Key Aspects of Care

- Identify burn patients who are undiagnosed diabetics (HgA1c).
- Assess diabetic control using HgA1c.
- Optimize glycemic / metabolic control for the burn patient.
- Optimize burn wound management for the diabetic patient.
- Treat microvascular disease associated with diabetes.
- Provide education and discharge plan to patient and family.

Initial Assessment

- Obtain history including diabetes management and medication history.
- Perform physical exam.
- Document the following:
  - TBSA
  - Depth of burn
  - Symptoms of diabetes-related complications:
    - Neuropathy
    - Retinopathy
    - Cardiovascular disease
    - Peripheral vascular disease
    - Previous problems with wound healing
- Obtain transcutaneous oximetry measurement (TCOM) to assess ability to heal the burn wound.

Laboratory Tests

- Ankle Brachial Index (ABI)
- CBC
- Chem 7
- C-Reactive Protein (CRP)
- EKG
- HbA1c
- Lipid panel
- Nutrition labs (total protein, albumin, pre-albumin)
- Serum creatinine
- TCOM
- Toe pressures

TCOM Levels / Hyperbaric Oxygen (HBO) Therapy

(See the Hyperbaric Oxygen Policy)

HBO therapy is indicated for wound healing:

- Angiogenesis occurs in response to increased oxygen tension
- Fibroblast proliferation and collagen synthesis is oxygen dependent

Transcutaneous oxygen (TcPO₂) levels

- **Baseline TcPO₂ Levels**
  - Normal: &gt; 50 mmHg
  - Adequate: &gt; 40-50 mmHg
  - Healing compromised: &lt; 40 mmHg
    - 30-40 mmHg: conservative care
    - &lt; 30 mmHg: vascular studies

Perform normobaric O₂ challenge if considering HBO

- &gt; 300 mmHg: Excellent, uncompromised arterial flow
- &gt; 100 mmHg: Adequate reversal, HBO candidate
- &lt; 100 mmHg: Significant ischemia / hypoxia, vascular referral, in chamber TcPO₂

In-chamber TcPO₂ trial

- &gt; 200 mmHg (at 2 ATA): Positive trial of HBO
- Repeat TcO₂ after 14 treatments. If baseline TcO₂ is improving, then continue for up to 20 treatments pre-grafting and a course of up to 20 treatments post-grafting.

Ankle Brachial Index (ABI)

ABI to rule out arterial disease:

- **0.00-0.40:** Severe peripheral arterial disease (PAD) sufficient to cause resting pain or gangrene
- **0.41-0.90:** PAD sufficient to cause claudication
- **0.91-1.30:** Normal vessels
- **&gt;1.30:** Non-compressible, severely calcified vessel

Toe Pressures

- ABI &gt; 1.40 or ankle pressure &gt; 250 mmHg.
- Toe pressures may provide accurate measurement of distal limb systolic pressures in vessels that do not typically become non-compressible.
- Toe pressure is normally approximately 30 mmHg less than ankle pressure.
  - An abnormal toe pressure is &lt; 0.70.

Semmes-Weinstein Monofilament Test

- This nylon “string” is specifically calibrated in stiffness to represent a baseline level of sensation that can be considered “the line” between having neuropathy and having normal sensation.
- When the string is placed against the foot and slightly bent due to the pressure of pushing it onto the foot, a person with normal sensation should feel it.
- If pressure is not felt in at least 4 out of 10 predefined areas, it is reasonable to assume that diabetic neuropathy is present and extra
precautions should be practiced to protect the foot from poor sensation.

- There are other methods of testing for neuropathy, and the monofilament test should never be used alone to determine if neuropathy is present in a diabetic who has never had neuropathy before.

Ongoing Testing

Capillary (bedside) blood glucose monitoring:
- In all patients (irrespective of diabetes status) for at least 48 hours and at the start of any enteral or parenteral feeding.
- Patients who have hyperglycemia or a history of diabetes should have monitoring throughout hospitalization.

Target glucose:
- Once enteral/parenteral feeds are at goal, BG monitoring may be discontinued if BG values are consistently < 150 mg/dL.

