Transcutaneous Oximetry Testing and Interpretation

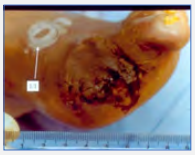
Dick Clarke, CHT

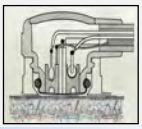
Transcutaneous Oximetry's Evidence-Based Importance

Pro-Con analysis of hyperbaric wound referral screening options

Primary Training in Hyperbaric Medicine
Columbia, South Carolina

Non-invasive physiologic assessment of skin microcirculatory oxygenation





Non-Invasive POC Extremity Wound Screening Options

- Blood pressure
- Blood flow
- Tissue oxygen saturation
- Wound tissue thermal reflectance
- Transcutaneous tissue oxygen tension

Laying the framework

HBO therapy routinely employed in the management of diabetic foot ulcers

HBO DFU efficacy & effectiveness data conflicting

HBO costly, frequently involves many weeks/several month commitment, not without risk

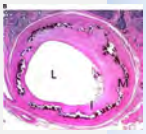
Even reviews favorably disposed to HBO therapy uniformly argue for *better patient selection*

Emerging NIRS & LWIR thermography technologies

Tissue viability, limb preservation & wound healing a function of oxygen availability

Blood pressure & blood flow common oxygen delivery surrogates

Blood pressure may be normal during development of calcinosis > falsely elevated ABI & reduced flow secondary to wall thickening > *undiagnosed low O2 delivery*



Blood flow may be normal while its oxygen content is not > *undiagnosed low O_2 delivery*

anatomic and/or physiologic dead space > ventilation-perfusion mismatch

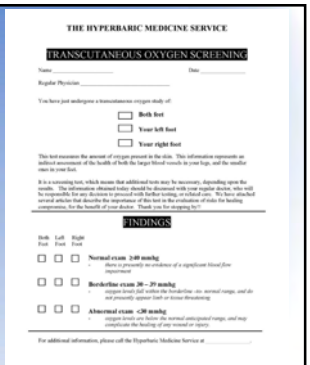
physiologic shunt per ARDS, pulmonary edema, alveolar collapse, pulmonary AVM

anemia; elevated altitudes

Risk factors for diabetic amputation

Pathophysiologic Factor	Odds Ratio
Cutaneous circulation *$tcpO_2$ <20 vs. >40mmHg*	161
Peripheral arterial circulation *Doppler ABI <0.45 vs. 0.70*	55.8
Neuropathy *lacking distal vibratory sense*	15.1
Ulcers become infected	10.1

Reiber GE, *et al.* 1992
Ann. Int. Med;117:97-105



THE HYPERBARIC MEDICINE SERVICE

TRANSCUTANEOUS OXYGEN SCREENING

Name _____ Date _____

Regular Physician _____

You have just undergone a transcutaneous oxygen study of:

☐ Both feet
☐ Your left foot
☐ Your right foot

This test measures the amount of oxygen present in the skin. This information represents an indirect assessment of the health of both the largest blood vessels in your legs, and the smaller ones in your feet.

It is a screening test, which means that additional tests may be necessary, depending upon the results. The information obtained today should be discussed with your regular doctor, who will be responsible for any decision to proceed with further testing, or related care. We have attached several articles that describe the importance of this test in the evaluation of risks for healing compromise, for the benefit of your doctor. Thank you for stopping by!!

FINDINGS

Both Feet	Left Foot	Right Foot	
☐	☐	☐	**Normal exam ≥40 mmhg** – *there is presently no evidence of a significant blood flow impairment*
☐	☐	☐	**Borderline exam 30 – 39 mmhg** – *oxygen levels fall within the borderline -to- normal range, and do not presently appear limb or tissue threatening*
☐	☐	☐	**Abnormal exam <30 mmhg** – *oxygen levels are below the normal anticipated range, and may complicate the healing of any wound or injury.*

For additional information, please call the Hyperbaric Medicine Service at _____

Blood Pressure

Ankle-Brachial Index (ABI)

1.0-1.2/1.4 normal exam

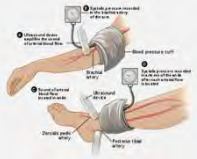
0.9-0.99 borderline exam +/- irregularity; "clinically acceptable"

0.8-0.9 modest impairment; identify & manage risk factors

0.5-0.8 greater impairment (50-80% perfusion); specialist referral

< 0.5 severe disease (< 50% perfusion); specialist referral

> 1.2/1.4 abnormal exam c/w incompressible vessels
clinically significant calcification may be present prior 1.0



European Society Vascular Surgery 2018

Blood Pressure

Ankle-Brachial Index (ABI)

Strengths

Long-standing most widely recognized/employed screening tool

Relative ease of testing; not operator dependent

Standardized interpretation largely c/w MRI/MRA findings

Weaknesses

Only assesses macro-vasculature

Doesn't localize disease

Doesn't assess below level of ankle cuff

No information related to oxygen delivery

Blood Pressure

Toe-Brachial Index (TBI)

0.7 essentially normal exam

<0.7 c/w arterial occlusive disease

Blood Pressure

Toe-Brachial Index (TBI)

Strengths

Assesses all-important foot/digits

Relative ease of testing; not operator dependent

Weaknesses

Poor consensus re threshold values

Not obtainable with Hallux; Ray; Ray revision; TMA amputations

Confounded by calcification; no formal elevated index guidance

No information related to oxygen delivery

Blood Pressure

Skin Perfusion Pressure (SPP)

Minimum BP required for restoration of microcirculatory & capillary flow

Laser light strikes RBCs as flow resumes > Doppler (wavelength shift) effect

Interrogates shifted & unshifted light; places arbitrary value on shifted light = RBCs

50-100 mmHg considered normal range

30-50 mmHg marginal ischemia +/- PAD symptoms

<30 mmHg CLI; wound healing/limb preservation problematic

Vasamed Sensilase

Blood Pressure

Skin Perfusion Pressure

Strengths

Unaffected by calcification

Unaffected by mild-moderate edema

Can be used when TBI not possible

Assesses microcirculation

Weaknesses

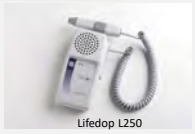
Pressure responses & predictive aspects poorly validated

