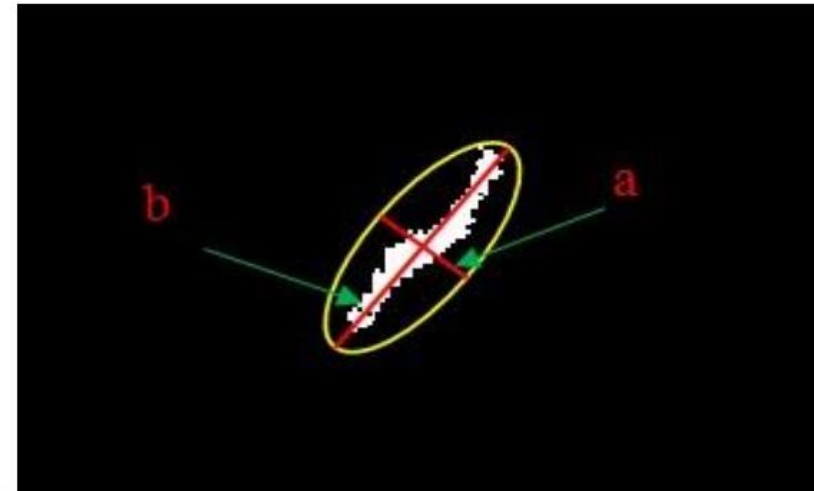
Acid Fast Bacilli (AFB) images are obtained from the Ziehl Nielsen (ZN) stain method

