

Indocyanin Green Angiography (ICGA):

Possible Angiogenic Effects of HBOT and Confounders in Interpretation

Enoch Huang, MD, MPH&TM and Trisha Nichols, CHRN

Wound Healing and Hyperbaric Medicine

Adventist Medical Center, Portland OR

Disclosures

- I have no financial interests to disclose regarding the technology discussed in this presentation
- Financial support was provided for printing of posters and travel/registration expenses for co-author

Background

- Technology assessment for new imaging device
- 3-month trial period

Fluorescence Angiography

- Indocyanin Green (ICG) is a fluorescent dye that is injected via a peripheral IV
- ICG binds to plasma proteins and is confined to the intravascular space
- If there is blood, there is ICG

Fluorescence Angiography

- Near IR laser light is shined on the area of interest
- ICG fluoresces and is picked up by the camera
- Quantitative analysis can be done using calculations of Ingress and Egress of ICG

Brightest Stats:

Start Intensity: 2
Ingress: 233
Ingress Rate: 24.2 units/sec
Curve Integral: 149314.6

End Intensity: 79
Egress: 156
Egress Rate: 1.3 units/sec

Fixed Baseline: 2

Ingress

$$\text{Ingress Rate} = \frac{\Delta \text{Ingress}}{\Delta \text{time}}$$

$$\text{Egress Rate} = \frac{\Delta \text{Egress}}{\Delta \text{time}}$$

Egress

Curve Integral

18.27 7.5 fps FOV unknown

Is it more than a pretty picture?

- Are there clinical correlations with the image?
- What does the image demonstrate?
- How will the results affect clinical decision making?
- Are there any limitations to what conclusions that you can draw?



Pre-HBOT

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



7.5 FPS
59.07s

Diabetic Foot Ulcer

Plantar Ulcer

TCOM at 1st webspace was 41 mmHg
ABI 0.88 on left DP
SPP 22 mmHg left great toe, 48 mmHg
lateral plantar foot

HBOT #40

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



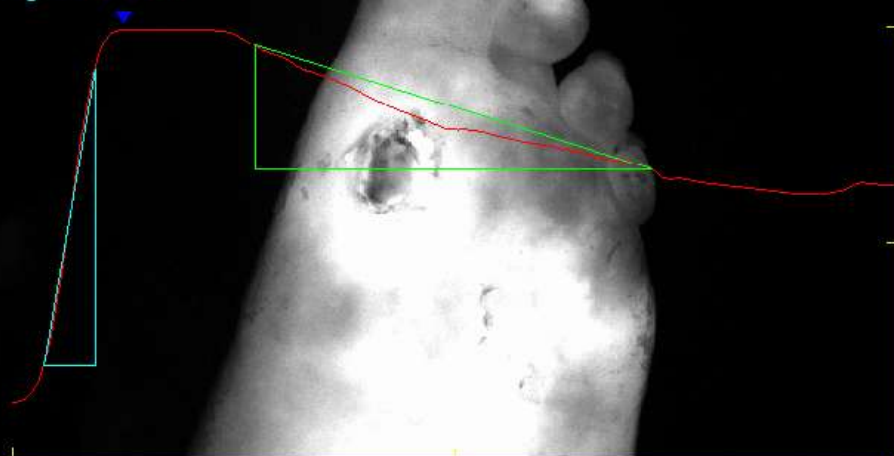
7.5 FPS
46.40s

Brightest Stats:

Fixed Baseline: 2

Start Intensity: 35
Ingress: 220
Ingress Rate: 20.4 units/sec
Curve Integral: 215382.1