No information related to oxygen delivery

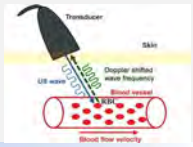
Blood Flow

Doppler Ultrasound/Ultrasonography

- Pulsed sound waves transmitted to area of interest
- Undergoes Doppler (shift in pitch) effect when bouncing off moving objects
- Returning sound interrogated to determine RBC speed & direction



Lifedop L250



Blood Flow

Doppler Ultrasound/Ultrasonography

Strengths

- Widely accepted & ubiquitous screening device
- Accurate & reliable
- Simple to use
- Unaffected by vessel calcification & very low flow rates

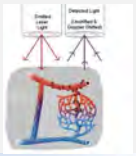
Weaknesses

- Resolution not great enough for microcirculation
- No information related to oxygen delivery

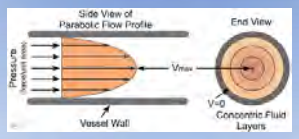
Blood Flow

Laser Doppler Flowmetry (LDF)

- Another Doppler-based technology; near infrared low power laser light
- Interchangeable probes for shallow & deeper penetration
- Assesses velocity & direction of RBCs
- Filters out reflected unshifted/scattered light ("noise")
- Generates proportional shifted light scale as estimate of flow



Laser Doppler Flowmetry (LDF)



Blood Flow

Laser Doppler Flowmetry

Strengths

- Accurate & reliable; hematocrit WNL
- Simple to use
- Unaffected by vessel calcification & very low flow rates

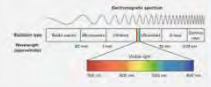
Weaknesses

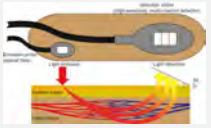
- Arbitrary perfusion scale (1-10) as flow surrogate
- Susceptible to hematocrit changes
- Signal return may include RBCs flowing below skin
- No information related to oxygen delivery

Local Tissue Oxygen Saturation

Near Infrared Spectroscopy (NIRS)

- Emits light (just outside visible spectrum) to area of interest
- Detects various reflective light spectrum differences
- Selectively measures OxyHb & DeoxyHB reflectance values
- Calculates percent "tissue" oxygen saturation





Local Tissue Oxygen Saturation

Near Infrared Spectroscopy (NIRS)

- Introduced as continuous non-invasive monitoring of brain tissue oxygen saturation (StO_2)
- Employment increasingly suggested elsewhere
- Longer wavelengths being researched

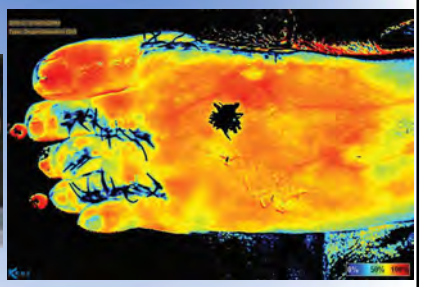
Somanetics INVOS

Local Tissue Oxygen Saturation

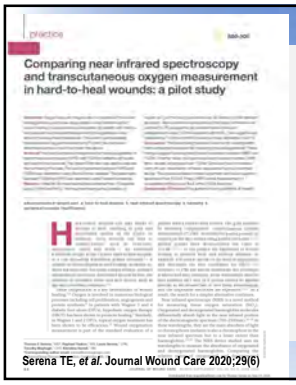
Near Infrared Imagining (NIR)

- Battery-operated, handheld device
- Single "snapshot" vs. continuous monitoring
- Initially two manufacturers: NIR vs. visible light
- Measures OxyHb; DeOxyHb > calculates StO_2

Snapshot NIR



With permission: Today's Wound Clinic/Kent Imaging



Comparing near infrared spectroscopy and transcutaneous oxygen measurement in hard-to-heal wounds: a pilot study

Serena TE, *et al.* Journal Wound Care 2020;29(6)

"The gold standard for assessing oxygenation is TCOM..."

TCOM has several drawbacks
- *Time/labor intensive*
- *Room temp must be between 68-72F*
- *Probes cannot be placed in wound bed*
- *Disposable are expensive*

Advantages of NIRS vs. TCOM
- *Non-invasive*
- *Does not require skin contact*
- *Does not require injectable dyes*
- *Immediate real-time data, avoiding delay in treatment regimen*

NIRS derived mmHg O_2...*electromagnetic light reflectance from IR wavelengths measured by a patented computer interface algorithm to generate calculated OxyHb level which is mathematically converted to StO_2, that is then mathematically converted to pO_2 using standard Servinghaus dissociation curve*

TCOM derived mmHg O_2...*direct measurement free oxygen that diffuses to skin surface.*

Conclusion: Data suggests TCOM overestimates O_2 measurements vs. NIR

Local Tissue Oxygen Saturation

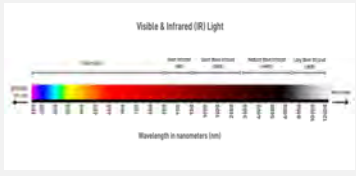
Near Infrared Imaging (NIR)

Strengths
- Battery-operated handheld; high image storage capacity
- Uniquely assesses regional StO_2
- Ease of use/interpretation; touch screen display StO_2 values
- Suggested healing response tracker

Weaknesses
- Does not measure tissue oxygenation
  So, no assessment plasma-borne oxygen delivery (basis for HBO)
- Unable to direct HBO case management as per $tcPO_2$
- Presently ill-defined normal/abnormal StO_2 values; some crossover
- Presently unclear as to clinical relevance wound StO_2

Wound Thermal Reflectance

Long-Wave Infrared Thermography (LWIT)

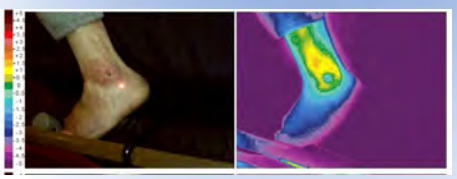


Wound Thermal Reflectance

Detects & maps thermal energy created by cellular metabolism

Reflects relative state of/changes in perfusion compared to healthy tissue

Does change (increase) in thermal reflectance indicate healing response?