Selected layers

$$IR(x, y) = IM_R(x, y) - IM_G(x, y)$$

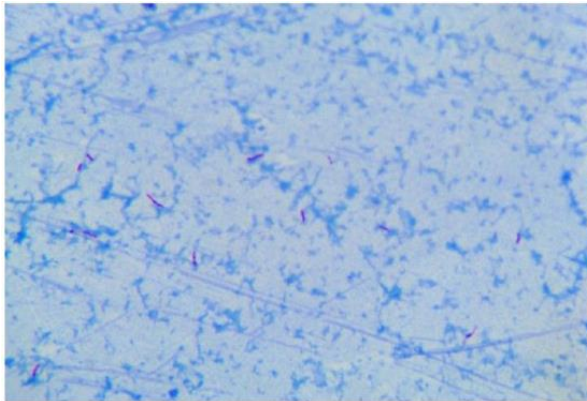


Segmentation by eccentricity



# Image segmentation of TBC samples

Original  
ZN AFB



Final  
Mask



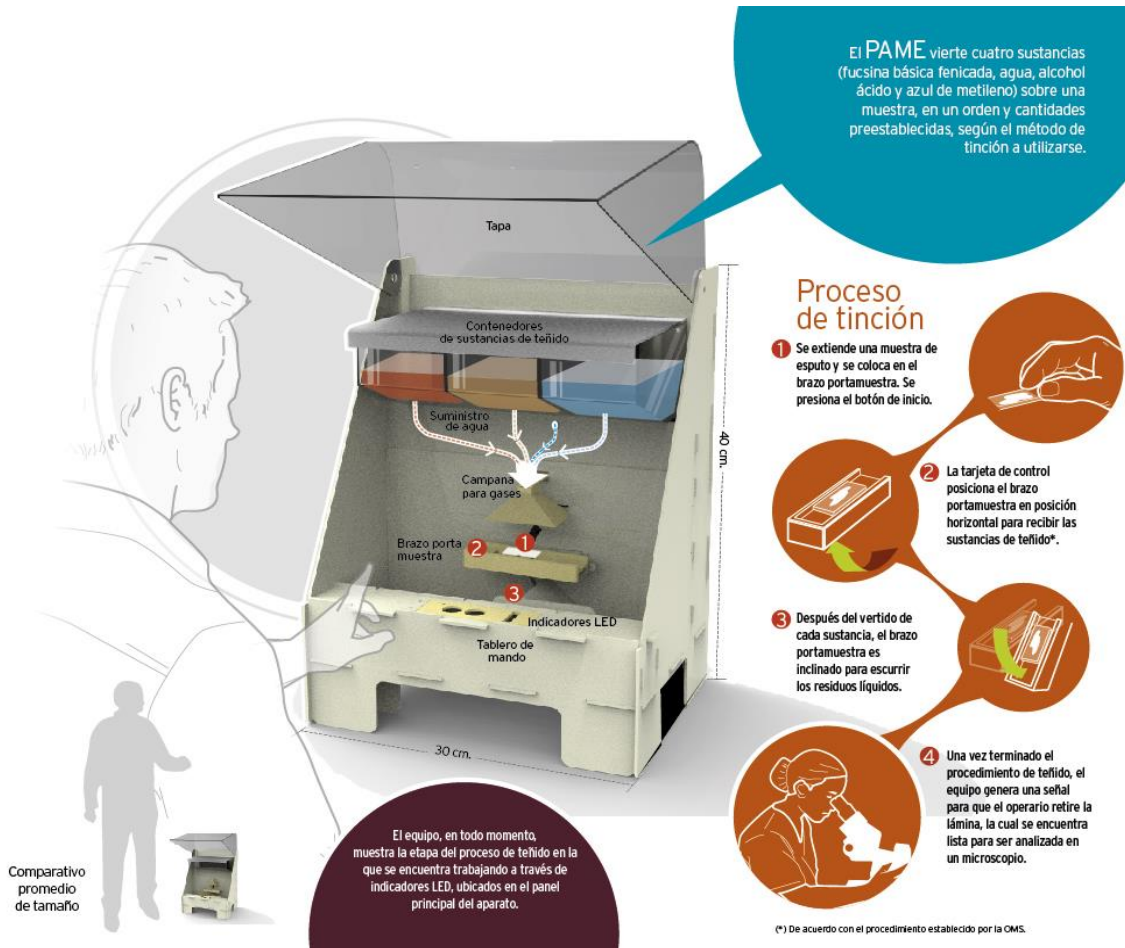
Sensitivity and Specificity analysis



Further improvements in the detection of bacilli can be achieved by the application of more parameters such as geometric descriptors, photometric measurements.

# Tuberculosis – Biomedical Instrumentation

## Automatic Processor Device for Sputum Samples (PAME)

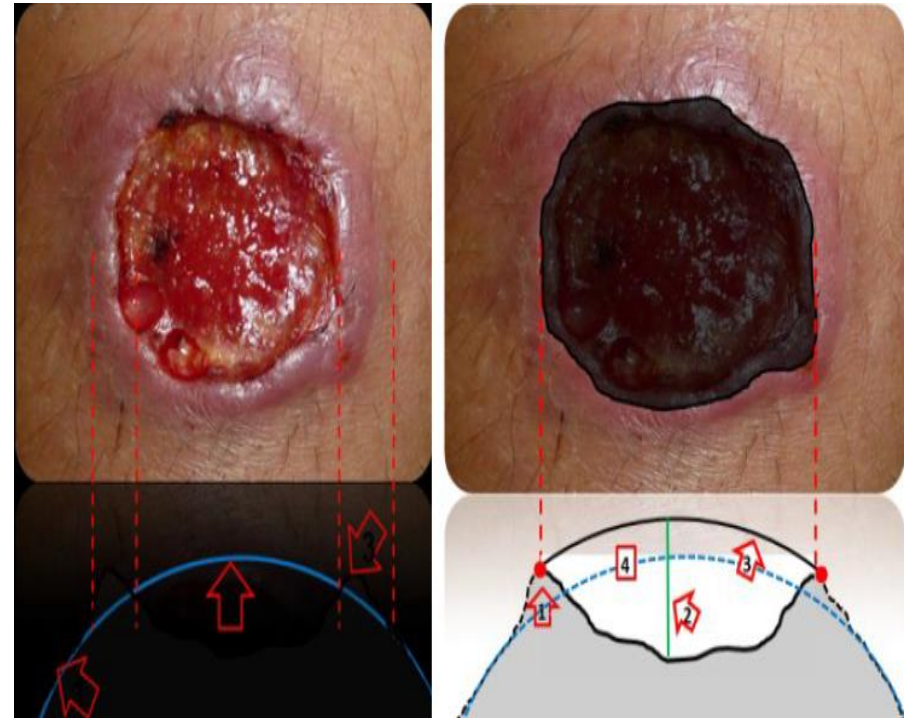


# Cutaneous Leishmaniasis

- One of the most frequent causes of consultation in primary health-care units (PHU) in tropical areas.
- The lack of dermatological expertise and modern diagnostic tools can lead to their incorrect diagnosis and treatment.

