Treatment of Pregnant Patients With Orthopaedic Trauma

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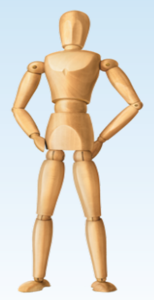

ABSTRACT

▪Fracture management in pregnant patients is challenging. Anatomic and physiologic changes in pregnancy increase the complexity of treatment. Maternal trauma increases the risk of fetal loss, preterm birth, placental abruption, cesarean delivery, and maternal death. Initial resuscitation and treatment in a facility equipped to handle the orthopaedic injury and preterm births are paramount. Pelvic and acetabular injuries are potentially life threatening. The benefits and risks of surgical treatment must be weighed carefully. The risks posed by anesthetic agents, antibiotic agents, anticoagulant agents, and radiation exposure must be understood. Positioning of the patient can affect viability of the fetus. If surgery is necessary, the left lateral decubitus position decreases fetal hypotension. A specialized team including an obstetrician, perinatologist, orthopaedic surgeon, general trauma surgeon, critical care specialist, anesthesiologist, radiologist, and nurse must collaborate to improve maternal and fetal outcomes

INTRODUCTION

▪Trauma is the leading cause of nonobstetric maternal death during pregnancy.[1,2] When a pregnant patient sustains a traumatic injury, treatment should address not only the mother, but also the fetus. Maternal and fetal optimization should be performed by a multidisciplinary medical team consisting of obstetric specialists, anesthesiologists, orthopaedic surgeons, general trauma surgeons, critical care specialists, emergency medicine specialists, and nursing staff.[3,4] Although the life of the fetus must be taken into consideration, initial management is directed toward the mother. When planning treatment of a pregnant patient with musculoskeletal injury, clinicians must be aware of the risks of miscarriage, preterm labor, placental abruption, preterm rupture of membranes, fetal demise, and developmental delays.[3,5-8] Understanding maternal physiologic changes during pregnancy is critical. These changes commonly alter patient presentation, affecting fetal and maternal outcomes.[5-8]

MATERNAL PHYSIOLOGY

▪Maternal physiologic changes in pregnancy are important for clinicians to understand. Physiologic characteristics of pregnant patients may mimic pathologic conditions seen in nonpregnant patients. These findings can complicate a trauma patient's clinical presentation. Further confusing the clinical picture, the mother's body may undergo physiologic adaptations to compensate for life-threatening situations. For example, a patient undergoing hemorrhagic shock may appear to be clinically stable, at the expense of the fetus.[3,5]

Trimester	Physiologic Changes	Related Risk Factors
First	Major organogenesis Central nervous system development Increased WBC count Increased ESR	Radiosensitive development period Increased risk of teratogenesis Hypercoagulable state Increased risk of abortion with general anesthesia
Second	Relatively radioresistant fetal central nervous system Increased WBC count Increased ESR	Increased risk of supine aortocaval compression Hypercoagulable state Increased risk of abortion with general anesthesia Increased risk of seat belt–related injury to the fetus
Third	Maternal blood volume increased by 40% to 50% Increased WBC count Increased ESR	Increased risk of supine aortocaval compression Increased risk of pregnancy-related osteoporosis Increased risk of seat belt–related injury to the fetus

Physiologic Change	Implication
Increased sacroiliac joint and pubic symphysis ligament relaxation	Decreased postural stability Increased predisposition to falls
Increased maternal blood volume	Attenuated initial response to hemorrhage Dilutional anemia
Increased red blood cell mass and white blood cell count	Predisposition to disseminated intravascular coagulation
Increased heart rate	Potential to mask early stages of shock
Decreased blood pressure	Potential to mask early stages of shock
Enlarged uterine size	Potential for supine hypotension syndrome resulting from aortocaval compression
Shift of uterine location anterior to and outside pelvis	Increased risk of injury to uterus and placenta
Decreased functional residual lung volume	Risk of hypoxemia from atelectasis
Increased renal plasma flow and glomerular filtration rate	Decreased oncotic pressure and increased risk of pulmonary edema

EVALUATION AND INITIAL MANAGEMENT

▪The primary goals are stabilization and evaluation of the pregnant trauma patient's vital signs. Aggressive resuscitation, diagnosis, and treatment promote the best outcomes for the mother and fetus.[3-5] A high Injury Severity Score, a low Glasgow Coma Scale score, low hemoglobin levels, the development of disseminated intravascular coagulation, and length of hospital stay are associated with adverse fetal outcomes.[4] Immediately after the patient is stable, fetuses of ≥24 weeks' gestation should be monitored with cardiotocography and high-resolution real-time ultrasonography to provide information on fetal motion, heart rate, and placental integrity.[4,6] Cardiotocographic monitoring should start in the resuscitation room and continue for a minimum of 4 hours.[12] The fetus should be monitored for 24 hours if the patient has uterine tenderness, abdominal pain, vaginal bleeding, sustained contractions, rupture of membranes, an abnormal fetal heart rate, a high-risk mechanism of injury, or serum fibrinogen <200 mg/dL.[12] Continuous electrical fetal heart rate monitoring remains the most common modality for monitoring of any fetus withstanding a traumatic event to ensure that the fetus maintains a normal fetal heart rate of 120 to 160 beats per minute.[6]

