



PEDIATRIC BONE MARROW HARVESTING

Surgical Specialty:	Hematology and Oncology
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Background:

- General Considerations
 - Bone marrow harvesting (BMH) is a means to obtain stem cells to treat certain hematologic disorders and cancers in related or unrelated individuals.
 - Hematopoietic stem cells can be obtained from peripheral blood or bone marrow; however, bone marrow is preferred as it has a lower risk of graft versus host disease.¹
 - Donors are identified according to major histocompatibility complex (HLA) for allogenic BMT.
 - It is also sometimes used to collect and preserve healthy bone marrow during periods of remission in a hematologic patient (autologous BMT).
 - Unlike a bone marrow aspiration/biopsy, which is typically performed as part of a diagnostic workup, obtaining only a small volume of bone marrow, a BMH is a longer and more involved surgical procedure that produces a significant volume of bone marrow for a recipient (**Figure 1**).
 - Harvesting physicians aim to obtain a volume of bone marrow that is safe for donor extraction and at a sufficient cell dose for the recipient.
 - Large volume extractions can present significant hemodynamic changes for the donor.
 - Surgical site pain is the most cited complaint, which may serve as a deterrent for potential donors.²
 - Other complications include nausea, anemia, and fatigue.
 - BMH requires the patient to be in the prone position to allow access to the bilateral posterior iliac crests.
- Patient Considerations
 - Adult donors can be related or unrelated to the recipient.
 - Unrelated donors are identified as matches via national programs such as the National Marrow Donor Program.
 - More than one-third of children undergoing allogeneic transplantations receive grafts from siblings under the age of 18.³
 - Sibling donors are a unique patient population undergoing an anesthetic for the sole benefit of their sibling.

- Additional goals of care for the case should include facilitating an expeditious recovery to allow the pediatric donor to reunite with their family and partake in the bone marrow transplant of their sibling.
- It is also important to provide adequate parental support as they have two children undergoing procedures within the same time frame, often the same day (BMH and bone marrow transplant).⁴

Anesthetic Planning:

- Pre-Anesthetic Evaluation
 - Donors are often overall healthy, with an ASA 1 or 2 classification, however a detailed pre-operative evaluation is required for any patient undergoing general anesthesia.
 - Physical exam should focus on any pre-existing symptoms of anemia or signs of common childhood medical diagnoses.
 - E.g., asthma, upper respiratory illnesses, loose teeth
 - Preoperative labs, including CBC and Type and Screen, are often obtained as part of the donor workup via the transplant team prior to the day of surgery.
 - Institutional NPO guidelines should be followed. Clear fluids are encouraged until 2 hours before operative time.
 - Discuss post op pain management options, including multi-modals and potential regional anesthesia techniques.
 - Consider acetaminophen 15 mg/kg oral as part of a multimodal pain medication approach and midazolam 0.5 mg/kg oral if anxious.
 - If general anesthesia is not accepted by the potential donor, neuraxial anesthesia is an acceptable alternative.⁵
- Specific or Unique Room Set-Up Requirements
 - Airway
 - Endotracheal intubation with an appropriately sized oral ETT.
 - Drugs/Infusions
 - Although the transmission of anesthetic drug to the recipient is minimal (dilution and bone marrow preparation process), the risk of passive drug transfer must be kept in mind (e.g., in case of patient allergy).
 - Limit opioid medications if possible.
 - Nitrous oxide is not contraindicated despite its known effects on methionine synthetase.⁶
 - Multimodal Analgesia
 - Acetaminophen 15 mg/kg oral or IV
 - Ketorolac 0.5 mg/kg (max 30 mg) IV
 - Ketamine as an alternative on induction (0.5 mg/kg IV)
 - Local Anesthetic for regional anesthesia
 - Regional anesthesia as part of a multimodal regimen has shown to decrease the perioperative need for opioid administration.⁶
 - Infiltration of the donor site periosteum by the hematologist with a long-acting anesthetic is common, and discussion of local anesthetic limits should occur.
 - Bilateral quadratus lumborum (QL) blocks are emerging as a viable regional anesthesia technique to mitigate postoperative pain.
 - This is due to the large area of sensory inhibition (T7-L2 in most cases).⁷

