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Review Article

Polytrauma in Pregnant Patients US, CT or MRI

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Abstract

The pregnant patient presenting with trauma in emergency departments are challenging for the clinicians and radiologist. We will try to stress some key aspects of the imaging approach of pregnant trauma patients, beginning with some general information and a pictorial review of the recommended modalities that we can use facing this situations. Ultrasonography plays an important role in initial evaluation of the fetus with a limited role in evaluation of maternal injuries, but anyway it's still first choice. Conventional radiography and computed tomography are the "workhorse" modalities for evaluation of pregnant trauma patients. Knowing the principles of their work radiologists must pay particular attention to radiation dose concerns. Magnetic resonance imaging is not the first modality for initial evaluation but for follow-up imaging. Radiologists must be familiar not only with the typical imaging features of injuries that are seen in other trauma patient but also with pregnancy-specific injuries, such as placental abruption, uterine rupture and a ruptured ectopic pregnancy. Although pregnant trauma patients are infrequently encountered, familiarity with imaging findings of injuries in these patients is essential to providing the best care for the mother and fetus.

Keywords: *Polytrauma; US; CT; MRI*

Introduction

Polytrauma or multiple trauma are medical terms describing the condition of a person who has been subjected to multiple traumatic injuries. It comes from Greek language (poli-multiple and trauma-injuries).

Polytrauma is a syndrome of multiple injuries exceeding a defined severity with sequential systemic reactions that can lead to dysfunction or failure of remote organs and vital systems, which have not themselves been directly injured.

The management should be fast and effective to prevent systemic complications or even death.

Complications and challenges

The worst complications of a polytrauma patients might be:

- Hemorrhagic shock.
- Systemic inflammatory response syndrome (SIRS).
- Multiorgan dysfunction syndrome.

Identification of a serious injury or a pathology is a real challenge because:

- Symptoms may not be manifested in initial assessment.
- Accompanying injuries or symptoms may distract the attention.
- Clinical symptoms may be unreliable.

Meanwhile in pregnant patients [1]:

- The awareness should be for two patients, the mother and the fetus.
- Physiological and anatomical changes during pregnancy may mask or look similar with injuries.
- Care for these patients needs multidisciplinary approach.

Diagnostic imaging role:

- To evaluate as soon as possible the patient and achieving definitive diagnosis to begin the appropriate treatment.
- To explore the injuries and complications.

Etiology (almost similar with non-pregnant patients) and epidemiology [2]

Trauma is the leading cause of non-obstetric maternal mortality affecting up to 7% of pregnancies [3-15] and is a significant cause of fetal loss [4-6]. In some other publications the affecting rate can reach up to 20% of pregnant patients.

Pregnant trauma patients are more likely to sustain serious abdominal injury than nonpregnant trauma patients [7] and most obstetric complications of trauma occur in the third trimester [15].

Causes of trauma in pregnancy include motor vehicle crashes (49%), falls (25%), assaults and domestic violence (18%), and gunshot injuries (4%) [16] (Table 1). The incidence of domestic violence sharply increases in pregnancy [7,8,13-15,17].

Trauma Type	Cause	Percentage
Blunt trauma	Motor vehicle crashes	49
	Falls	25
	Assaults	18
	Burns	1
Penetrating trauma	Gunshot wounds	4
	Stab wounds	

Table 1: Cause of trauma in pregnant patients [16].

The Frequency rate of trauma becomes greater with an increased gestational age.

During pregnancy, there is a spatial redistribution of the viscera inside the abdominal cavity due to the progressive increase in the size of the uterus. The abdominal viscera are displaced cephalad as the uterus reaches the central region of the abdomen. That is the reason why penetrating abdominal injuries during the third trimester of pregnancy are associated not only with high maternal morbidity, but also with a significant increased incidence of uterine and fetal injury (60 - 70%), including a very high fetal death rate (40 - 65%).

The impact of abdominal trauma on the fetus depends to high degree on the gestational age at the time of the trauma. Direct injury to the uterus and fetus is unlikely during the first 12 weeks of gestation due to the protective effect of the bony pelvis, unless the traumatic event has caused complex pelvic fractures [18].

Major injuries can lead at about 25% lethality. Fetal death is more common than maternal death.

Possible effects of trauma in pregnancy [19]

Consequently, clinicians may encounter a wide range of trauma in their practice. Trauma, severe or non-severe, has been associated with an increased risk of spontaneous abortion, premature labor, preterm, premature rupture of the membranes, uterine rupture, placental abruption, fetal distress, maternal death, and stillbirth.