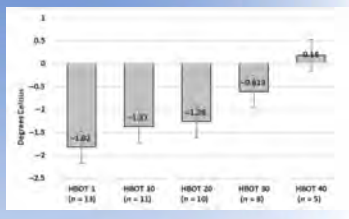


With permission: M. Heyboer, SUNY

Wound Vision Scout

Pilot study: Utility of long-wave infrared thermography as a correlate to transcutaneous oximetry for candidates of hyperbaric oxygen therapy

Heyboer M, *et al.* Wound Repair Regeneration 2022; 1-7



Wound Tissue Thermal Reflectance

Strengths

Battery-operated handheld, ease of operation

Directly measures changes in wound/tissue thermal energy

Preliminary data...correlates with TCOM improvement during ulcer healing

High quality evidence: Detects pre-visual temp. anomalies before visual pressure injuries

Weaknesses

Possible confounding factor peri-HBO changes in environmental temperature

Value as a wound management/hyperbaric screening tool not yet quantified

Transcutaneous Tissue Oxygen Tension

Transcutaneous Oximetry (TCOM)

Air breathing $tcpO_2$ values at 1.0 ATA offer no useful healing prediction
progressively decreasing values likewise offer no specific guidance
identifies local hypoxia

Oxygen breathing $tcpO_2$ values at 1.0 ATA likewise provide no useful prediction
can indicate need for additional arterial testing

In-chamber $tcpO_2$ values offer some guidance; lack statistical precision
$tcpO_2$ > 200 mmHg most associated with healing response

PeriMed PeriFlux 6000

Four-part transcutaneous oximetry screening questionnaire

Is wound healing complicated by local hypoxia?
~ *are patients EXPECTED to benefit?*

Is any such hypoxia reversible?
~ *are patients CAPABLE of benefiting?*

Is there early evidence of response?
~ *ARE patients benefiting?*

Has a therapeutic endpoint been reached?
~ *have patients SUFFICIENTLY benefitted?*

Is wound healing complicated by local hypoxia?

Normal lower extremity/foot $tcpO_2$ defined as **> 50 mmHg**

Matsen FA, et al. Surg Gynec Obstet 1980;150:525-528
Chgi S, et al. Angiology 1981;32(12):833-839
Hauser CJ, et al. Ann Surg 1983;197:337-343
Dowd GSE, et al. J Bone Joint Surg 1983;65B:79-83
Dowd GSE, et al. Clin Phys Physiol Meas 1985;4(2):165-68
Coleman LS, et al. Clin Phys Physiol Meas 1986;7(3):259-263
Dooley J, et al. Undersea Hyper Med 1997;24:235-244
Tandara AA, Mustoe TA. World J Surg 2004;28:294-300

Support of tissue viability & wound healing defined as $tcpO_2$ **≥ 40 mmHg**

Dowd GSE, et al. J Bone Joint Surg (Brit) 1983;79-83
Smart DR, et al. Diving Hyperbaric Medicine 2006;36(2):72-86
Ruangsetakit C, et al. J Wound Care 2010;19(5):202-206
Uccioli L, et al. Diabetes Care 2010;33(5):977-982

Impaired wound healing threshold defined as $tcpO_2$ **< 40 mmHg**

Hunt TK, et al. World J Surg 1987;11
Padberg FT, et al. J Surg Research 1996;60(2):365-369
Kalani M, et al. Diabetes Care 1999;22(1):147-151
Gralnick RE, et al. American Surg 2001;67:1072-1080
Smart DR, et al. Diving Hyperbaric Medicine 2006;36(2):72-86
Trinks TP, et al. Diving Hyperbaric Medicine 2017;47(2):82-87

Critical limb ischemia defined as $tcpO_2$ **≤ 30 mmHg**

Cina C, et al. J Vascular Surg 1984;1(2):362-371
Bellland JL, et al. J Vascular Surg 1995;22:485-492
Padberg FT, et al. J Surg Research 1996;60(2):365-369
Bunt TJ, et al. Ann Vascular Surg 1996;10:224-227
Benhamou Y, et al. Neph Dial Trans 2012;27(5):2066-2069
Abayazeed K, et al. European Heart J 2018;39:763-821

Is any such hypoxia reversible?

Normobaric 100% oxygen challenge tcpO2 **≥ 100 mmHg**

per NRB mask @ 14-16 lpm

Strauss MB, et al. Foot Ankle Int. 2002;23(10):933-937
Fife CE, et al. Wound Regen Repair 2002;10:198-207
Niinikoski J. Wound Regen Repair 2003 ;11:458-461
Fife, CE, et al. Undersea Hyperbaric Med 2009;36(1):43-53
Moon H, et al. Undersea Hyperbaric Med 2016;43(6):641-648

> 300 mmHg…c/w normal distal arterial perfusion
200-300 mmHg…c/w minimal occlusive disease
100-199 mmHg…c/w moderate occlusive disease
51-99 mmHg…c/w significant occlusive disease **
< 50 mmHg…c/w highest grade occlusive disease **

** further arterial work-up indicated

Is there early evidence of response to HBO?

