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Clinically Validated Non-Invasive Automated Burn Diagnostic System for Healthcare using Artificial Intelligence: AMBUSH-AI

Mohamed El Masry MD, PhD[1], Md Masudur Rahman PhD[2], Surya C. Gnyawali PhD[1], Yexiang Xue PhD[2], Juan P. Wachs PhD[2], Gayle Gordillo MD[1]

[1]McGowan Institute for Regenerative Medicine, Department of Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA, United States

[2]Purdue University, West Lafayette, IN, 47907,

Background

In the US, 1.25 million people are treated for burns annually, with 40,000 hospitalized, costing $7.9 billion per year[1]. Early burn depth assessment is crucial as it predicts pathological scarring in 30-91% of cases. Accurate assessment determines the need for surgery but remains a clinical challenge, with burn surgeons achieving 50-76% accuracy[2].

Objective

The study evaluates a novel AI framework using multimodal harmonic ultrasound imaging (HUSD B-mode) and Tissue Doppler Elastography Imaging (TDI) to predict burn depth and classify burn pathology, aiming to improve accuracy with AI techniques.

Methods

A- Preclinical model:

1- Pig burn model (n=12) was used to develop the AI framework that was applied to a nonrandomized prospective clinical study of thermal burn patients (n=30).

2- Burn wounds (2"x2") of different degrees were created on the dorsum of domestic pigs (70- 80lbs) using standardized burner[3] per IACUC approved protocol.

3- Burn wounds were monitored with non-invasive imaging (digital photos, HUSD B-mode, and TDI) for 42 days.

4- Burn depth was confirmed by histopathological analysis and compared with Ultrasound-acquired data.

5- The AI model was trained with annotated and preprocessed TDI data and compared with the ground truth of tissue biopsies.

B- Clinical trial:

1- The platform was validated in a clinical trial (n=30 patients).

2- Human data was collected from patients treated at an American Burn Association (ABA) verified burn center under IRP approved protocol.

3- Eligible subjects had thermal burns within 72 hours of enrollment without prior surgical debridement, aged 18-89 years, TBSA ≤ 75%. Chemical, electrical or radiation burns were excluded.

4- Digital photos, HUSD B-mode, and TDI data were collected and annotated before processing with AI.

Experimental outlines for AMBUSH-AI framework

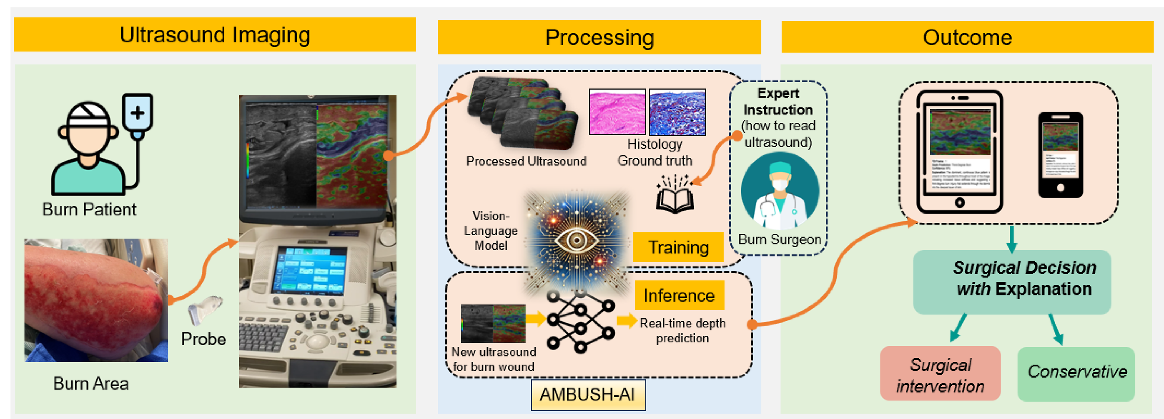

Figure 1. Experimental outlines for AMBUSH-AI framework. A schematic diagram showing Ultrasound B-mode and TDI data collection from the patient followed by data processing, surgeon input and histological validation. The outcome is displayed through digital platform with the burn depth prediction and the recommended surgical decision**.**