Of course, in the setting of a trauma complicated by pregnancy, there are two patients, and fetal loss rates approach 40% - 50% in life-threatening trauma. While fetal loss occurs at a much lower rate with minor injuries (1% - 5%) and minor injuries are much more common.

Possible injuries of fetus [1]

Direct injuries of fetus are uncommon because it is protected from soft tissues of abdomen, uterus, placenta and amniotic liquid.

Lethality at the fetus depends from the type of injury. Uterine rupture (100%), Maternal shock (80%), Penetrating injuries (70%), Placental disruption (60%).

Possible injuries of mother [20]

Urinary bladder injuries and pelvic vessels (especially 2nd and 3rd trimester). Retroperitoneal and vaginal hemorrhage, Amniotic embolism. Penetrating injuries: lower abdomen (uterus), upper abdomen (intestinal bowels).

Radiologists must identify non-pregnancy-related injuries as expeditiously as possible. Intracranial injuries are the major cause of maternal deaths and CT is the preferred modality for evaluation of suspected intracranial pathology [21]. The first-line imaging choice for suspected injuries in the chest, abdomen, and pelvis is intravenous contrast-enhanced CT.

Basic principles that should be in mind facing one polytrauma pregnant patient [1]

Every women with trauma in emergency department should be considered pregnant until the opposite is proved. There is no survival of the fetus without survival of the mother. So, mother life should have precedence over the fetus life. In cases of trauma in third trimester of pregnancy and the mother is at high risk of death because of poor prognosis is recommended to do Cesarean section to let the baby birth. We should not hesitate for diagnostic imaging tests in major traumas.

Imaging evaluation

The use of imaging studies to evaluate for specific maternal injuries has several important benefits. First, avoiding non-obstetrical laparotomy is beneficial, given that non-obstetrical laparotomy

alone results in a 26% incidence of preterm labor in the second trimester and an 82% incidence of preterm labor in the third trimester [22,23]. Thus, using imaging studies to exclude injuries or to detect injuries that can be managed non-operatively is beneficial. Furthermore, early diagnosis of maternal injuries is paramount because shock, a poor outcome for both the mother and fetus, with fetal death rates approaching 80% [23]. The use of imaging studies allows the clinical team to be aggressive and proactive in addressing injuries to avoid the consequences of delayed treatment. In major trauma, the pregnant trauma patient is imaged with radiography, CT and angiography as necessary. Imaging begins with portable radiography of the chest and, when clinically indicated, the pelvis. Focused abdominal sonography for trauma (FAST) is performed in the trauma bay to identify free intraperitoneal fluid and pericardial fluid. Ultrasound also enables determination of gestational age, fetal heart rate, amniotic fluid volume and placental position. Unfortunately, although free of ionizing radiation, ultrasound is of limited utility in detecting maternal injuries, including active arterial bleeding. Radiography, CT and angiography produce ionizing radiation. Radiation risk using diagnostic imaging that produce ionizing radiation in pregnant trauma patients is low especially in severe traumas compared with the risk of underdiagnosed or missed injuries. CT is the proven modality for the evaluation of trauma patients and remains the test of choice for injured pregnant patients. However, efforts are made to eliminate unnecessary scans, reduce overlap of body sections and avoid multiple passes where possible. It is important to generate a diagnostic test, and for that reason extreme low-dose protocols are not used. Finally, if surgery is required, imaging studies can be used to guide the surgical technique and to ensure that all known injuries are addressed as efficiently as possible.

X-ray

The "workhorse" modalities for the imaging evaluation of pregnant trauma patients are conventional radiography and CT. As described in the 2008 American College of Radiology practice guidelines for imaging pregnant or potentially pregnant patients and supported by the American College of Obstetricians and Gynecologists and the National Council on Radiation Protection and Measurements, fetal radiation doses of less than 50 mGy are not associated with increased fetal anomalies or fetal loss throughout pregnancy [24-26]. This concept is important because the radiation doses of essentially all diagnostic imaging examinations using ionizing radiation that would be used in a trauma evaluation should be well below this threshold.

