BURN SURGERY

Surgical Specialty:	Pediatric Surgery, Non-OR Anesthesia (NORA)
Authors:	Brady Still, MD and Ellen Choi, MD The University of Chicago Medicine, Chicago, IL

Background:

- **General considerations**
  - Patients with higher-degree and/or large surface area burns often require serial debridements and skin grafts in the operating room (OR).
  - Depending on institutional practices, anesthesiologists may also be involved in providing sedation for bedside dressing changes.
- **Patient considerations**
  - Patients can have comorbidities unrelated to the presenting burn injury.
  - During the initial presentation, patients can have occult inhalational injuries, carbon monoxide, and/or cyanide poisoning.
    - 20-30% of infants and children with large burns have associated inhalational injuries.[1]
  - Patients with significant burns have profound fluid requirements, are at risk for opportunistic infection, have poor thermoregulation, and high metabolic rate resulting in higher caloric demand.
  - Depending on the affected body part(s), vascular access and airway management can be challenging.
  - Burns trigger a pro-inflammatory state that can progress to multiorgan system failure.

Anesthetic Planning:

- **Pre-Anesthetic Evaluation**
  - Assessment of non-burn comorbidities.
  - Review of prior anesthetics; burn patients often have multiple anesthetics over the course of their hospitalization.
  - Basal metabolic profile, complete blood cell count, arterial blood gas and carboxyhemoglobin level, type and screen (if scheduled for burn debridement/skin graft)
  - Assessment of nutritional supplementation: total parenteral nutrition (TPN) versus enteral nutrition.
    - Given the high caloric needs, TPN should be continued perioperatively. If enteral nutrition is being administered via a jejunostomy or transpyloric tube, it should also be continued perioperatively after radiographic confirmation.

    - **Discussions to have with surgeon/family:**
        - Possible need for central access if unable to obtain peripheral access.
        - Possible need for blood transfusion.
        - Possible need for postoperative mechanical ventilation.
        - Possible need for pediatric intensive care unit (PICU) bed in the event of significant blood loss or need for postoperative mechanical ventilation.
- **Specific or Unique Room Set-Up Requirements**
    - **Airway:** age-appropriate endotracheal tube (ETT); if facial burns, consider alternative ETT securement (ties, tape over un-burned area, etc.) A smaller size ETT may be required due to airway edema. Anticipate difficult airway if facial or airway burns.
    - **Drugs/infusions:** ketamine bolus and/or infusion often utilized for analgesia. Avoid using succinylcholine after the first 24 hours, due to the risk of exaggerated hyperkalemic response.
    - **Monitors:** standard American Society of Anesthesiologists monitors; arterial line for debridements
    - **Blood availability:** immediately available for debridement; consider balanced transfusion (1 PRBC to 1 FFP to 1 platelet, or "1:1:1") if very large BSA debridement
    - **Other indicated resources:**
        - **For debridement or skin graft:** fluid warmer, heat moisture exchanger (HME), heated circuit. Warm room preoperatively, arterial access (if indicated)
        - **For dressing change at the bedside:** standard emergency equipment (mask, AMBU bag, suction). Depending on availability/institutional practice, consider utilizing Child Life specialists.

Intraoperative Considerations:

- **General:**
    - **For debridement or skin graft:**
        - Compensate for significant ongoing blood loss which can be subtle or difficult to quantify.
        - Fluid resuscitation
        - Maintain normothermia
    - **For dressing change:**
        - Maintain adequate depth of anesthesia
    - **For both:**
        - Postprocedural pain control

Induction:

- **For debridement or skin graft:**
    - Patients typically have an intravenous (IV) catheter *in situ.*
    - Inhalational induction is not contraindicated if no IV access is present.
    - Avoid using succinylcholine after the first 24 hours, given the high risk of hyperkalemia.
- **For dressing changes:**
    - IV sedation; numerous viable approaches
    - Ketamine often utilized as a bolus and/or infusion, given analgesic and anti-inflammatory properties.[2,3]

- **Positioning:**
    - Close communication with the surgeon; variable positioning depending on the burned area.