End Intensity: 164
Egress: 91
Egress Rate: 1.1 units/sec



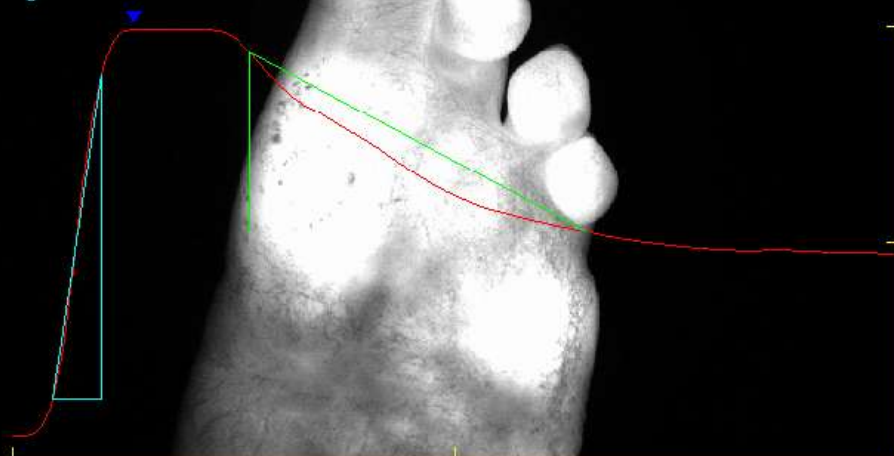
18.80 7.5 fps FOV unknown

Brightest Stats:

Fixed Baseline: 2

Start Intensity: 14
Ingress: 241
Ingress Rate: 23.3 units/sec
Curve Integral: 182039.4

End Intensity: 123
Egress: 132
Egress Rate: 1.9 units/sec



20.53 7.5 fps FOV unknown

SPY^Q

May 12, 2014 8:36:16 AM

Top Sequence: 15 - 10:25:28
Bottom Sequence: 17 - 15:30:34

Mode: AutoView
Algorithm: None

Ingress/Egress Comparison

Ingress: + 9%
Ingress Rate: + 14%

Egress: + 45%
Egress Rate: + 71%

Comments: pre and post hbot

Diabetic Foot Ulcer

Pre-HBOT vs. Post-HBOT

TCOM 41 mmHg on 1st webspace

ABI 0.88 on left DP

SPP 22 mmHg left great toe, 48 mmHg
lateral plantar foot



Pre-HBOT

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



7.5 FPS
60.00s

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



7.5 FPS
48.67s

HBOT #40



HBOT #1

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



HBOT #23

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



7.5 FPS
61.73s



7.5 FPS
42.93s

Questions Remain

- Do the images represent a response to normal wound healing or to HBOT?



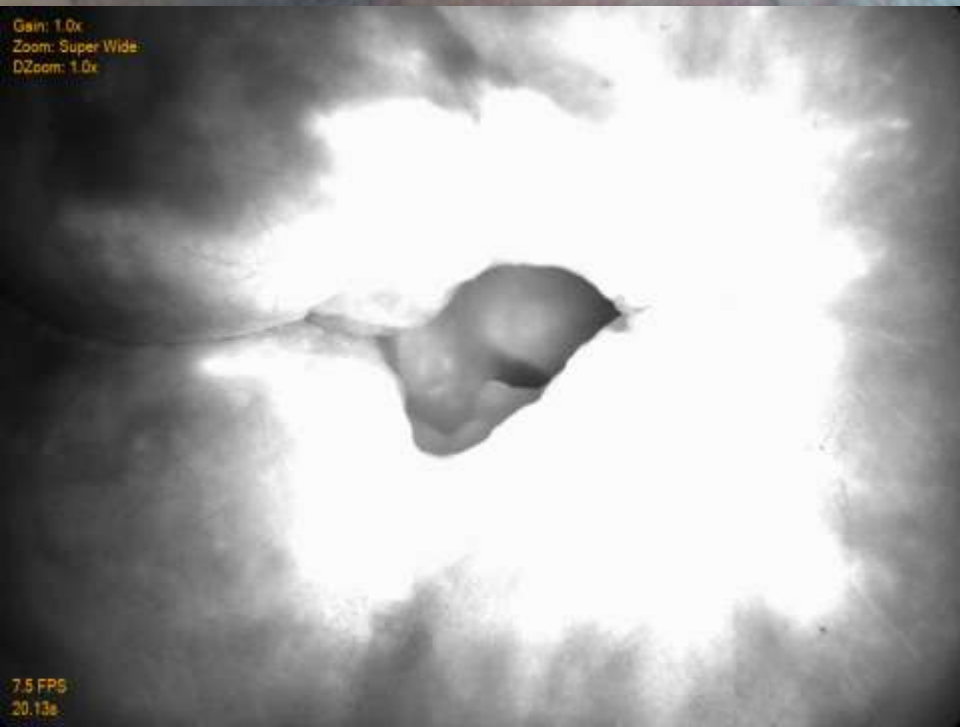
Sacral Ulcer and Chronic Radiation Tissue Injury