HbA1c:
- At admission for all patients unless documented within the previous 2 months.
- The HbA1c must be drawn before any red blood cell transfusions.

Optimal Glycemic Control and Therapy

Continuous IV insulin
- Infusion is preferred for persistent glucose (two consecutive checks) despite intervention >180 mg/dL early in the hospital course.
- Use continuous IV insulin until the patient is eating, hemodynamically stable, and well-controlled for a period of time that is sufficient to calculate basal insulin requirements (ideally 12-24 hours—Furnary).
  - See the OSUWMC IV insulin infusion guideline
  - for details located on the pharmacy website.
  - See OSUWMC guidelines:
    - Diabetes: Type 1 Diabetes Mellitus (T1DM) and Diabetic Ketoacidosis (DKA)
    - Diabetes: Type 2 Diabetes Mellitus (T2DM) and Other Non-Diabetes-Associated Hyperglycemia
- For patients who are eating while receiving IV insulin, provide concomitant SQ rapid-acting insulin for carbohydrate coverage (see below, “Subcutaneous insulin,” item 2).

Note: The contents of the insulin pump while under the pressure of the HBO chamber can cause unintended delivery of insulin. Monitor patient blood sugar both before and after being in the HBOT chamber.

Subcutaneous insulin
- The preferred means of treatment for hyperglycemia in the hospital.
- Base the regimen on the patient’s home regimen, severity of hyperglycemia, and risk for hypoglycemia (such as renal failure), and include the following three components in most individuals:
  1. Basal insulin: ≤ 50% of the total daily dose in patients who are eating. See Table 1.
  2. Prandial insulin:  o ≥ 50% of the total daily dose in patients who are eating. See Table 2.
     o Patients receiving enteral or parenteral nutrition may require most of their insulin requirements in the form of prandial insulin.
  3. Correction:
     o Supplemental or sliding scale. See Table 2.

Note: Prolonged use of sliding scale insulin, when used as monotherapy, has been found to be ineffective, and is associated with higher complication frequency in surgical patients. See OSUWMC Inpatient Management of Diabetes Mellitus in Non-Pregnant Adults guideline for management of hyperglycemia in hospitalized patients, and see the OSUWMC Pharmacy Guidelines for Insulin Glargine Prescribing in the Medical Intensive Care Unit (MICU).

Table 1. Basal Insulin Initiation in Patients Not Receiving IV Insulin*

<table>
<thead>
<tr>
<th>Blood Glucose</th>
<th>Insulin Naïve</th>
<th>Not Insulin Naïve</th>
</tr>
</thead>
<tbody>
<tr>
<td>140-200 mg/dL</td>
<td>0.1-.20 units/kg</td>
<td>50% of previous total daily dose</td>
</tr>
<tr>
<td>&gt; 200 mg/dL</td>
<td>0.25 units/kg</td>
<td>60% of previous total daily dose</td>
</tr>
</tbody>
</table>

*Correlate with patient’s home dose and weight requirements (total daily dose ~0.4-0.5 unit/kg)

Table 2. Prandial Carbohydrate Coverage

<table>
<thead>
<tr>
<th>Total Daily Dose (units)</th>
<th>Insulin:Carb (units:grams)</th>
<th>Correction Factor (1 unit per mg/dL &gt; 150 mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>1:20 (low dose)</td>
<td>100 (low dose)</td>
</tr>
<tr>
<td>30-40</td>
<td>1:15</td>
<td>50 (standard dose)</td>
</tr>
<tr>
<td>41-50</td>
<td>1:10 (standard dose)</td>
<td>50 (standard dose)</td>
</tr>
<tr>
<td>51-80</td>
<td>1:8</td>
<td>25 (high dose)</td>
</tr>
<tr>
<td>81-120</td>
<td>1:5 (high dose)</td>
<td>25 (high dose)</td>
</tr>
</tbody>
</table>
Oral Agents

Most oral medications should be stopped at admission in favor of insulin therapy (possible exceptions include DPP-4 inhibitors such as Sitagliptin).