Repeat normobaric air breathing tcpO2 test after 15 treatments

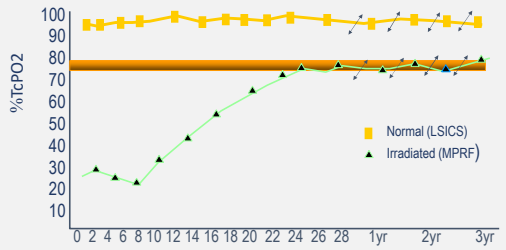
"A lack of improvement in tcpO2 measurements should discourage further HBO"
Hyperbaric Oxygen Therapy Indications 14th Edition 2019

"One should see (tcpO2) changes by 10-15 HBO treatments to determine response"
Hyperbaric Oxygen Therapy Indications 15th Edition 2023

"Multiple HBO exposures increased wound response/tcpO2 values"
Sheffield PJ. Hyperbaric Oxygen Review 1985;6:18-46

In responders, five days weekly HBO with weekly f/u tcpO2 testing

Vascular density change over time

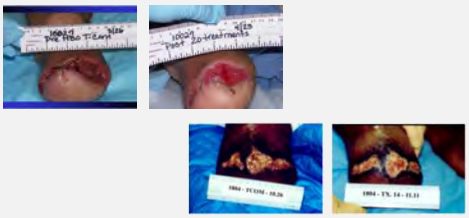


Marx, RE *et al.* 1985
JADA;111,49-54

Has therapeutic endpoint been reached?

Support of tissue viability & wound healing defined as tcpO2 **≥ 40 mmHg**

Dewel GST, et al. J Bone Joint Surg [Br] 1981;79-83
Smart DR, et al. Diving Hyperbaric Medicine 2006;36(2):72-86
Rusingortelek C, et al. J Wound Care 2010;19(5):202-206
Uzzell L, et al. Diabetes Care 2010;33(5):977-982



Four-step tcpO2 screening

Is wound healing complicated by local hypoxia?
< 40 mmHg

Is any such hypoxia reversible?
≥ 100 mmHg

Is there early evidence of response to HBO?
after 15 treatments

Has therapeutic endpoint been reached?
peri wound value(s) ≥ 40 mmHg

Table 1 Transcutaneous Oximetry Screening Guidelines

Low tcpO2 predicts abnormal arteriography

96% of 66 limbs with tcpO2 < 30mmHg had abnormal arteriogram

Ballard JL, *et al.* 1995

tcpO2 <30mmHg reliable indicator of need for arteriography, with 98% limbs showing significant disease

Bunt TJ, *et al.* 1996

What about any control sites?

Left second intercostal space as 'central' oxygenation state....*normal range 65-90mmHg (1.0 ATA)*

regional perfusion index (RPI)

Contra-lateral sites may represent poor comparison of normal to diseased perfusion states

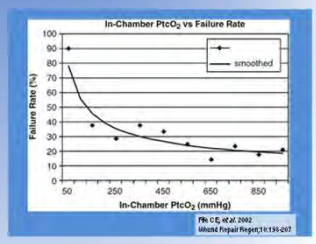
Testing process

Upon site preparation & sensor(s) attachment...air breathing until value(s) stabilization

- *~ semi-recumbent*
- *~ 10-15 mins*

Value(s) < 40 mmHg...100% O2 challenge @ 14 lpm per non-rebreather mask

- *~ 10 mins.*



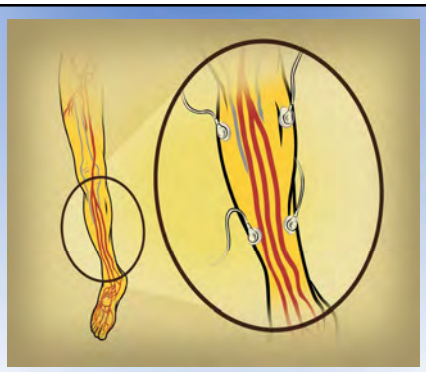
Fife CE, *et al.* Wound Rep Regen 2002;10

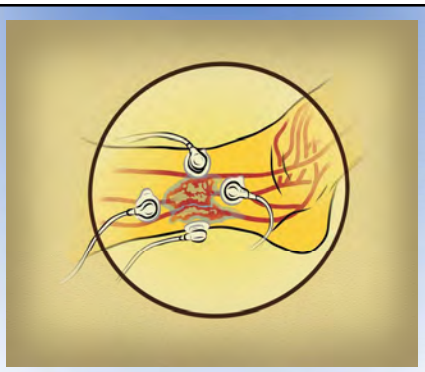
Factors influencing tcpO2

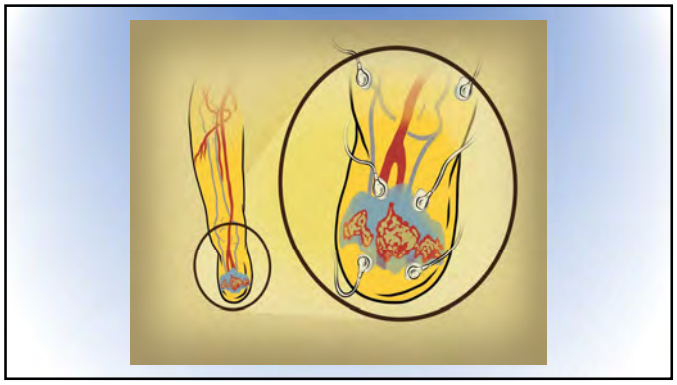
Systemic	Local
Pulmonary & cardiac function; oxygen content	Obesity
Central & peripheral vascular perfusion	Edema
Smoking/nicotine, caffeine ingestion	Increased skin thickness
Vasoactive pharmacologic agents	Cutaneous late radiation tissue injury
Environment (temperature /altitude)	Bony prominences
	Poor skin preparation
	Poor electrode attachment

