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IMAGING OF TRAUMATIC AND NON-TRAUMATIC EMERGENCIES – ONE APPROACH*

S.M. Goldman, L.K. Wagner[1]

Selection and design of the most appropriate imaging studies during an emergency involving pregnant and/or potentially pregnant female has been the topic of numerous recent articles. While radiation dose must be limited to the necessary amount, a cautious application must never be so severe as to compromise the ability to make the correct diagnosis. No one approach suits all facilities or all circumstances. All approaches need to be institution specific, and may be country or continent dependent. In this article we review our approach to this scenario.

Key-words: Pregnancy, irradiation in – Trauma.

The fear of radiation in the human population is deep seated and dates back at least as far as the start of the nuclear arms race. It was even present shortly after the discovery of Roentgen's mysterious X-rays (1). In medicine, the goal is to use radiation wisely and in limited quantities while not permitting unwarranted fear to compromise medical need. The benefits of any study must appropriately exceed the risks and application of diagnostic radiation and must not be so attenuated as to constrain one's ability to obtain diagnostic information. On the other hand, numerous papers have been published by radiologists and physicists, in the recent few years that have advocated legitimate ways of decreasing patient exposure (2-7).

Other articles focus primarily on risks by applying risk factors to large populations with only casual reference to the benefits that that radiation represents to the population (8). In 2009 a US government appointed commission recommended a significant decrease in the number of mammograms performed in the female population, contrary to evidence that suggests that the present recommendations are working to reduce breast cancer mortality (9). This was preceded by a report from the NCRP that medical radiation exposure has increased by a factor of about 6 since 1980 (10); primarily due to increases in the use of CT and cardiological nuclear medicine. While useful information, the media focused on this as a negative change rather than addressing the issues of the benefits that this brought in terms of better management of heart disease or better cancer diagnosis or improved surgical management of patients, etc.

In this article we review our approach to imaging pregnant females in emergency situations. Our management plan is divided into Traumatic and Non-traumatic emergencies.

Relative basic science

The effects of radiation on human concepti are based on extensive animal studies as well as exposures of the Japanese population to atomic bomb radiation, individuals who had therapeutic radiation for varying forms of pelvic cancer in the female population, radiation accidents from situations like Chernobyl, radiation from pelvimetry, a wide range of diagnostic imaging doses in various situations worldwide, etc. (11).

Radiation effects are typically categorized into two types: deterministic and stochastic. Deterministic effects are caused by an accumulation of radiation damage and a minimum level of radiation absorbed dose is required before these types of effects can occur. Once radiation absorbed dose exceeds the required threshold, the likelihood of the event occurring increases with additional dose as does the potential severity of the effect. Radiation-induced malformation in a developing conceptus is a deterministic effect. Stochastic effects can be caused by subcellular changes in a single cell. For example, changes in a critical macromolecular structure caused by a collision with an ionizing particle might convert a normal cell into a cancerous cell. These changes in cells occur as a result of random damage within the cell. Theoretically, any level of radiation exposure might result in such a critical change, but the likelihood is extremely small. Most such subcellular damage is corrected without consequence by cellular repair mechanisms. Accumulation of more exposure increases the number of random events, resulting in an increased likelihood of converting a normal cell into a neoplastic tissue. For these effects, the only protection is to keep exposure to radiation as low as reasonably possible.

Benefits versus risks in imaging the pregnant patient

Table I lists estimates of effective doses for various radiological examinations along with the comparable time required to accumulate a similar amount of background radiation exposure (adapted from RSNA/ACR website). Risk estimates are also available in other articles (12-14).

Radiation exposure to the conceptus of a pregnant individual should be divided into two groups: radiation exposure outside the abdomen and radiation exposure that directly exposes the abdomen. Radiation outside the mother's abdomen, which is of little concern to the management of the conceptus, and can be generally performed without concern in most cases. On the other hand, direct exposure to the abdomen must be seriously evaluated by the requesting physician, and especially by the participating radiologist as to its magnitude and necessity.

Abdominal CT especially has potential to expose the conceptus to significant amounts of radiation. First consideration for diagnostic imaging workup must be given to modalities that use no ionizing radiation or that use only low dose radiation. However, in time-critical situations these should not be used when this will lead to a sacrifice of diagnostic accuracy. When higher

From: 1. Department of Radiology, The University of Texas-Houston Medical School.
Address for correspondence: Pr S.M. Goldman, Department of Radiology, The University of Texas-Houston Medical School, Houston, USA.
E-mail: Catherine.M.Yarborough@uth.tmc.edu
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Table I. — Effective doses for radiological examinations.