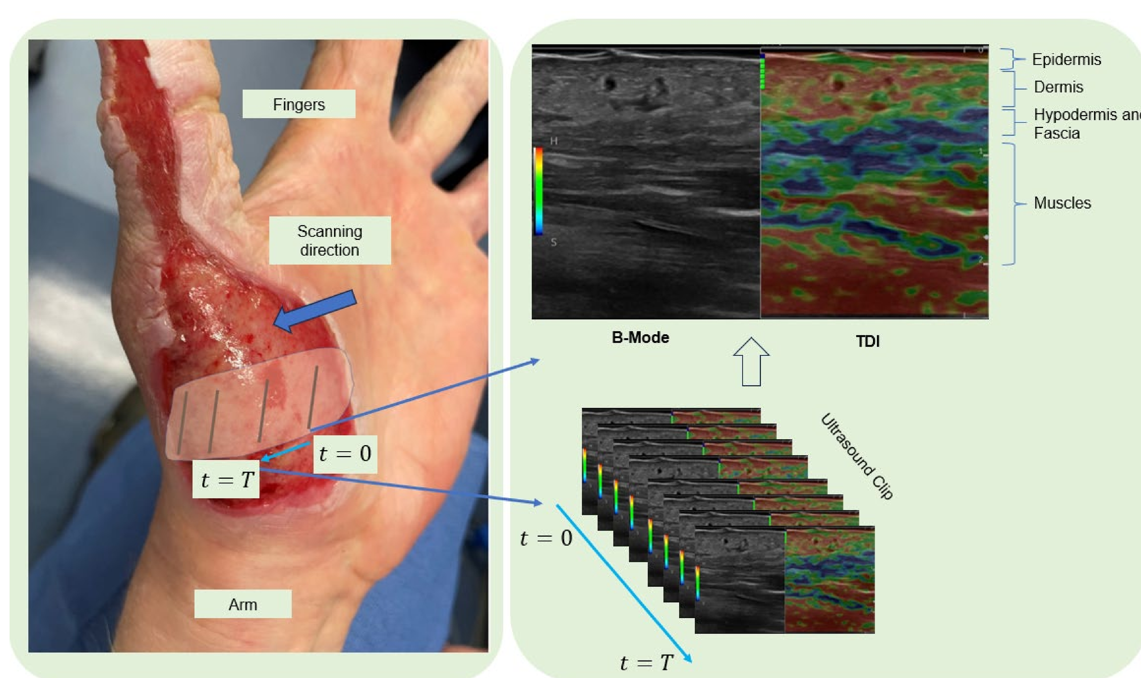

Figure 2. Human data set of digital photos and ultrasound collection and processing. The Probe scans the burn area and generates a video of B-Model and TDI ultrasound data. The TDI data consist of a color pattern which is correlated with B-mode anatomical skin layers (from top to bottom are epidermis, dermis, and hypodermis).

Red tones signify supple tissue characteristic of healthy or unaffected subcutaneous layers. Conversely, blue tones represent stiff tissue resulting from burn injuries.

Predictors: The observed color patterns in the TDI images serve as the predictor variable. These patterns, when analyzed, are used to predict burn depth based on predefined expert instructions.

Outcomes

- Outcomes measured were the AI model's accuracy and explainability in predicting the burn depth and the necessity of surgical intervention compared to expert burn surgeons..