IMAGING

▪According to the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the American College of Radiology, and the American College of Obstetricians and Gynecologists, the safest and most appropriate diagnostic study that yields the best result by providing an accurate diagnosis outweighs the low risks of radiation to the fetus during trauma.[3,6,8,19] The National Council on Radiation Protection and Measurements states that the maximum cumulative radiation dose to the fetus during pregnancy should not exceed 5 rad (50 mGy).[19,20]

Radiographic Study	Radiation Exposure (1 rad=0.01Gy)	Number of Studies to Reach or Exceed 5-rad Cumulative Exposure
Chest radiograph (two views)	0.00007	71,429
Upper or lower extremity radiograph	0.001	5,000
Cervical spine radiograph	0.002	2,500
Thoracic spine radiograph	0.009	555
Pelvic radiograph	0.04	125
CT, head (10 slices)	<0.050	>100
CT, chest (10 slices)	<0.1	>50
Hip radiograph (single view)	0.213	23
Ventilation-perfusion scan	0.215	23
Abdominal radiograph (multiple views)	0.245	20
Lumbosacral spine radiograph	0.359	13
CT, abdomen (10 slices)	2.6	2
CT, lumbar spine (five slices)	3.5	2

PROPHYLACTIC THERAPY

▪The indications and dosing schedule for antibiotic administration are the same in pregnant and nonpregnant patients.[29] The safest antibiotics during pregnancy are cephalosporins, penicillins, and macrolides.[8] Skin flora pathogens, including *Staphylococcus aureus*, gram-negative bacilli, coagulase-negative staphylococci, and β-hemolytic streptococci are most common during orthopaedic procedures.[29]

Type of Procedure	Recommended Agent	Alternative Agents in Patients With Beta-Lactam Allergy
Clean surgical procedures involving hand, knee, or foot and not involving implantation of foreign materials	None	None
Hip fracture repair	Cefazolin	Clindamycin, vancomycin
Implantation of internal fixation devices (nails, screws, plates, wires)	Cefazolin	Clindamycin, vancomycin
Spinal procedures with or without instrumentation	Cefazolin	Clindamycin, vancomycin
Total joint arthroplasty	Cefazolin	Clindamycin, vancomycin

PROPHYLACTIC THERAPY

▪Medications that should not be given to pregnant patients.

Antibiotic	Pregnancy Category
Amikacin	D
Doxycycline	D
Gentamicin	D
Kanamycin	D
Metronidazole	B (contraindicated during first trimester)
Minocycline	D
Neomycin	D
Nitrofurantoin	B (contraindicated during third trimester)
Streptomycin	D
Sulfamethoxazole-trimethoprim	D
Tetracycline	D
Tobramycin	D

▪Low-molecular-weight heparins have replaced UFH as the agents of choice for pregnant patients sustaining orthopaedic fractures.[13,26] Low-molecular-weight heparins do not cross the placenta, have a more convenient administration schedule, do not require monitoring of anticoagulant activity, and carry a lower risk of heparin-induced thrombocytopenia, side effects, and osteoporosis.[4,8,13,24]

Agent	Pregnancy Category	Formulation	Reversal Agent	Monitoring
Apixaban	B	Oral	None	Not required
Aspirin	Not formally categorized, risk in first and third trimesters	Oral	None	Not required
Dabigatran	C	Oral	Idarucizumab	Not required
Edoxaban	C	Oral	None	Not required
Fondaparinux	B	Subcutaneous	None	Anti-Xa
Low-molecular-weight heparins (enoxaparin, dalteparin)	B	Subcutaneous	Protamine (partially effective)	Not required
Rivaroxaban	C	Oral	None	Not required
Unfractionated heparin	C	Subcutaneous, intravenous	Protamine	aPTT
Warfarin	X	Oral	Vitamin K	PT/INR

ANESTHESIA

▪An anesthesiologist specializing in the administration of anesthetic agents during pregnancy is recommended because of the altered anatomy, physiology, pharmacokinetics, and pharmacodynamics of a pregnant woman and fetus.[36,37] If possible, the surgical procedure should be delayed until after the first trimester.[8]

Anesthetic Approach Before 24 Weeks' Gestation
Postpone surgery until the second trimester or until the postpartum period if possible (not practical in trauma setting).
Request preoperative assessment by obstetrician.
Counsel the patient and family preoperatively.
Administer a nonparticulate antacid preoperatively.
Monitor and maintain oxygenation, carbon dioxide level, normotension, and euglycemia.
Use regional analgesia for postoperative pain relief when appropriate.
Document fetal heart tones before and after the procedure.