- Patients who are well-controlled (HbA1c <7%) on one or two oral agents at admission may start with prandial insulin using a rapid-acting insulin analog (lispro, aspart, glulisine) according to carbohydrate intake plus correction insulin.
- Basal insulin (using glargine or detemiran) may be added at 0.1-0.2 unit/kg if the patient remains hyperglycemic on hospital day 2.
- Patients who are moderately or poorly controlled (HbA1c > 7%) on oral agents at admission typically require basal + prandial + correction insulin during hospitalization.

Subsequent Treatment

- Adjustments should be made daily to the insulin regimen in increments of 10-20% per day, tailored to the glucose pattern.
- Hypoglycemia should be addressed first, and downward-dose adjustments of 20-50% may be required.

Discharge Regimen

Good Control (HbA1c <7%)

- The pre-admission regimen may be resumed at discharge in such patients provided that there are no contraindications.
- For example, metformin should not be restarted within 48 hours of IV contrast, or, in case of renal failure, thiazolidinediones should not be restarted in patients with heart failure.

Moderate Control (HbA1c 7-9%)

- Patients require 1-step or 2-step intensification of their regimen at discharge, which often includes insulin therapy:

  **Stepwise Therapy**
  Oral→combination oral→oral + basal insulin→basal + prandial/correction or split mixed insulin or basal insulin + long-acting GLP-1 RA

Poor Control (HgA1c > 9%)

- Patients usually require multi-dose injection therapy basal + prandial/correction (4 injections per day) vs. split mixed insulin (2 injections per day) or basal insulin plus long-acting GLP-1 receptor agonist.

Perioperative Management

- HOLD oral diabetic meds
- Scheduled SQ insulin for tube feed coverage should be held while the patient is NPO

Insulin

- If patients are receiving tube feedings, stop IV insulin infusion when the tube feedings are stopped. Start dextrose containing IV fluid. If the BG >150, consider restarting the insulin at 1-2 units/hr.
- For long-acting insulin (i.e., detemiran and lantus):
  - **Option 1**: Reduce the evening dose of long-acting insulin 50% when expected to be NPO for surgery; start dextrose containing maintenance IV fluids while NPO.
  - **Option 2**: Hold the preoperative evening lantus dose and start an insulin drip once glucose is > 180 mg/dl until the next evening when patients get their scheduled lantus dose (assuming tube feeds and/or diet are restarted).
- In patients with Type 1 diabetes, basal insulin should never be withheld; however, a small dose reduction of 10-20% would be reasonable.

Consults

- Occupational Therapy, Physical Therapy
- Social Work
- Nutrition
- Diabetes
- Hyperbaric Medicine

Burn Wound Care

- Choice of dressing will depend on the purpose: absorptive, debridement, protection, antimicrobial coverage.
- The **Burn Wound Care Policy** will be followed for cleansing and dressing of the burn.
- Silver dressing, either barrier or topical creams, are the most widely available and used.

Silver Sulfadiazine

- Broad spectrum antimicrobial activity including Gram-negatives, *MRSA*, VRE, and *Candida*
- Pseudomembrane can form; therefore, aggressive cleansing may be necessary
- Caution with sulfonamide allergy
- Can cause leukopenia and may delay epithelialization
- Poor eschar penetration

Mafenide

- Demonstrated broad spectrum bacteriostatic and Gram-positive (*MRSA*) activity against Gram-negatives, including *pseudomonas* and *acinetobacter*
- Lacks fungal coverage; therefore, has been associated with fungal overgrowth
- Carbonic anhydrase inhibitor, associated with metabolic acidosis
- Caution with sulfonamide allergy and renal insufficiency

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• Can rapidly penetrate eschar

Silver-Containing Dressings
• Silver ions slowly released from dressing, with broad-spectrum antimicrobial activity
• Nanocrystalline silver group in five clinical trials demonstrated a significantly lower rate of infection

Dakins Solution (i.e., sodium hypochlorite)
• Activity against vegetative bacteria, viruses, and some fungi
• Requires prolonged contact for antibacterial action and is inactivated by pus
• May delay epithelialization

Acetic Acid
• Bactericidal against most Gram-positive and Gram-negative organisms, including pseudomonas
• Limited activity against biofilm

Bacitracin
• Activity against Gram-positive organisms only
• Minimal data in burns Antimicrobial activity