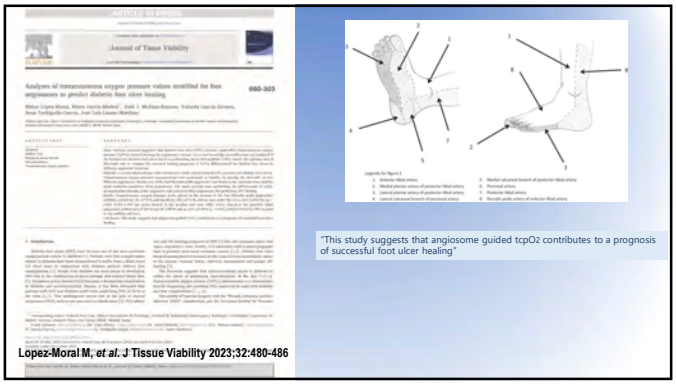
Site selection; anatomic factors

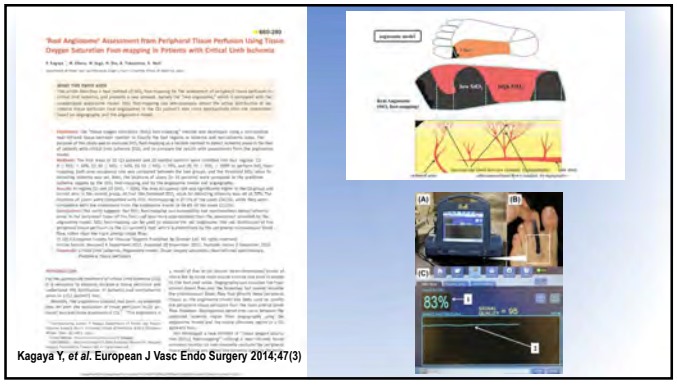
- Clear understanding of question in need of address
- Appreciate arterial anatomy associated with question
- Principal testing site(s) consistent with that determinant
- Any necessary secondary testing site(s)











When to delay testing

Immediately post hemo-dialysis
Nutritive skin perfusion impaired during dialysis, sufficient in some cases to cause chest/cardiac & leg pain
~ significant tcpO2 decreases in pts. with & without PVD
Weiss T, *et al.* 1998
Neph Dial Trans; 13

Markedly edematous tissue
Diffusion barrier between functioning capillaries & skin
Stephens M, *et al.* 1999
UHM;26(2):93-97

Caffeine ingestion
Restrict caffeine-containing substances prior to testing
Dooley J, *et al.* 1996
UHM;23(3):167-174

Nicotine
Avoid any use for at least two hours prior to testing
Jensen JA, *et al.* 1994
Arch Surg126:1131-1134

Supplemental oxygen administration
Absence of conversion factors

Post-successful flow augmentation tcpO2 responses

Several day delay exists from revascularization to significantly improved skin oxygenation
- ~ *even 3 days postop, 5/11 pts still had values < 30 mmHg*

Arroyo CI, *et al.* 2002
J Foot Ankle Surg 41(4)

"It takes 3-4 weeks after PTA for tcpO2 values to reach optimal levels for wound healing"
- ~ *"findings suggest that, when surgery can be delayed, best time to perform aggressive debridement/minor amps. is 3-4 weeks post PTA"*

Caselli A, *et al.* 2005
Diabetes Medicine 22

"tcpO2 continued to increase up to 8 weeks after PTA, while ABI remained constant"
- ~ *"perhaps revascularization in sparsely perfused areas causes increase in angiogenesis processes leading to an increase in capillary function?"*

Pardo M, *et al.* 2015
British J Radiology 88

Possible etiologies:
Post-operative edema; vasospasm due to high pressures; ischemia-reperfusion injury; endothelial cell trauma; micro embolic events; effects of dye; angiogenesis processes

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Newly introduced sensor technology based on fluorescence
- *no oxygen consumption*

No electrochemical sensor electrode wear/replacement

No regular calibration required

Readout ~ 8 minutes; notification of steady state

40 - 44 C sensor range

Medicap, Germany: Precise 8008 Gen.2

Basic Science Research

Comparison of Photo-optical Transcutaneous Oxygen Tension Measurement with Electro-chemical Transcutaneous Oxygen Tension Measurement in Patients with Arterial Claudication

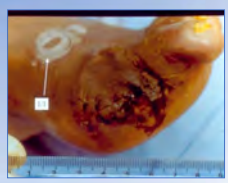
Leenstra BS, *et al.* Ann Vascular Surgery 2021;77:274-279

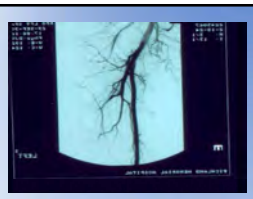
Photo-optical tcpO2 demonstrated acceptable agreement with electro-chemical tcpO2

Photo-optical values are in general higher in comparison

74-year-old DM underwent left great toe amputation secondary to ischemia; primary closure via rotational flap
F/U: tenderness 1st metatarsal & plantar surfaces, erythema & edema; ischemic superior flap

Pt. admitted, further surgery contemplated, HBO consulted





Transcutaneous Tissue Oxygen Tension

Strengths

Directly measures tissue oxygen tension; Hb bound & plasma borne

Unique composite indicator of micro & macro vascular health

In-chamber testing capability

Guides evidence-based case management

Demonstrated to improve clinical outcomes

Enhances cost-effectiveness

Weaknesses

Requires more training than other options to gain competence

Site selection inconsistency

More time consuming (~ 30 minutes)