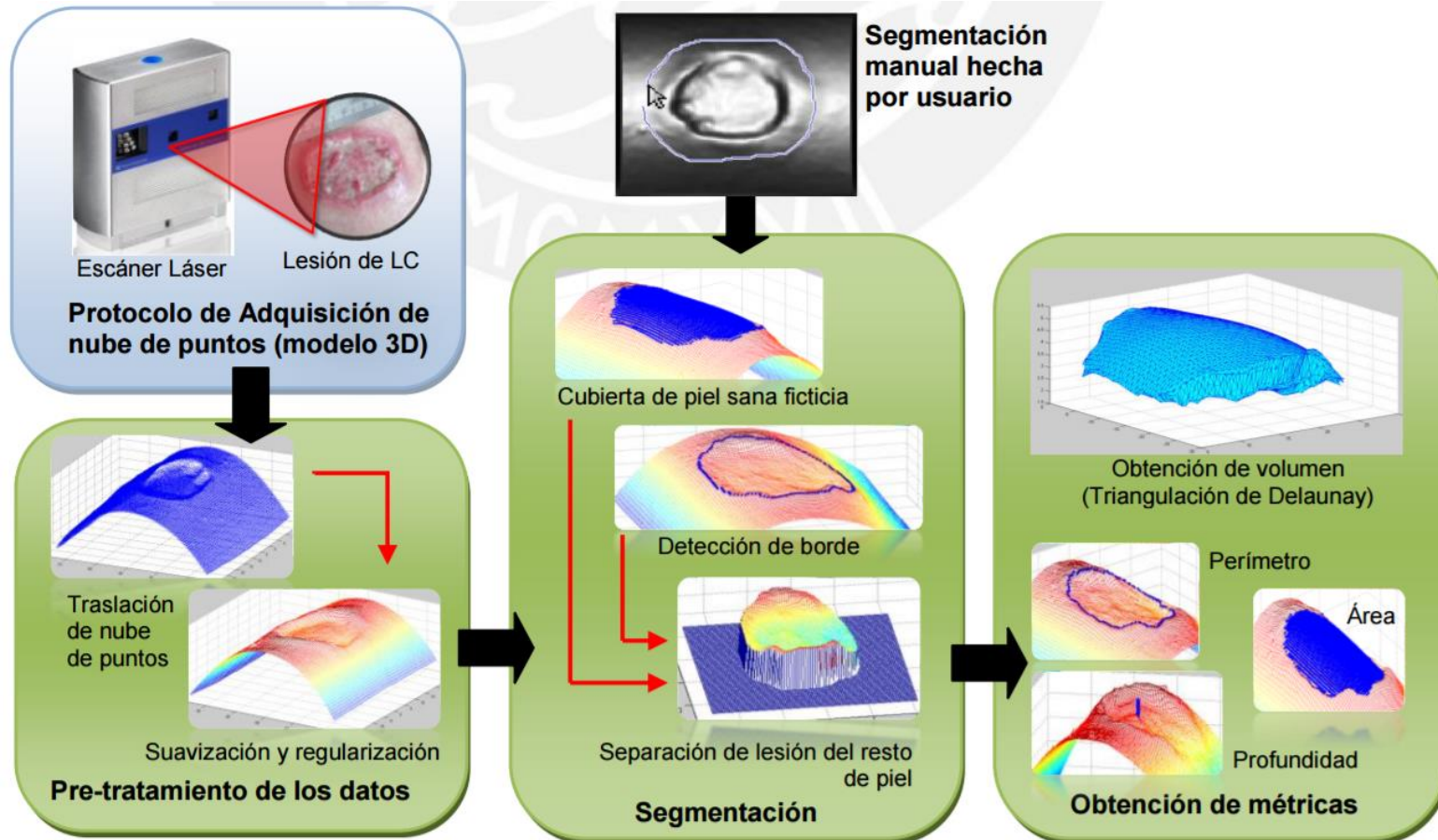
## THEREFORE...

- The development of algorithms based on image processing technologies is required to the aid of the diagnosis and follow up of treatment of skin wounds.