X ray examinations in this category of trauma patients might be one initial modality for vertebral spine, for chest and other articulations. We should consider pregnancy related changes in interpretation of chest X-rays. Changes of pulmonary vasculature which is cephalized, a bit widened of mediastinum, cardiomegaly. Similar changes we might expect also in radiographs of pelvis with widening of pubic symphysis or sacroiliac joints. Because of radiation risk exposure we shouldn't withheld X-ray examination studies. There are so many factors included in radiation risk of fetus like the specific exam study, techniques used, shielding of patient or not and gestational age. The risk of radiation is higher in greater doses and in earlier gestational age. In general, the moment of greater sensitivity of fetus from exposure is the organogenesis which corresponds from 2 to 7 weeks. But in this period of pregnancy unfortunately patients can't suspect. So is important not only asking patients in radiology department if they are or not pregnant but also when has been the first day of last period. Now is accepted that radiation doses lower than 1 cGy (rad) has lower risks. Doses of 15 cGy, has a 15% chance of microcephaly, a 3% chance of cancer in a 3% chance of childhood cancer and a 6% chance of mental retardation [28]. One pelvis radiograph has a risk of fetal expose a fetus at about 1 cGy. X rays of chest and cervical spine has lower exposure risks even more if uterus is covered. In 20 weeks' of gestation one more, radiation risk is much lower for fetal anomalies and if cumulative dose exposure is less than 10 cGy [29].

In summary we can say that x ray can evidence fractures and luxation's, free peritoneal air, foreign bodies, pneumothorax and hemothorax, diaphragmatic rupture. Required x ray may be done in every period of pregnancy with monitoring the fetal dose radiation.

US and FAST

Ultrasound is the first imaging modality choice in stable pregnant patient according to American College of Radiology.

FAST (focused abdominal sonogram in trauma) is shown to have high sensitivity in identifying peritoneal fluid [30-33]. For stable trauma patient, beside FAST an obstetric ultrasound evaluation is necessary and recommended in emergency departments without delay. FAST exam is becoming routine at many trauma centers in recent years. FAST is done not only by radiologists but widely used with high sensitivity in identifying free fluid intrapleural, intraperitoneal or pericardial by emergency or trauma surgeons with minimal training. [31,32]. Using FAST in polytrauma pregnant patients has to many advantages. Overall, it has no radiation exposure because in the base of its function is ultrasound and can quickly assess fetal condition and morphology in a little while. The gestational age is evaluated approximately and the heart rate. By ultrasound we can look for amniotic fluid which lead us to be worried or not for rupture of membranes. Also respiratory activity, fetal move-

ments and one of fetus can be assessed by ultrasound. While some authors have reported widely ranging sensitivities and accuracy for the detection of free intraperitoneal fluid via US in the setting of trauma, with some values reported over 90%, others have noted that small amounts of free intraperitoneal fluid (< 400 mL) are much more difficult to detect [34-36]. Placental abruption which is potentially fatal can be identifiable by using ultrasound, but should be aware that ultrasound alone can't ruled out it. Identification of retroplacental clot or subchorionic hemorrhage may help in early diagnosis.

Computed tomography

Computed tomography (CT) is used frequently in trauma patients for evaluation head, abdomen and chest. Depending on what type of CT scan is used and on techniques varies and the radiation doses. New CT scan machines compared with older ones produces lower dose rates of radiation but still significant for fetus. For example one abdominal CT scan exposures the fetus with radiation doses from 5 - 10 cGy. Meanwhile the CT of chest and head are safer compare with abdominal CT, with minor exposures especially when the uterus is protected with shielding. We should avoid abdominal CT in early pregnancy; using by these times other diagnostic imaging modalities like ultrasound or MRI where they are effective. And CT itself, has lower sensitivity for intrauterine injuries and retroperitoneal injuries. For emergencies in chest and head because there are no alternative modalities CT is indicated, because is proved that the radiation is low. Radiation doses are different in different types of machines and vary by the technique of study. It is important to generate a diagnostic test, and for that reason extreme low-dose protocols are not used. At Harborview Medical Center, diagnostic abdominopelvic CT is performed in the portal venous phase after a 70-second delay. Delayed scans at 5 - 10 minutes are performed selectively to evaluate for collecting system rupture in the setting of renal trauma or to evaluate for active bleeding into hematomas when the diagnosis is in doubt on the initial scan. Delayed scans are focused on the area of interest and are performed with a lower dose than the initial scan. CT scans of the spine and bony pelvis are reconstructed from the original dataset. The decision to perform abdominopelvic CT in a pregnant trauma patient to diagnose serious abdominal injury typically encountered in high energy trauma, such as motor vehicle crashes, is at the discretion of the treating physician. IV iodinated CT contrast material is a Food and Drug Administration (FDA) category B agent with no known adverse effects to the pregnancy and is administered as necessary [37,38]. Specifically, it does not alter neonatal thyroid function [39,40].