Polymyxin B
• Activity against Gram-negative organisms, including pseudomonas, but resistance is emerging
• Minimal data in burns

Distributing Pressure on the Foot – Offloading
• Half shoes or postoperative shoes, wedge sole that off-loads either the fore foot or the hind foot.
• Healing sandals; or rocker-bottom cast shoes.
  ▪ They are designed to limit plantar progression by limiting dorsiflexion of the MTP joints.
• Therapeutic or bespoke shoes
  ▪ These are custom diabetic shoes.
• Scotch cast boots; fiberglass casts, lighter than plaster casts; functions to reduce pressure on the wound while wearing with a rocker-bottom cast shoe to maintain mobility.
  ▪ There is no high-level evidence to compare healing rates with other standard casts.
• Removable cast walkers
  ▪ These are basically fracture boots, which if fitted properly, will fixate the foot and allow for pressure dispersion and off-loading the first metatarsal head while keeping the foot in neutral.
• Instant total contact cast (iTCC)
  ▪ This basically takes a walking fracture boot.
  ▪ It is secured on the patient with wrap/cast tape, which inhibits the patient from taking the boot off. This way, there is a TCC effect that gives the practitioner access to the wound by simply breaking the seal and redoing it after wound care.

Discharge Education

Diabetes Education
• Patients should be taught to record glucose levels and receive survival skills education including:
  ▪ Glucose monitoring
  ▪ Injection teaching
  ▪ Insulin regimen instructions
  ▪ Recognition / management of hypoglycemia/ hyperglycemia
  ▪ Importance of annual retinal exam and foot exam
  ▪ Basic carbohydrate awareness
• Survival skills education may be performed by staff nursing with the assistance of the nurse, CNS, and Diabetes Unit Resource Nurse (DURN) for the unit.
• Consider a diabetes education consultation for patients with more advanced needs (multiple injection therapy, new diagnosis, or very poor control).
• Consider nutrition consultation for carbohydrate counting / awareness. If required, order diabetes education consultation early in the hospital course (< 48 hours).

Burn Care Education
• Patients should receive the burn discharge book; and patient and family will provide a return demonstration of the wound care / burn exercises.

Hyperbaric Oxygen
• Patients should receive education related to ongoing hyperbaric oxygen treatments at discharge.

Following Discharge
• For patients with inadequate glycemic control, PCP or endocrinologist follow-up within 2 weeks; also, podiatry and/or ophthalmology follow-up if last exam > 1 year ago.
• Burn follow-up within 2 weeks of discharge.
• Nutrition or diabetes education follow-up as needed.

Order Sets
• OSU IP BURN: ADMISSION CRITICAL CARE BURN (2111)
• OSU IP BURN: ADMISSION NON ICU BURN (2109)
• OSU IP ED: DKA/HYPERGLYCEMIA (2439)
• OSU IP END: DKA FOCUSED-CRITICAL CARE (2048)
• OSU IP END: FOCUSED DIABETES (2056)
• OSU IP BURN: FOCUSED WOUND CARE (2171)
Policies

Burn Wound Care Policy
Hyperbaric Oxygen Policy

Quality Measures

- Hospital length of stay
- Percent of patients who undergo amputation as a result of diabetic foot burn
- Percent of patients who receive hyperbaric oxygen therapy (HBO)
- Glycemic control:
  - Percent of patients with blood glucose <150 mg/dL on hospital day 2
  - Mean blood glucose level on hospital day 1, 2, and 3
- Percent of patients who receive the following medications:
  - Silver sulfadiazine
  - Mafenide

References

Diabetes

Hyperbaric Oxygen

Ankle Brachial Index

Toe Pressure

Wound Care
• Moon CH, Crabtree TC. New wound dressing techniques to accelerate healing. Current Treatment Options in Infectious Diseases. 2003; 5:251-2

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Approval Date

Disclaimer: Clinical practice guidelines and algorithms at The Ohio State University Wexner Medical Center (OSUWMC) are standards that are intended to provide general guidance to clinicians. Patient choice and clinician judgment must remain central to the selection of diagnostic tests and therapy. OSUWMC’s guidelines and algorithms are reviewed periodically for consistency with new evidence; however, new developments may not be represented.