Results

AMBUSH- AI accuracy in pig burn depth prediction with ground truth validation

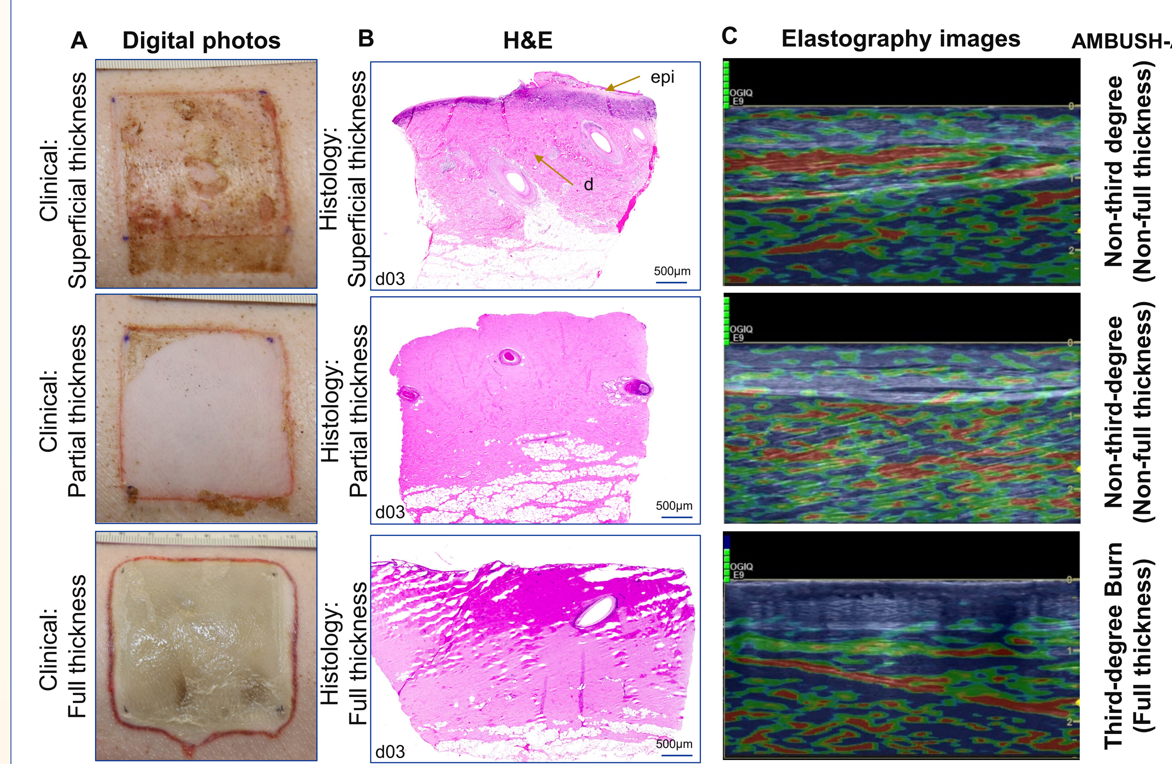

Figure 3. Ground truth histological validation of burn depth in pigs. A- digital photos of different burn degrees. B- H&E-stained pig skin biopsies, to show different burn degrees. C- Elastography images. Scale bar=500 μm. epi=epidermis, d=dermis.

AMBUSH AI method achieved a 100% accuracy in predicting the need for surgical intervention in pigs.