For this procedure	Your effective radiation dose is*:	Comparable to natural background radiation for:
Abdominal region:		
Computed Tomography (CT) – Abdomen and Pelvis	10 mSV	3 years
Computed Tomography (CT) – Body	10 mSv	3 years
Computed Tomography (CT) – Colonography	10 mSv	3 years
Intravenous Pyelogram (IVP)	3 mSv	1 year
Radiography – Lower GI Tract	8 mSv	3 years
Radiography- Upper GI Tract	6 mSv	2 years
Bone:		
Radiography – Spine	1.5 mSv	6 months
Radiography – Extremity	0.001 mSv	Less than 1 day
Central Nervous System:		
Computed Tomography (CT) – Head	2 mSv	8 months
Computed Tomography (CT) – Spine	6 mSv	2 years
Myelography	4 mSv	16 months
Computed Tomography (CT) – Chest	7 mSv	2 years
Computed Tomography (CT) – Chest Low Dose	1 to 3 mSv	4 months to 1 year
Radiography – Chest	0.1 mSv	10 days
Children's Imaging		
Voiding Cystourethrogram	5-10 yr. old: 1.6 mSv Infant: 0.8 mSv	6 months 3 months
Face and neck:		
Computed Tomography (CT) – Sinuses	0.6 mSv	2 months
Heart:		
Cardiac CT for Calcium Scoring	3 mSv	1 year
Men's Imaging:		
Bone Densitometry (DEXA)	0.001 mSv	Less than 1 day
Women's Imaging:		
Bone Densitometry (DEXA)	0.001 mSv	Less than 1 day
Galactography	0.7 mSv	3 months
Hysterosalpingography	1 mSv	4 months
Mammography	0.7 mSv	3 months

*All CT dose estimates are for single phase studies only.

dose ionizing radiation examinations are needed, consideration should be given to having pre-determined modification to the regular study in order to reduce radiation dose to the conceptus. For example, only single phase studies of the abdomen are advised. Multi-phase CT should almost invariably be avoided. If absolutely necessary, one of the phases should be performed at much reduced technique.

Use of Gadolinium (Gd) for MRI is generally discouraged, even in a patient with a normal keratinize and renal function. Gd crosses the placenta and a small amount enters the maternal milk. Although Gd has not been approved in the US, the Contrast Media Safety Committee of the European Society of Uroradiology (ESUR) has not documented any ill effects from its use (15).

In considering benefit/risk for the patient, the timing of the examination with the gestation age is an important factor. The International Commission On Radiological Protection (ICRP) states, "During the first ten days following the onset of a menstrual period; there can be no risk to any conceptus, since no conception has occurred. The risk to a child who has previously been radiated in utero during the remainder of a 4 week period following the onset of menstruation, is likely to be so small that there need be no special limitation on exposures within this period" (16). The most critical period occurs during the second through fifteenth weeks postconception when detriment to the development of organ systems is a risk. Dose limitations are especially critical so that threshold doses for deterministic effects are not approached. Multiple higher dose examinations, such as multiple-phase or multiple single-phase CT studies are usually necessary before these thresholds are approached. The critical threshold is typically quoted as 100 mGy to the conceptus, but doses between 50 and 100 mGy may result in subtle but clearly undesirable effects. Such doses can be reached after 2-3 single-phase CT studies, for example. Doses less that 50 mGy in this period have not been associated with deterministic effects, but stochastic effects (e.g., induced cancer) are still a concern and so dose limitation remains an important practice during this and later stages of gestation (11).

Trauma in pregnancy

Data resources

This paper is the result of many years of work in the field by both authors. In regard to the trauma section, which will follow, one is referred to (14), which is the com-

bined experience of the University of Texas and the University of Tennessee over a two year period. This data corroborates data from previous studies, and although informally restudied by the authors, the percentages listed under the next section are reasonably accurate, even with the number of emergency room visits in recent years. In regard to non-traumatic emergencies, our experience was derived from reviewing the emergency room trauma registry during a two year period (17). Our impressions since that study are that the percentages of emergencies based on organ systems (liver, brain, etc.) or disease processes (Crohn's, Ulcerative Colitis, PRESS Syndrome, etc.) remain stable.