Anesthetic Approach After 24 Weeks' Gestation
Postpone surgery until the postpartum period if possible.
Counsel the patient and family preoperatively.
Obtain obstetric consultation and discuss use of perioperative tocolysis.
Use aspiration prophylaxis of choice.
Maintain uterine displacement perioperatively.
Monitor and maintain oxygenation, carbon dioxide level, normotension, and euglycemia.
Consider use of fetal heart monitoring intraoperatively.
When choosing an anesthetic technique, consider that no difference in outcome has been shown between regional and general anesthesia.
When choosing an anesthetic agent, consider that no difference in outcome has been shown among anesthetic agents.
Monitor uterine contractions and fetal heart tones postoperatively.

SURGICAL TREATMENT

▪Surgical management of a pregnant patient's injury should be as short in duration as possible while maintaining optimal care to minimize perioperative complications.[6] All emergent open fractures, life-threatening injuries, or fractures associated with vascular injury should be treated, regardless of pregnancy status.[8]

▪The primary goal in fracture fixation should be to use the fixation technique that requires the least amount of radiation without compromising fracture care. Minimally invasive percutaneous plating techniques are commonly used. However, these difficult techniques often require high cumulative radiation exposure, which should be avoided in pregnant patients. Intramedullary nailing of comminuted long bone fractures is another example of a difficult technique. Reduction before nail insertion can be challenging, and ensuring proper alignment of the guidewire potentially increases the radiation exposure time. When the risk of radiation exposure becomes problematic, open plating techniques that involve minimal irradiation should be considered.[4]

▪After the patient is determined to be hemodynamically stable, additional imaging studies should be performed to guide definitive treatment. If closed reduction of the pelvis and fluid resuscitation do not restore hemodynamic stability, venous plexus bleeding can be repaired by means of an open laparotomy with retroperitoneal packing and external fixation. If the source of bleeding is arterial, angiography may be more beneficial than laparotomy, depending on the clinical situation.[5]

▪Surgical treatment of pelvic fractures is indicated when the patient has an open pubic symphysis rupture secondary to severe vaginal tearing, diastasis of the symphysis of ≥4 cm, substantial malreduction of the pelvis, diastasis with the pelvic binder in place, or displacement of one or both of the sacroiliac joints. If these characteristics are not present, nonsurgical management consisting of bed rest, pain control, traction, and the use of a pelvic sling, followed by early mobilization with a walker should be attempted.[8]

▪If surgical intervention is needed, external fixation may be considered for the management of diastasis of the pubic symphysis that reduces in a pelvic binder. External fixation reduces further insult to the uterine environment and allows the fetus to reach 34 weeks' gestation. A supra-acetabular fixation approach can allow the patient to sit up and receive proper nursing care without interfering with the uterus. Although more difficult than placing the pins in the iliac crest, the use of supra-acetabular pins allows a stable construct to be established without risk of breaching the uterine environment.[42] Percutaneous iliosacral screws may be used after reduction of the pubic symphysis if the sacroiliac joints remain unreduced.[43]

▪After the acetabular or pelvic fracture is healed, vaginal delivery may be an option if the pelvic structure is not disrupted.[4,5] Considerations in the choice of delivery method include the current gestational age of the fetus relative to the gestational age at which the injury occurred, whether the fracture is healed, the magnitude of fracture displacement, and the presence of bone that would interfere with the fetus or bladder during delivery. Normal healing takes 8 to 12 weeks after an injury.[5] Therefore, if the fracture occurred during the early stages of pregnancy, vaginal delivery may be an option. If displacement of the pubic rami is observed, cesarean delivery should be considered. [5]

MATERNAL AND FETAL OUTCOMES

▪In this study, patients with pelvic fractures had the highest rates of placental abruption, compared with patients who sustained other fractures.[46] In addition, preterm birth rates significantly increased in gestation weeks 24 to 33 (17% versus 3%; $P < 0.001$) and >37 weeks (31% versus 3%; $P < 0.001$) in trauma patients, compared with nontrauma patients. Patients with pelvic fractures had the highest rates of preterm birth.[46] Also, patients with traumatic injuries delivered more frequently on admission than did patients without traumatic injuries (34% versus 13%; $P < 0.001$).[46] Fetal death rates also were significantly higher in trauma patients than in nontrauma patients (5% versus 1%; $P = 0.006$). Pelvic fractures have the highest rates of fetal death compared with other fractures and are associated with high maternal mortality (9%) and fetal mortality (35%).[46-49] In patients with major trauma, the rate of fetal mortality has ranged from 55% to 65%.[1]