AMBUSH- AI accuracy in human burn depth prediction with ground truth validation

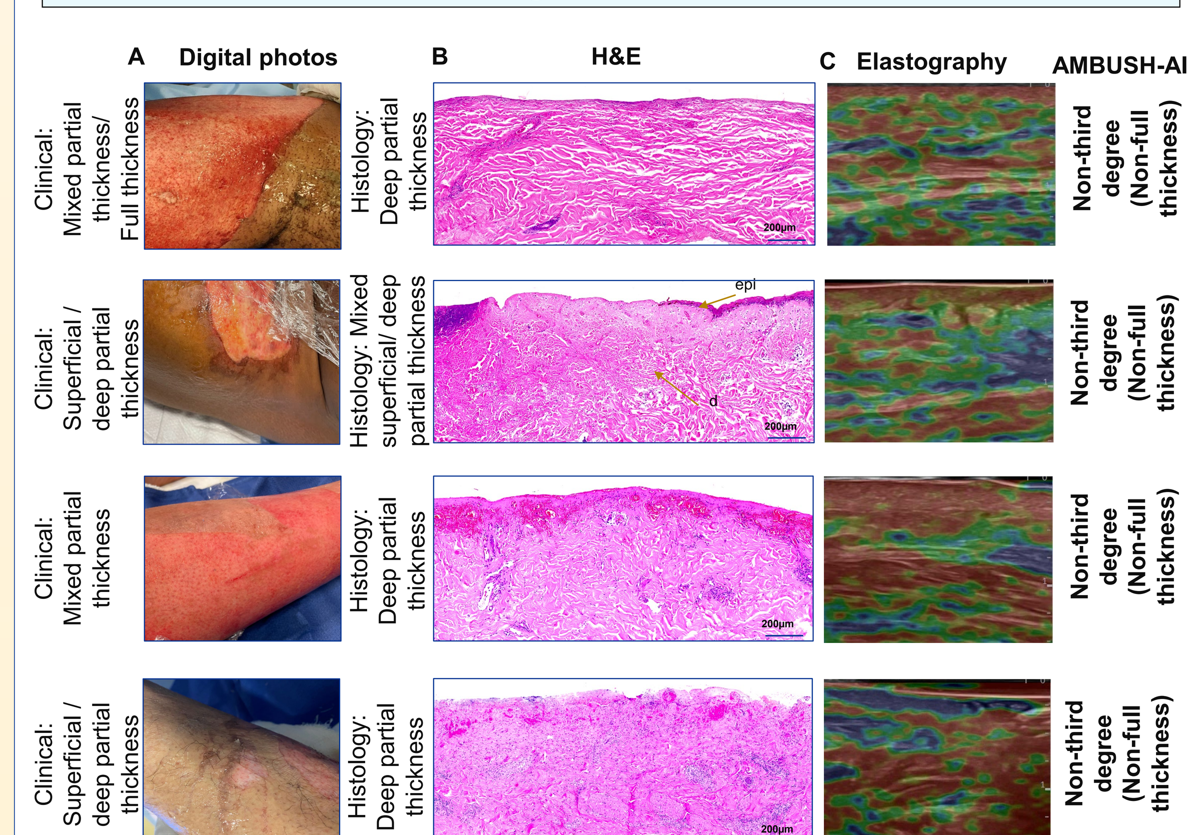

Figure 4. Ground truth histological validation of burn depth in human tissues. A- digital photos of different burn degrees. B- H&E-stained skin biopsies to show different burn degrees. C- Elastography images. Scale bar=200 μm. epi=epidermis, d=dermis.

AMBUSH AI method achieved a 95% accuracy in predicting the need for surgical intervention in humans.

AMBUSH-AI correlation with surgical decision

Item	Number
Patients evaluated (Total)	29
Surgery case (Third-degree) (3 for training and 7 for evaluation)	10
Non-surgery case (Non-third degree) (3 for training and 16 for evaluation)	19

Parameter	Results
Overall identification (3rd degree/operative vs non 3rd degree/non-operative)	22 out of 23 (95%)
Surgical case identified (3rd degree)	7 out of 7 (100%)
Non-Surgical case identified (non-3rd degree)	15 out of 16 (94%)
Frame-by-frame accuracy within TDI videos (all patients)	211 out of 235 frames (89%) (n=23 patients)

Conclusion

The AMBUSH-AI model significantly advances the non-invasive, accurate burn depth assessment, addressing a current clinical challenge. It uses Ultrasound and tissue stiffness measurements, overcoming limitations of light-based imaging technologies. Integrating AMBUSH-AI to assist in images interpretation results in high accuracy in predicting burn depth. Thus, improving treatment strategies and patient outcomes.

Future direction

Developing the AMBUSH-AI interface and integration with patient medical records for real time decision support.

References

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Contact: moelmasry@pitt.edu