Nature of the problem

Multiple studies, including our own, have shown that 6-7% of all pregnant females have trauma of some consequence (13). Most of these occur in the 3rd trimester. Part of this reflects the increased instability of the mother due to weight distribution changes and hormonal imbalances that effect coagulation patterns, etc. Most of the injuries (2/3) result from falls related to the above. However, over a 1/3 of the injuries appear to be secondary to spousal or other physical abuse. Trauma is the leading cause of maternal mortality (up to 20% of deaths) (12). In a combined study, 595/275,000 patients seen in the emergency room were pregnant (14). Ninety-two percent were seen after a motor vehicle accident, 25% during the first trimester, 25% in the second trimester, and 50% of the injuries occurred during the 3rd trimester. In our series, 48 (9.1%) had CT examinations of the chest and/or abdomen and pelvis. In regard to the maternal injuries, 19/48 had no maternal injury (40%), 31% (15/48) had non-uterine maternal injuries. Twenty-seven showed combined fetal and maternal injuries. Five mothers died (10.4%) three of which were secondary to brain injuries. The fetal death rate was 33% (11 isolated, 5 due to maternal deaths). Of the fetal deaths, 80% were under 25 weeks, and 20% over 25 weeks. Unfortunately, restraints (e.g., seat belts) of any kind did not appear to change the incidence of outcome. C-sections were performed in 4 of 48, with 3 survivors among the babies (37-39 weeks). The fourth died at 35 weeks from abruptio placenta.

Basic fundamentals of trauma management in pregnancy (12-14)

There is very little chance of fetal survival without maternal survival. Therefore, all initial efforts must be geared to maintaining maternal survival.

As in all traumas, the first hour is the "Golden Hour of Survival".

It is critical to keep the mother alive before the arrival at the hospital. The classic A (airways) B (breathing), C (cardiac) fundamentals need to be maintained and monitored on route. A special practice is to remember that wherever possible, the mother should be kept with her right side up to alleviate any decrease in venous return from the lower torso/legs that may result from compression of the inferior vena cava (IVC) (Fig. 1).

If possible to accomplish without compromising maternal and/or fetal welfare, the patient should be ultimately transferred to a major/medical facility where all the appropriate level of care is available for mother/baby.

During transfer to the major facility, ongoing monitoring should be maintained by the primary response team and should be communicated either verbally or by telecommunication to the accepting hospital. Based on the information, an appropriate group of specialists should be assembled to manage the patient/fetus.

It should be noted that the severity of trauma bears no relationship to fetal outcome. Even minor trauma can result in fetal demise. Therefore, conservative management is the true path of valor. Until it can be absolutely ascertained that there is no further chance of the deterioration of the fetus or the mother, the patient should not be discharged from the accepting hospital. This means, even in a stable patient, fetal monitoring needs to be continued for at least several hours.

Upon arrival at the receiving hospital, immediate evaluation of the mother must be performed to determine if she is stable; and everything necessary to assure stability

Fig. 1. — Pregnant female in motor vehicle accident (MVA). Fetus aborted in transit. On arrival regular imaging could be performed of the pelvis, as no fetus present.
A. Axial CT shows fracture of iliac wing and opening of sacroilliac joint.
B. 3D reconstruction performed for possible surgical intervention.

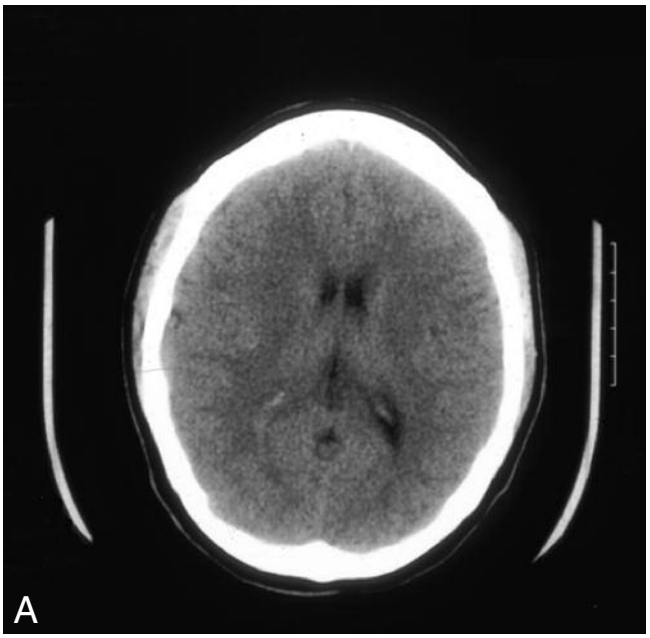


Fig. 2. — 21 yr. old pregnant female (fetus 6 weeks old) in MVA.

A. CT of the head shows evidence of an intraventricular bleed. Note filing with blood of the posterior horn of the ventricle. Mother stable post CT.