CT can cover to many body parts in a short time and can evaluate uterine rupture, placental disruption, placental ischemia and for all maternal injuries.

Radiation risk to fetus

There are a lot of researches about of potential effects of radiation and has accumulated a lot of knowledge even though uncertainties exist. The purpose of looking for risks of radiation from examinations is to build a database which will serve as reference in what kind of radiological examination to choose in different clinical conditions facing pregnant patients in emergency room with trauma or other emergencies. These is done weighting potential benefits for the fetus and mother against ionizing radiation. Studies have summarized potential effects of radiation depending on age of fetus and cumulative dose of radiation [41,42].

The threshold below which teratogenesis does not occur is not known but is thought to be between 50 and 150 mGy. Although the fetal radiation dose for CT examinations almost always falls below the threshold of 50 mGy, it is important to minimize the radiation dose in pregnant trauma patients, particularly given the small but increased risk of carcinogenesis and the high likelihood of the need for additional imaging. CT scans should be modified to use the lowest dose possible, which includes reducing the tube potential (kilovolt peak) and tube current-time product (milliampere-second), increasing the pitch, and decreasing the z-axis coverage.

Type of CT Examination	Dose (mGy)	CT Protocol		Imaging Parameters	
		Slice thickness mm	Noise Index	Tube Current-Pitch Time	Pitch Product (mAs)
CT of the chest	0.02	2.5	30	80	1.375
CT pulmonary angiography	0.02	1.25	30	88	0.984
CT of the abdomen	1.3	2.5	36	110	1.375
CT of the kidney, ureter, and bladder	11	2.5	36	110	1.375
CT of the pelvis	13	2.5	36	130	1.375
CT of the abdomen and pelvis	13	2.5	36	130	1.375
CT angiography	13	2.5	30	130	1.375

Table 2: Estimated average fetal radiation doses from a single acquisition with a 64-row multidetector volume CT scanner [24-26,28].

Magnetic resonance imaging

Given long examination times and the need to remove the patient from the acute care setting, magnetic resonance (MR) imaging is typically not used in the initial evaluation of pregnant patients involved in trauma. After the initial evaluation, MR imaging can be an excellent choice in specific situations, including spinal, complex neurologic, and soft-tissue injuries. MR imaging may also have a role in reducing radiation exposure in patients who require follow-up imaging of injuries diagnosed at initial presentation, or in stable patients who develop new pain or concerning symptoms after an initially negative evaluation.

In the most recent American College of Radiology white paper for safe MR practices published in 2013 [43], the use of MR imaging was deemed acceptable at any stage of pregnancy if the risk-benefit ratio to the patient warrants that the study be performed and if the required information cannot be obtained with another modality that does not use ionizing radiation. There is no evidence of harmful effects to the fetus as a result of MR imaging. MR imaging protocols for pregnant patients should be tailored to include the minimum number of sequences required to answer the particular clinical question. Gadolinium is considered a pregnancy category C drug by the FDA, which means that animal studies have shown adverse effects but adequate data are not available in humans, and the potential benefits may warrant its use in pregnant women if it is considered critical for evaluation. Typically, the use of gadolinium-based contrast material is not necessary in pregnant trauma patients because essential clinical information can be obtained with nonenhanced MR imaging.

When we can't perform other forms of non-ionizing modalities of diagnostic imaging in a pregnant patient or when these modalities aren't capable of diagnostic accuracy we might perform MRI. Even though until now there aren't data for possible side effects we should inform the pregnant patient [44,45].

Conclusion

Trauma is one of the causes of non-obstetrical of mother fatality and a significant cause of fetal loss. Both major and minor trauma result in an increased risk of fetal loss. Whenever we can and if clinical conditions allow in one acute pregnant patient we must use examinations that don't use ionizing radiation.US is the preferred one and the first to choose and MR imaging as the second line but no other examination should be avoided in important clinical conditions. Exposure to ionizing radiation may be unavoidable, but there is no evidence to suggest that the risk to the fetus after a single imaging study and an interventional procedure is significant. All efforts should be made to minimize the exposure, with consideration of the risk versus benefit for a given clinical scenario. In major trauma, when there is concern for maternal injury, CT is the mainstay of imaging.

In a pregnant patient asking for ionizing radiation examinations especially in trauma the risks of radiation is low compared with the risk of delayed diagnosis or missing them. In minor trauma, when there is no concern for maternal injury but there is concern about the pregnancy, ultrasound is performed but is insensitive in diagnosing placental abruption.

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