Limitations; diffusing barriers; suppl. O2; dialysis; caffeine, nicotine

Associated consumables expense

Table 1 Transcutaneous Oximetry Screening Guidelines

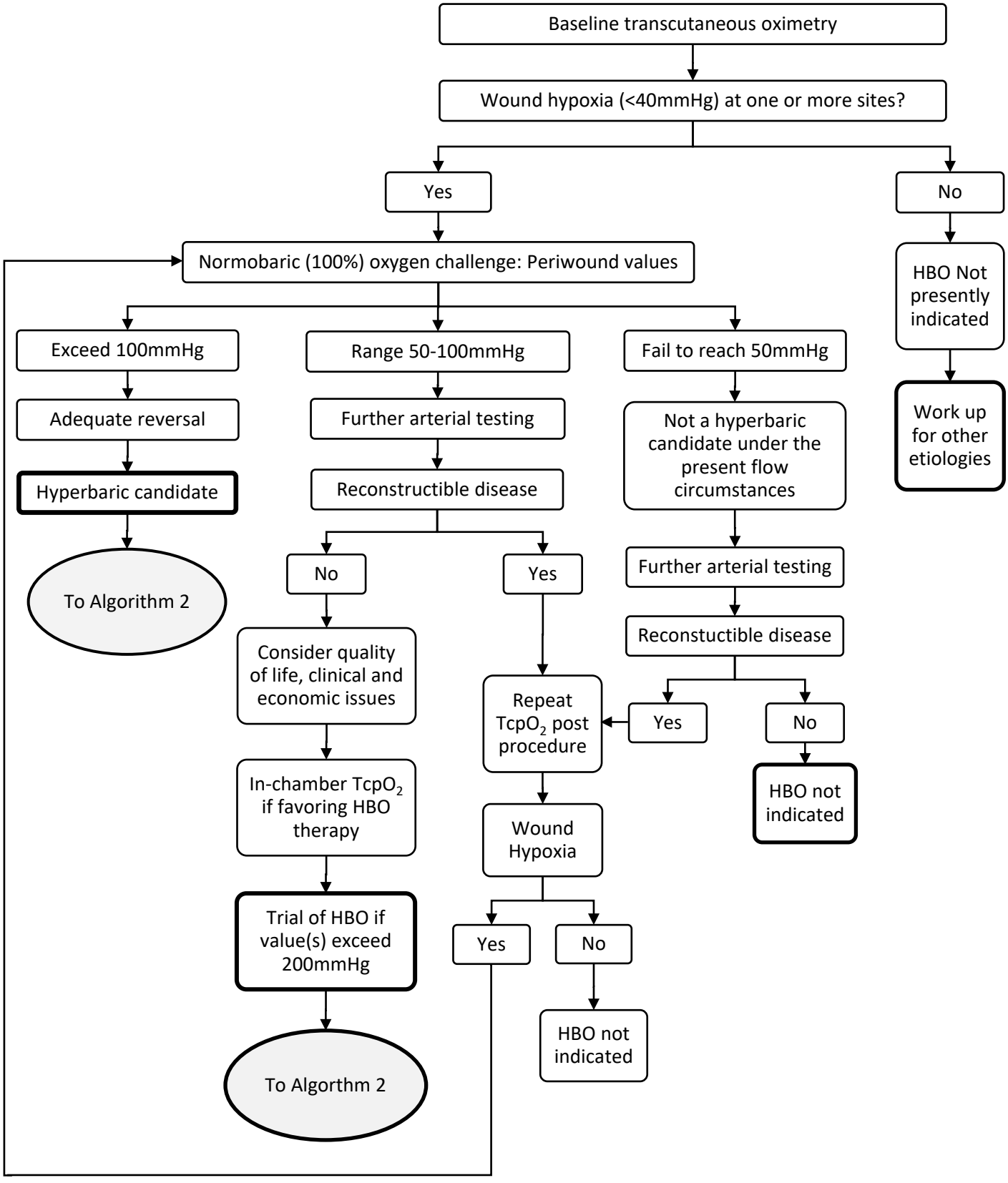
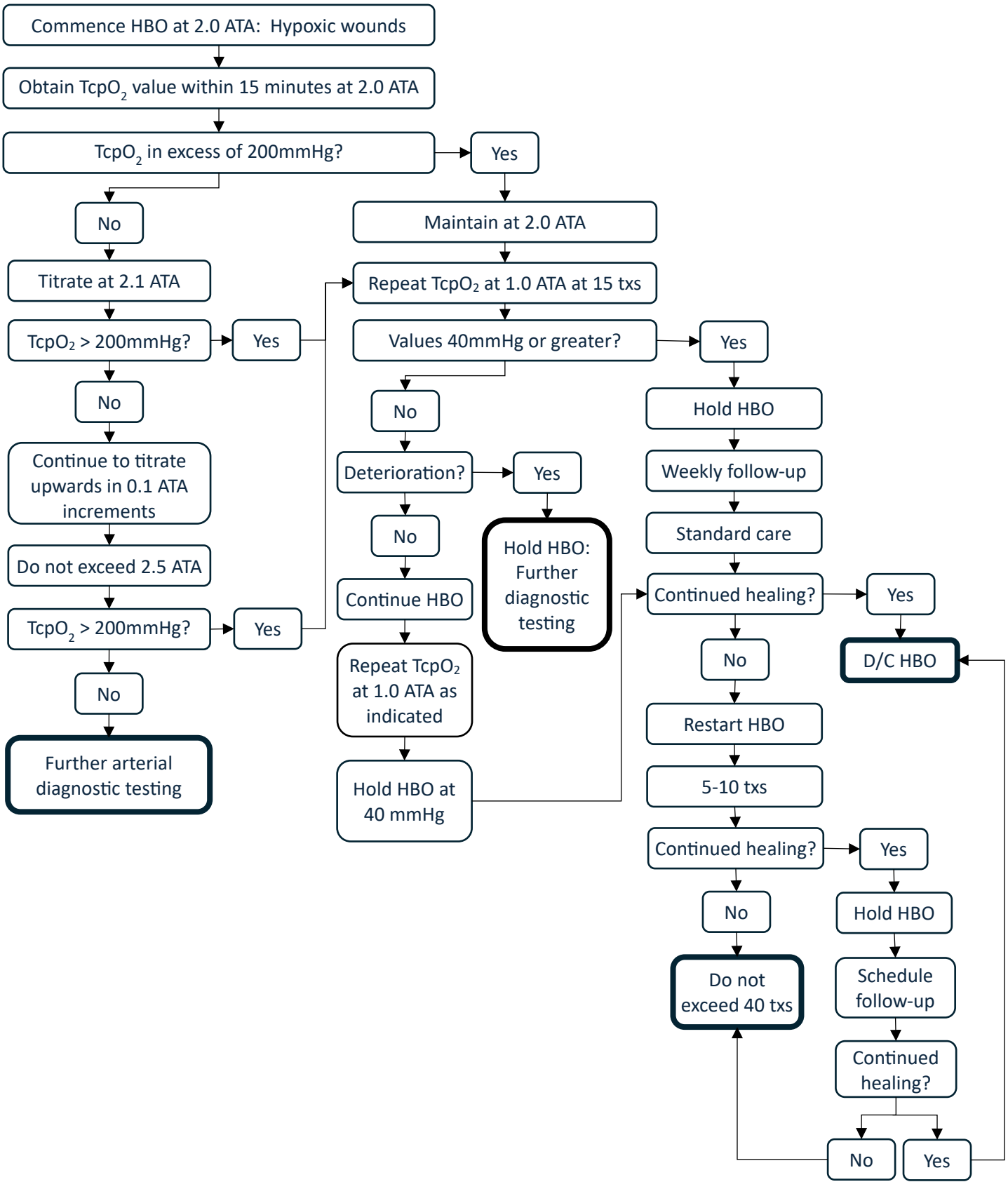