- Compared to other truncal fascial plane blocks (e.g., Transverse Abdominal Plane), QL blocks provide somatic and visceral analgesia as the local anesthetic spreads through the thoracolumbar fascia, anesthetizing the lateral cutaneous branches of the ilioinguinal, iliohypogastric, and subcostal nerves.⁸
- Traditionally thought of as an abdominal wall block used for abdominal and pelvic procedures, there is growing literature for the QL block in various other procedures.⁹
 - Recommend Ropivacaine 0.2% 0.5 mL/kg per side (up to 20 mL per side).
- PONV prophylaxis
 - Dexamethasone 0.1 mg/kg IV (after bone marrow has been harvested)
 - Ondansetron 0.1-0.15 mg/kg IV
- Emergence Delirium Prophylaxis
 - Dexmedetomidine 0.25- 0.5 µg/kg IV
- Monitors
 - Standard ASA monitors
- Blood Availability
 - Usually not required intraoperatively, but may be necessary postoperatively at the discretion of the hematologist.
 - A CBC is typically obtained at the completion of the harvest or upon arrival to the post-anesthesia care unit (PACU) at which time the transplant team will determine the appropriateness of blood transfusion.
- Postoperative Admission
 - BMH is typically an outpatient procedure.
 - Postoperative admission is at the discretion of the institution.
 - Admission to the ICU is rare.
- Other Indicated Resources
 - Communication with the regional anesthesia team/attending regarding timing for QL blocks.

Intraoperative Considerations:

- Induction
 - Either mask or IV induction is appropriate.
 - Regional anesthesia is best performed following induction and intubation, with the patient in the supine position on the stretcher or prone position on the OR Table, prior to surgical incision.
 - The goal is for the blocks to have adequate time to set prior to incision.
 - Block failure is always a possible outcome with regional anesthesia techniques.
 - It may be appropriate to administer intravenous opioids for adequate pain control if block is inadequate.¹⁰
- Positioning
 - Prone with gel rolls to elevate the iliac crests.
 - Ensure pressure points are padded, and the genitalia are free of compression.

- The neck should be neutral, and the eyes free of pressure with an appropriately sized face cradle.
- Confirm the absence of compression of the thorax or abdomen.
 - Can check the presence of the dorsalis pedis pulse to rule out compression of the femoral vessels.
- Maintenance
 - Inhalational anesthesia versus TIVA at the discretion of the anesthesia team.
 - PONV prophylaxis
- Hemodynamic/Physiologic goals
 - Hypotension is common with larger volume harvests.
 - Communication between anesthesia and hematology teams is crucial for volume resuscitation.
 - Delay in IV fluid administration to compensate for volume harvested can result in hemodynamic collapse, especially in smaller children.
 - Prior to starting the harvest, the anesthesia team should know the estimated harvest volume and calculate what percentage of the donor's estimated blood volume this represents. Additionally, the team should ensure autologous blood is available for the donor.
 - Fluids:
 - Crystalloid or colloid administration at the discretion of the anesthesia team.
 - Unlikely to need blood products intraoperatively.
 - Discuss with the transplant team prior to administering.
 - Phenylephrine boluses or infusion as needed for hypotension after fluid resuscitation.
- Surgical Considerations
 - If the case is prolonged or a large volume of fluids is expected to be given, recommend placing a Foley catheter at the start of the case or straight catheterize at the end of the case (unlikely in the pediatric population).
 - Before starting the procedure, knowing the total volume the hematologist plans to harvest and how much it represents of the patient's estimated blood volume can help guide fluid and blood product administration.
- Emergence/Disposition
 - Extubation, then recovery in PACU.
- Post-op Care
 - Opioids as needed and sparingly, especially if a regional anesthetic technique is utilized.
 - Labs per transplant team- they will decide if blood transfusion is indicated and communicate this with the PACU staff.
 - Additional nausea treatment if necessary.
 - Patients are often discharged immediately from the PACU to the oncology floor to participate in the bone marrow transplant of a family member.