History of Radiation for Malignant
Pilonidal Cyst

Large soft tissue defect with necrotic
tissue

Surgically debrided

Baseline Image





HBOT #3

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



7.5 FPS
20.13s



HBOT #18

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



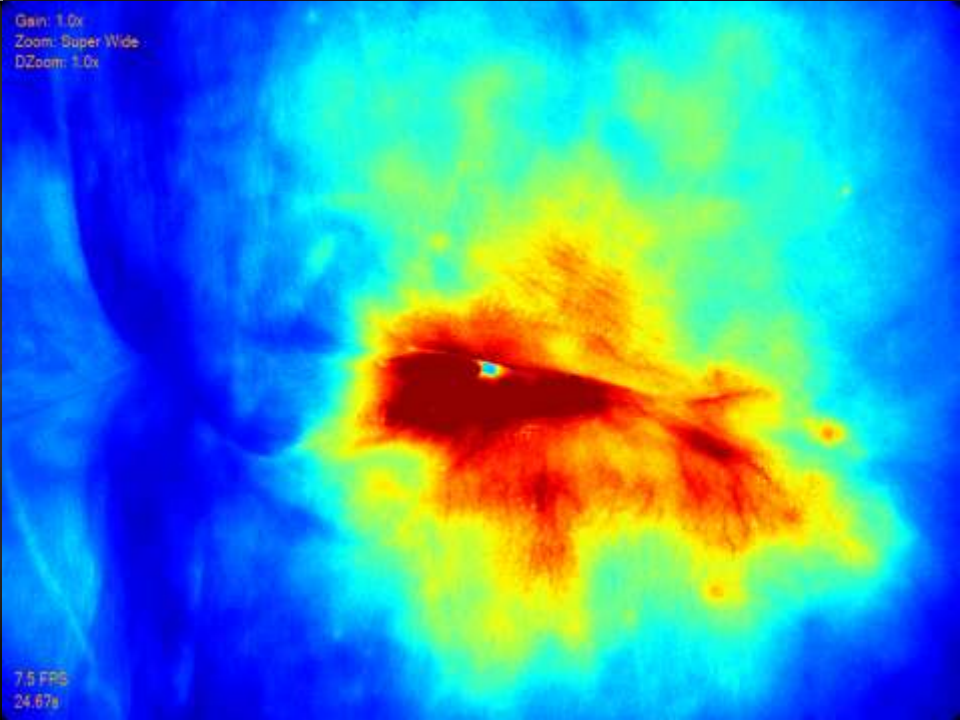
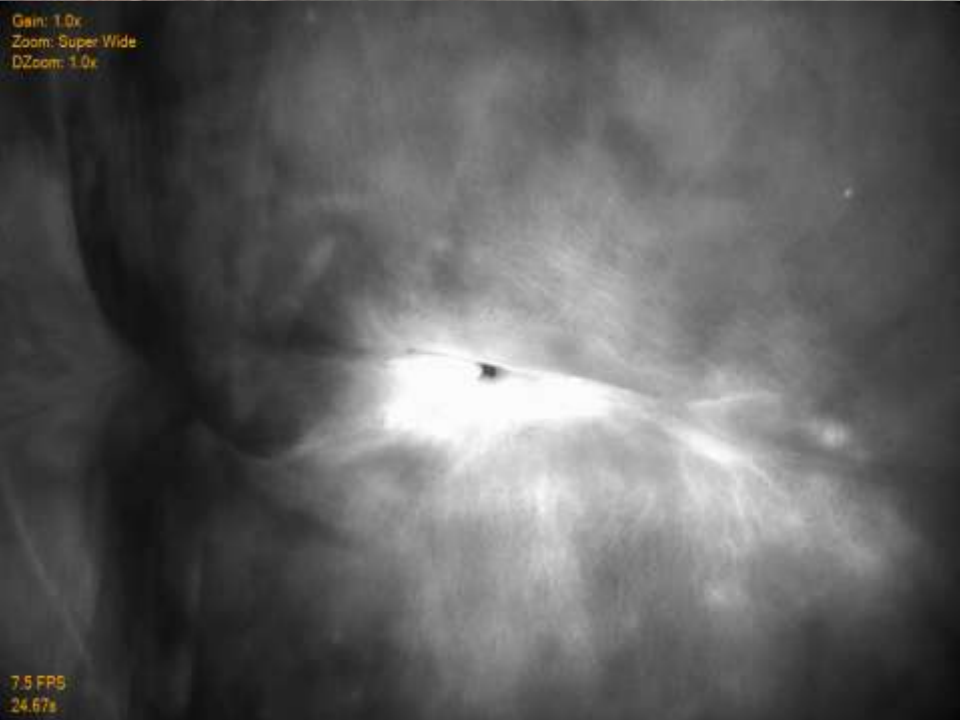
7.5 FPS
18.00s