B. Uterine U/S shows fetus to be viable on a color Doppler and on wave form images.

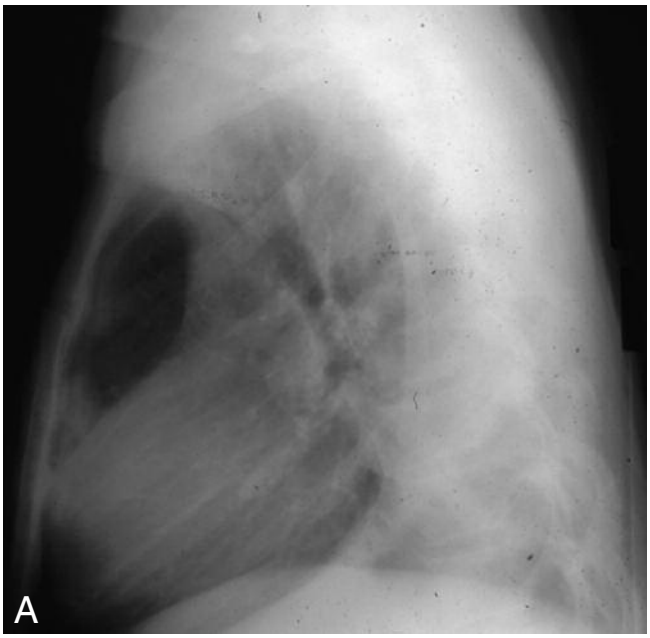


Fig. 3. — 33 yr. old female (fetus 26 weeks) was stable in MVA, but aspirated. Frontal (A) and bilateral (B) views of chest showed LLL collapse. One day later patient went into premature labor. As stated, there is no relationship of the degree of injury to fetal outcome.

must be instituted immediately, if stability cannot be maintained, the patient should be immediately taken to the operating room, etc.

Once the mother is stable, an ultrasound evaluation of the fetus is indicated. Evidence of fetal distress, i.e. bradycardia, tachycardia, etc., requires immediate surgical intervention to save the fetus.

Based on the clinical situation, appropriate necessary imaging should be obtained to expedite management as efficiently as possible with appropriate, but necessary radiation used. In this regard, any interventional procedure should be performed by an appropriate level senior staff to exclude unnecessary radiation exposure (Fig. 2).

The types of injuries to the chest, extremities, head and neck are generally no different than those seen in non-pregnant patients. For example, intrathoracic injuries include: rib fractures, pneumothorases, hydro-hemothorases, lung contusions, lung collapse, complete bronchial tear, etc. (Fig. 3). Similarly, the etiology of neurological injuries include; skull fractures, subdural & epidural bleeds, intracerebral bleeds, intraventricular bleeds, intra & extra cord injuries, vertebral injuries, etc. (Fig. 4).

The situation is much more serious in regard to abdominal injuries since the enlarged uterus is present. As the uterus expands, the pelvic structures are displaced from the abdominal pelvis into the upper abdomen. Thus, these structures are much more vulnerable to injury dur-

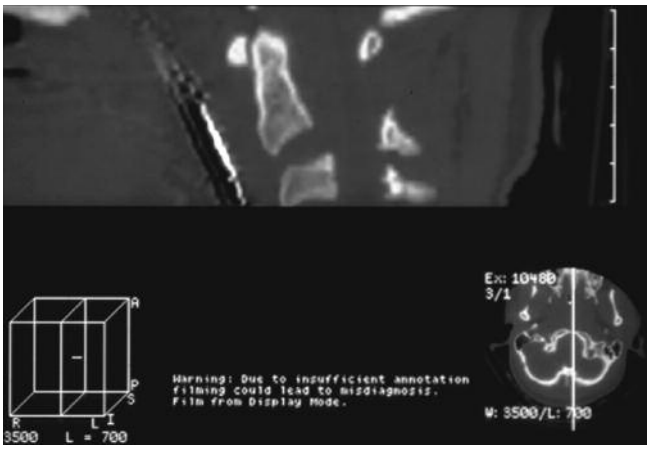
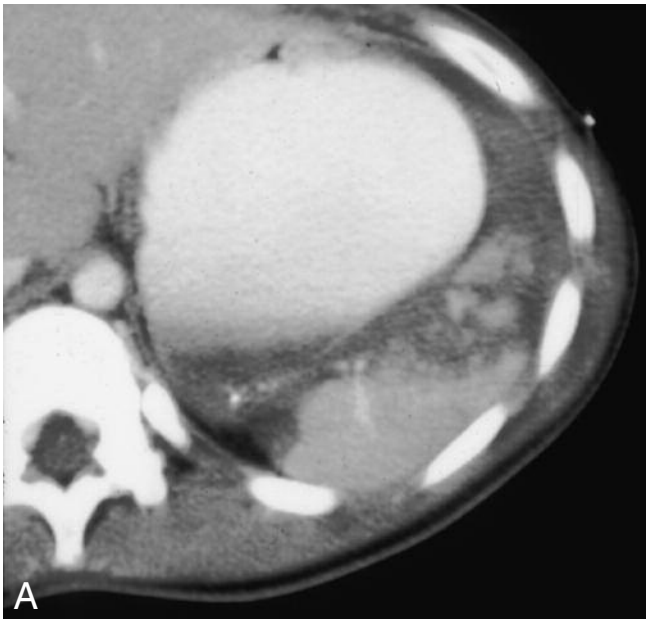