Table 2 Transcutaneous Oximetry Dosing Guidelines



Transcutaneous Algorithms

Narrative and References

Hyperbaric wound healing referrals undergo a comprehensive work-up, including a detailed medical history, physical examination, and selected diagnostic testing. Baseline transcutaneous oxygen screening is followed up in an algorithmic manner in those patients whose risk-benefit ratio is in favor of a trial of hyperbaric oxygen therapy. Algorithm 2 addresses four essential questions:

I. Is wound healing complicated by hypoxia?

II. When present, is hypoxia reversible?

III. Is the patient responding to hyperbaric oxygen therapy?

IV. Has the patient reached a therapeutic endpoint?

I. Is wound healing complicated by hypoxia?

- Normal lower extremity transcutaneous oxygen values exceed 50mmHg* (1,2,3)
- Values ranging from 35-40mmHg, and higher, are considered sufficient to support oxygen-dependent wound healing (4,5,6)
- Values below this range represent a risk of healing compromise, the degree of which increases as value decreases (7,8)

II. When present, is hypoxia reversible?

For hyperbaric oxygen, a systemic method of dose delivery, to be effective, a certain degree of regional perfusion must be present.

- Breathing 100% oxygen at normobaric pressure, following the recording of a steady-state ambient air breathing value, evaluates regional arterial inflow capacity.
- Oxygen challenge values in excess of 300mmHg represent essentially uncompromised regional perfusion.
- Screening values in excess of approximately 100mmHg are suggestive of sufficient regional perfusion for limb viability, and reflect a suitable candidate for in-chamber follow-up transcutaneous oxygen testing.
- Screening values that fail to reach 100mmHg are consistent with a significant inflow abnormality, and warrant further arterial work-up. The decision to incorporate hyperbaric oxygen therapy into the treatment plan would be made on a case by case basis, in these circumstances and following decisions regarding any flow augmentation options, and as identified in Algorithm 1.

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* *when recorded at sea level pressure (760 mmHg)*

III. Is patient responding to hyperbaric oxygen therapy?

The above patient selection process does not predict outcome. It identifies those patients who have the physiologic capacity to deliver high oxygen tensions to the wound in question. There has been an unsuccessful effort to incorporate transcutaneous oximetry as an outcome predictor.[9,10,11,12,13] This should not be too surprising, given the complexity of such lesions, particularly in the diabetic patient. Improvement in ambient (21% O_2) transcutaneous oximetry over time probably remains the best indicator of therapeutic response.[11] Absence of increasing tissue oximetry values alerts the clinician to a potential non-responder. This should prompt evaluation of other possible impediments to wound repair, thereby avoiding an otherwise lengthy, unsuccessful and expensive course of therapy.

Transcutaneous oxygen reevaluation of the perilesional area should occur at 15 treatments, and in accordance with recommendations of the UHMS.

a. If values are increasing, the patient is considered a responder, and hyperbaric treatments are continued to Step IV.

b. If there has been no change, or if deterioration is evident, the patient undergoes further work-up for etiologies other than hypoxia. Hyperbaric oxygen therapy may be held at this point.

The goal of Step III is to reduce the likelihood of lengthy and ultimately unsuccessful courses of hyperbaric oxygen therapy.

IV. Has the patient reached the endpoint?

In this era of evidence-based medicine and cost containment, greater scrutiny is being directed at the health care delivery system in general, and those modalities not entirely entrenched within mainstream medical practice, in particular. It is important, therefore, that the decision to utilize hyperbaric oxygen therapy be mediated, in part, by its financial impact. In carefully selected patients, managed along algorithmic and evidence-based lines, hyperbaric oxygen therapy provides generally encouraging and clinically enduring outcomes, while reducing the patient's total health care cost. When used in a largely indiscriminate manner, it can be expensive and of questionable clinical value.

In terms of the wound referral, transcutaneous oxygen monitoring holds promise as an algorithmic management and cost containment tool. Well-oxygenated chronic wounds are directed to management strategies other than hyperbaric oxygenation. Hypoxic wounds that are the consequence of high-grade regional ischemia are likewise referred from the hyperbaricist for flow augmentation. In those patients entered into a hyperbaric treatment protocol, non-responders are identified early, rather than following many weeks, or even months, of treatment.

The final step is to identify when a course of hyperbaric oxygen therapy has produced sufficient angiogenesis to support further and spontaneous healing. It is not necessary, nor is it cost effective, to treat such wounds to complete resolution. Once the environment around the wound has been "normalized", and the patient converted to a locally host-competent state, hyperbaric oxygen can be stopped. Peri-wound transcutaneous oxygen values that reach or exceed 40 mmHg suggest adequate neovascularization has been formed. Typically, clinical evidence of healing responses will be apparent at this time. The wound may not be completely healed, however. At this point, hyperbaric oxygen therapy can be stopped. Standard wound care measures remain in force, and the patient is followed for continued healing responses. If the wound plateaus, or regresses, hyperbaric oxygen therapy is reinstituted. This is uncommon. In the setting for which this protocol is designed, the chronic and refractory skin ulceration, withholding hyperbaric therapy for one or two weeks is unlikely to represent a limb-threatening event. Should there be very significant improvement in wound quality, yet not all peri-wound values have reached the 40mmHg threshold, a one-week treatment hold, with the above evaluation schedule, would be appropriate.