Sacral Ulcer #2 and Chronic Radiation Tissue Injury

History of Radiation for Colon Cancer
Exposed bone in center of ulcer
MRI ruled out osteomyelitis

Baseline Image



Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x

7.5 FPS
24.67s

HBOT #7

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x

7.5 FPS
24.67s

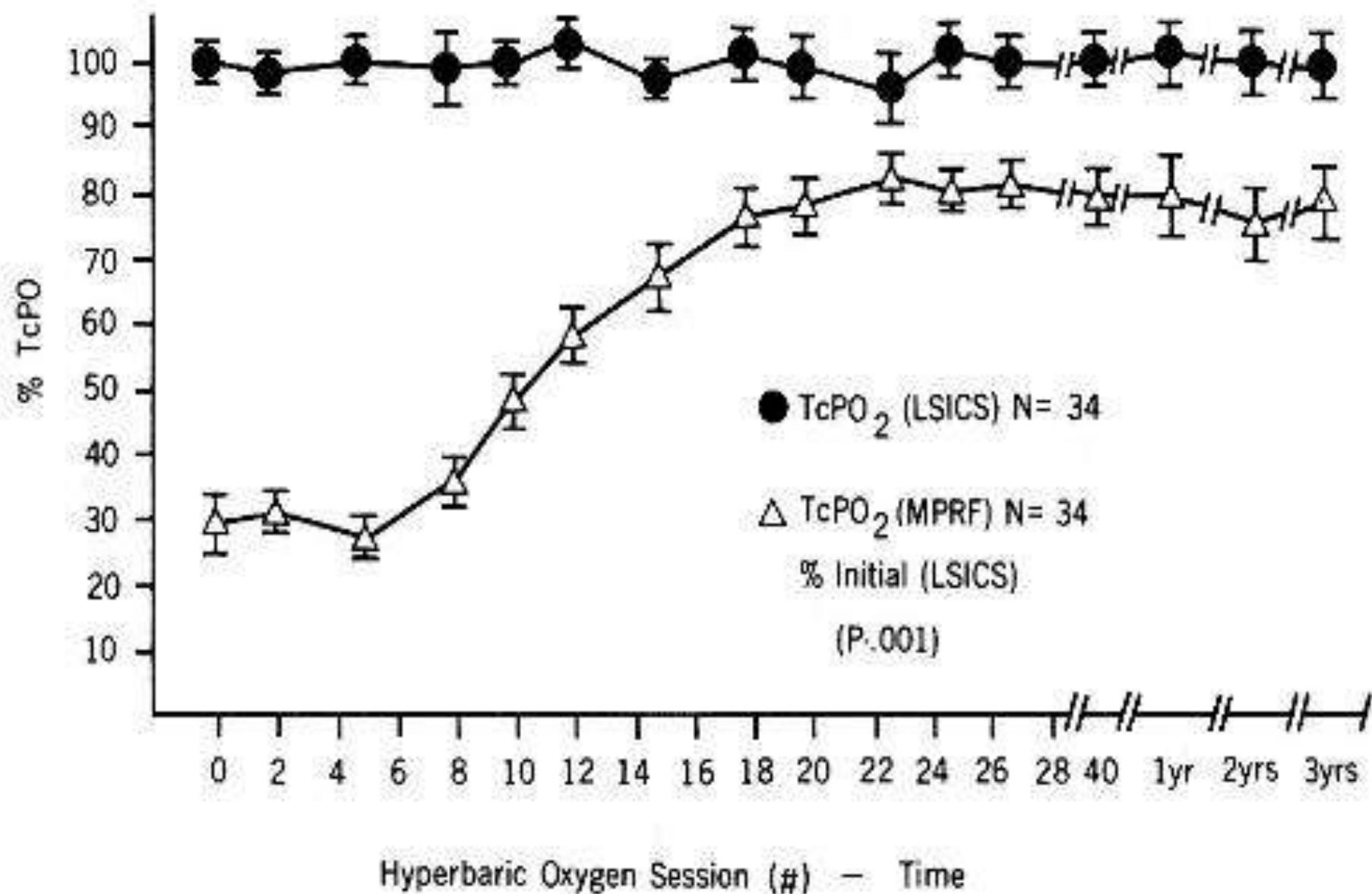
Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x