Leishmaniasis skin wound

# Volumetric Reconstruction using 3D Laser Triangulation

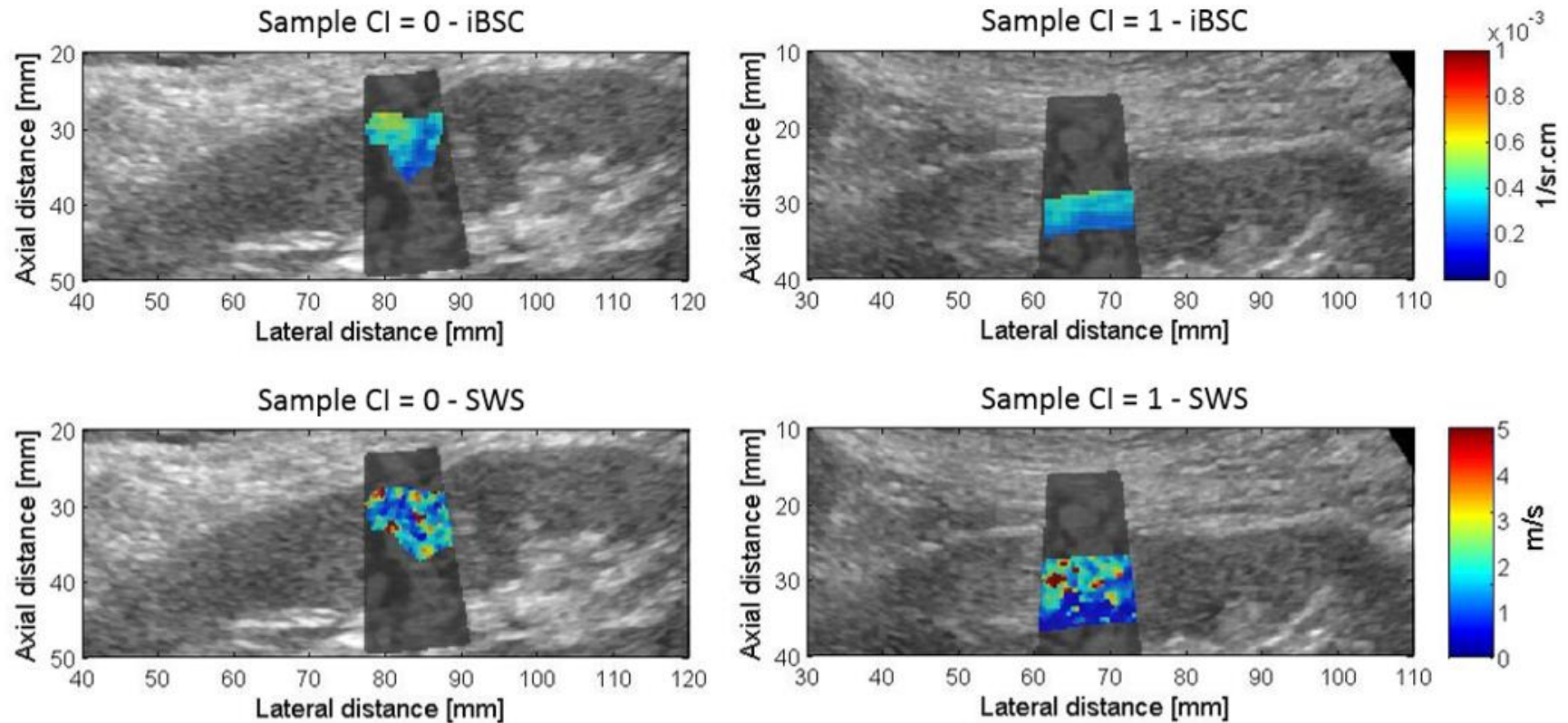


Volume measurement system architecture and other metrics in Lesions of cutaneous Leishmaniasis consisting of three stages: pre-treatment of Data, segmentation, and metrics

# Renal trasplant monitoring

- Renal transplants in the USA: 16,900 on 2010
  - 90,051 patients on waiting list by 2011
- Renal transplant needs follow-up using biopsy
  - Check for signs of rejection
  - Biopsies suffer from complications (less than 1%) and sampling errors
- No radiological method exists yet for non-invasively diagnose renal graft integrity.

# In vivo kidney imaging



Sample pair of iBSC (top) and SWS (bottom) images obtained from patients with kidney biopsy resulting in a CI score of 0 (left) and 1 (right).



# Conclusions

- Many challenges in medical imaging remain to be addressed.
- The role of software solutions (i.e., signal processing, computer vision, bioinformatics) is vital for addressing major health care problems.
- Exciting, novel techniques are being continuously developed...

and many of them here at PUCP!

# Acknowledgments

## Grants

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## Collaborations





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