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Hyperbaric Medicine Service

Transcutaneous Oximetry Assessment

Patient Label:

Patient Name _____ Date _____ HBO # _____ Photo ☐

Interpreting Physician _____ Clinician _____

Pulse Oximetry _____ % Patient on _____ L of O2 BP _____ P _____ R _____ T _____

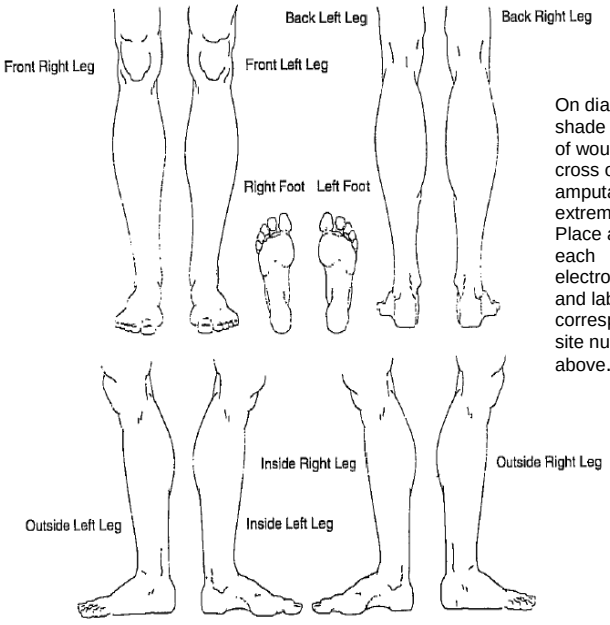
Diabetic: Yes No Dialysis: Yes No *If yes, last tx* Smoker: Yes No *If yes, last use*

Reference Site: _____ **mmHg on Room Air** **Reference Site Location:** **Chest** ☐ **Arm** ☐

Site 1		Site 2		Site 3	
Location Description:		**Location Description:**		**Location Description:**	
RPI:		**RPI:**		**RPI:**	
Baseline Measurement on Air:	**mmHg**	**Baseline Measurement on Air:**	**mmHg**	**Baseline Measurement on Air:**	**mmHg**
1 Min on 100% O_2:	**mmHg**	**1 Min on 100% O_2:**	**mmHg**	**1 Min on 100% O_2:**	**mmHg**
2 Min on 100% O_2:	**mmHg**	**2 Min on 100% O_2:**	**mmHg**	**2 Min on 100% O_2:**	**mmHg**
3 Min on 100% O_2:	**mmHg**	**3 Min on 100% O_2:**	**mmHg**	**3 Min on 100% O_2:**	**mmHg**
4 Min on 100% O_2:	**mmHg**	**4 Min on 100% O_2:**	**mmHg**	**4 Min on 100% O_2:**	**mmHg**
5 Min on 100% O_2:	**mmHg**	**5 Min on 100% O_2:**	**mmHg**	**5 Min on 100% O_2:**	**mmHg**
10 Min on 100% O_2:	**mmHg**	**10 Min on 100% O_2:**	**mmHg**	**10 Min on 100% O_2:**	**mmHg**

Site 4		Site 5		Site 6	
Location Description:		**Location Description:**		**Location Description:**	
RPI:		**RPI:**		**RPI:**	
Baseline Measurement on Air:	**mmHg**	**Baseline Measurement on Air:**	**mmHg**	**Baseline Measurement on Air:**	**mmHg**
1 Min on 100% O_2:	**mmHg**	**1 Min on 100% O_2:**	**mmHg**	**1 Min on 100% O_2:**	**mmHg**
2 Min on 100% O_2:	**mmHg**	**2 Min on 100% O_2:**	**mmHg**	**2 Min on 100% O_2:**	**mmHg**
3 Min on 100% O_2:	**mmHg**	**3 Min on 100% O_2:**	**mmHg**	**3 Min on 100% O_2:**	**mmHg**
4 Min on 100% O_2:	**mmHg**	**4 Min on 100% O_2:**	**mmHg**	**4 Min on 100% O_2:**	**mmHg**
5 Min on 100% O_2:	**mmHg**	**5 Min on 100% O_2:**	**mmHg**	**5 Min on 100% O_2:**	**mmHg**
10 Min on 100% O_2:	**mmHg**	**10 Min on 100% O_2:**	**mmHg**	**10 Min on 100% O_2:**	**mmHg**

RPI= Extremity site divided by reference site on air. **ABI**: _____



On diagram, shade location of wound, cross out amputated extremities. Place an X on each electrode site and label with corresponding site number above.

Interpretation:

_____

_____

_____

_____

Physician Signature: _____

Site #_____ Room Air _____mmHg

In-Chamber TCOM

Record values every 10 mins up to 200mmHg:

2.0 ATA		**mmHg**
2.1 ATA		**mmHg**
2.2 ATA		**mmHg**
2.3 ATA		**mmHg**
2.4 ATA		**mmHg**
2.5 ATA		**mmHg**

ATA x 14.7-14.7=psig

Revised 9/2015

THE HYPERBARIC MEDICINE SERVICE

TRANSCUTANEOUS OXYGEN SCREENING

Name _____ Date _____

Regular Physician _____

You have just undergone a transcutaneous oxygen study of:

☐ **Both feet**

☐ **Your left foot**

☐ **Your right foot**

This test measures the amount of oxygen present in the skin. This information represents an indirect assessment of the health of both the larger blood vessels in your legs, and the smaller ones in your feet.

It is a screening test, which means that additional tests may be necessary, depending upon the results. The information obtained today should be discussed with your regular doctor, who will be responsible for any decision to proceed with further testing, or related care. We have attached several articles that describe the importance of this test in the evaluation of risks for healing compromise, for the benefit of your doctor. Thank you for stopping by!!

FINDINGS

Both Feet	Left Foot	Right Foot	
☐	☐	☐	**Normal exam ≥40 mmhg** - *there is presently no evidence of a significant blood flow impairment*
☐	☐	☐	**Borderline exam 30 – 39 mmhg** - *oxygen levels fall within the borderline –to- normal range, and do not presently appear limb or tissue threatening*
☐	☐	☐	**Abnormal exam <30 mmhg** - *oxygen levels are below the normal anticipated range, and may complicate the healing of any wound or injury.*

For additional information, please call the Hyperbaric Medicine Service at _____.

Random Report

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