7.5 FPS
23.60s

HBOT #28

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x

7.5 FPS
23.60s



Question Remains

- Can ICGA replace TCOM in measuring angiogenesis in Chronic Radiation Tissue Injury?

Confounders

- How sensitive is the test to the dose of ICG?
- What does a normal foot look like?
- How reproducible are the results?
- How sensitive is the test to external factors (i.e., TCOM, debridement, elevation, pressure)?
- Do you have to do the test before or after HBOT?

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



2.0 cc ICG

7.5 FPS
11.87s

3.0 cc ICG

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



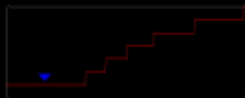
7.5 FPS
11.87s

Confounders

1. Dose of ICG affects the image

Question

- What happens when you inject a “normal” foot?



Confounders

1. Dose of ICG affects the image
2. Low Glow does not equal Low Flow

Question

- How reproducible are the results?



Ingress	27	27	31
Ingress Rate	0.2	0.2	0.3
Egress	N/A	N/A	N/A
Egress Rate	N/A	N/A	N/A
Curve Integral	17300.4	23903.4	26378.6



Ingress	51	44
Ingress Rate	1.2	0.7
Egress	6	1
Egress Rate	0.1	0.0
Curve Integral	50354.3	42210.4

Question

- Does TCOM testing affect the images obtained?

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.1x



7.5 FPS
47.47s

Confounders

1. Dose of ICG affects the image
2. Low Glow does not equal Low Flow
3. High Glow does not equal High Flow

Question

- Should you test before or after HBOT?



Do you test before or after HBOT treatment?

DFU

Immediately Pre-HBOT
Immediately Post-HBOT

Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



Gain: 1.0x
Zoom: Super Wide
DZoom: 1.0x



Confounders

1. Dose of ICG affects the image
2. Low Glow does not equal Low Flow
3. High Glow does not equal High Flow
4. HBOT does not appear to have an affect on image (n=1)

Other Confounders

- Was the wound debrided before ICGA?
- Was the patient sitting/lying on the wound before ICGA?
- What is the camera angle?
- Does smoking affect the ICGA?

Clinical Uses

- Demonstrates perfusion to region of interest
- Allows you to “see” benefits of interventions
- Provides increased level of comfort that you are making positive progress
- Allows faster decision making about viable and non-viable tissue

Future Directions

- Track patients with chronic wounds to determine the natural progression of wound healing
- Track patients pre- and post-revascularization with correlation to wound healing to see whether ICGA can predict healing outcome
- Registry of patients pre- and post-XRT to see whether we can track changes of capillary density and correlate with CRTI, as well as subsequent images pre- and post-HBOT to measure angiogenic effect

Questions?

enoch.huang@mac.com