Case-Specific Complications/Pitfalls

- Large volume extractions can present significant hemodynamic changes for the donor.
- When block placement is expeditiously followed by the start of the procedure, intravenous opioids may need to be administered to the anesthetized patient to facilitate appropriate intraoperative pain control until the analgesic effect of the local anesthetic is evident.

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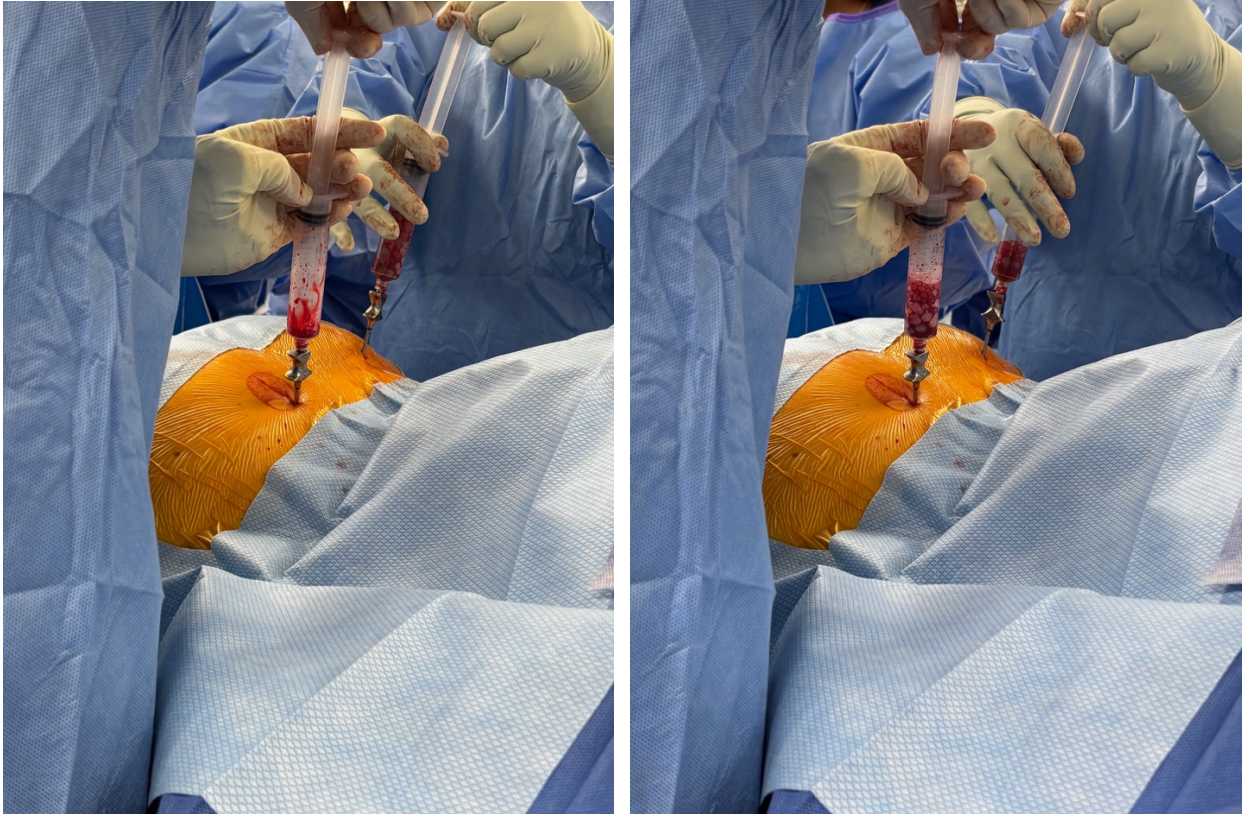


Figure 1. Bone marrow harvesting performed on bilateral iliac crests with patient under general anesthesia in the prone position. Original images taken by N. McCoy.