- **Maintenance:**
  - No specific considerations
- **Hemodynamic/physiologic goals:**
  - **For debridement or skin graft:**
    - Normothermia; consider using a fluid warmer, HME, and heated circuit, if available.
    - Normovolemia
      - Consider using the Cincinnati or Galveston formula (pediatric-specific formulae) for initial burn resuscitation[4]:

Formula	Equation	Fluid
Cincinnati	4 mL/kg x %TBSA burned + 1500 mL/m^2 TBSA	**First 8 hours:** LR + 50 mEq/L $NaHCO_3$ **Second 8 hours:** LR **Third 8 hours:** LR + 12.5g albumin + 5% dextrose as needed to avoid hypoglycemia
Galveston	5000 mL/m^2 burned + 2000 mL/m^2 TBSA Half given over first 8 hours, half given over remaining 16 hours	LR + 12.5 g albumin per 1L LR + 5% dextrose as needed to avoid hypoglycemia

BSA = body surface area, TBSA = total body surface area, LR = Lactated Ringer's

      - Adult resuscitation formulae (Parkland, Brooke, etc.) are **not** to be used on pediatric patients due to the difference in body surface area (BSA) to mass ratio.[4]
      - Colloids are often preferred over crystalloids after thee initial resuscitation.
      - Continuously evaluate resuscitation endpoints (urine output ≥ 0.5 mL/kg/hr if over 30 kg, urine output ≥ 1 mL/kg/hr if under 30 kg, stable or declining lactate, stable or declining base deficit, PPV if arterial access available).[4]
    - Compensation for blood loss
      - Pay close attention to surgical field; frequent arterial blood gases (ABGs) to assess hemoglobin.
      - Large BSA burns may require massive transfusion; consider 1:1:1 transfusion to minimize dilutional coagulopathy.
  - **For dressing change:**
    - Maintain an appropriate depth of anesthesia (moderate or deep sedation)
    - Maintain spontaneous ventilation.
- **Surgical considerations:** blood loss as described previously
- **Emergence/disposition:**
  - Ensure adequate analgesia prior to emergence.
  - Floor vs. PICU vs. dedicated burn unit for postoperative disposition.

- **Postoperative care:**
  - Extensive somatic and neuropathic pain is common.
  - Burn patients often develop opioid tolerance and psychological sequelae that exacerbate pain.
  - In addition to opioids (infusion versus patient-controlled analgesia [PCA]), consider adjunctive therapies such as acetaminophen, gabapentinoids, and dexmedetomidine.[1]
  - Consider psychological support needs.
  - Consider regional anesthesia for donor tissue sites.
  - Consider acute pain consultation.

Case Specific Complications/Pitfalls

- **For debridement or skin graft:**
  - **Blood loss:** can be extensive and difficult to quantify, as it often manifests as ongoing dermal and subdermal bleeding rather than frank hemorrhage. Vigilance and frequent assessment are required.
  - **Hypothermia:** Burn patients are at high risk for hypothermia. A fluid warmer and HME should be used. Consider using a heated circuit if available.
  - **Distributive shock:** Burn patients are at high risk for opportunistic infections and can rapidly develop sepsis. In addition, the burn itself triggers a hyperdynamic distributive shock state.[2] Ensure adequate resuscitation and consider use of vasopressor if there is a high clinical suspicion for distributive shock.
  - **Tumescent local anesthetic and LAST:** The surgeon may utilize tumescent local anesthetic with epinephrine to minimize bleeding; verify appropriate dose.
- **For dressing change:**
  - **Analgesia:** Pain is often underestimated/undertreated; consider using non-opioid adjuncts.

References

1. Jeschke MG, Herndon DN. Burns in children: standard and new treatments. *The Lancet*. 2014;383(9923):1168-1178. PubMed Link
2. Pardesi O, Fuzaylov G. Pain Management in Pediatric Burn Patients: Review of Recent Literature and Future Directions. *Journal of Burn Care & Research*. 2017;38(6):335-347. PubMed Link
3. Bittner EA, Martyn JAJ. Acute and Perioperative Care of the Burn-injured Patient. *Anesthesiology*. 2015;122:448-64 PubMed Link
4. Romanowski KS, Palmieri TL. Pediatric burn resuscitation: past, present, and future. *Burns & Trauma*. 2017;5. PubMed Link

---

Reviewed by:

Reviewer #1: Anita Akbar Ali, MD, Arkansas Children's Hospital

Reviewer #2: Luigi Viola, MD, Johns Hopkins All Children's Hospital

Reviewer #3: Sara B. Robertson, MD, FASA, University of Mississippi Medical Center

---