Fig. 4. — 17 yr. old pregnant female (12 week fetus) in MVA. CT of neck performed as abdomen unremarkable. Study showed anterolisthesis and tilt at C2. Fetus died within 24 hours of study.



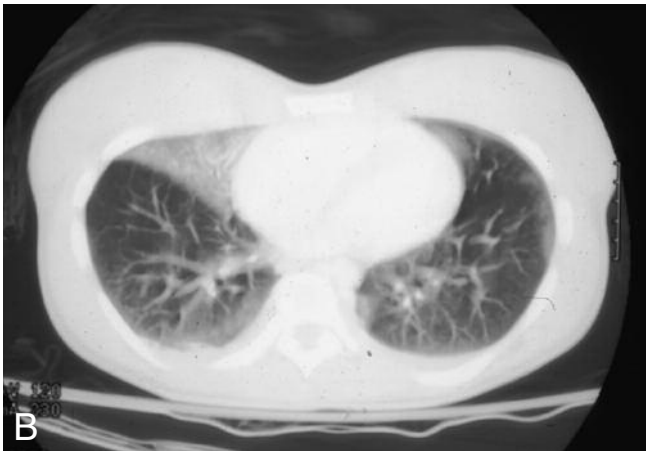


Fig. 5. — 20 yrs. old pregnant female (17 week fetus) in MVA. Among the findings in this case:
A. Multiple splenic tears
B. Collapse of a portion of the left lung.

ing later pregnancy than during the first trimester. Similarly, injuries to the spleen and liver also increase because of the increased abdominal pressure as the uterus expands.

In regard to injuries outside the pelvis, all necessary imaging techniques can be used in general, without particular fear of the radiation effects to the conceptus. In a later section, we discuss exposure of the female breasts to radiation.

In regard to the abdomen, ultrasound should be used first. MRI without Gd, would be ideally the second choice. However, many radiologists are not familiar with the MRI imaging characteristics of trauma in pregnancy, it usually requires obtaining the services of a MRI trained technologist at night from home, the time involved is still significantly increased compared to CT even with the faster scanning techniques and monitoring of an extremely ill patient is difficult, if not impossible, because many of the monitors are metallic. In our practice, a single pass CT is often done (Fig. 5, 6). In fact, where there is any question, a special trauma protocol of the entire patient is often necessary, especially in the non-communicative patient. This is also our approach in the multi-trauma patient.

Imaging of non-traumatic emergencies in pregnancy

Neurological emergencies

One of the most common and serious emergent conditions is bleeding from intracerebral aneurysms (12/21). This occurs because of fluid overload, the increased elasticity of the blood vessels and the effect of hormones on clotting factors. The diagnosis can readily be made by a contrast CT. Therapeutic intervention with coils should be doable when performed by an experienced interventional neuroradiologist (17). In recent years a whole host of peripartum neurologic disorders have been identified on MRI. These include: posterior reversible edema syndrome (PRESS), Eclamptic Encephalopathy, Postpartum Cerebral Angiography (PCA), Cerebral Brain Thrombosis (CVT) Pituitary Apoplexy, Sheehan Syndrome, Lymphocytic Adenophypophysitis, a variety of neoplastic disorders, etc. An excellent review appeared in RadioGraphics (18). These latter entities are best diagnosed by MRI. Please again note that Gd has not been approved for pregnant patients in the US, although up to the present, no harmful effects of Gd have been reported (15).

Chest abnormalities

Pneumonias are probably the most common chest emergency of pregnancy. This relates to the abnormalities in hormones, immune-antibodies, etc. Abdominal shielding is a necessity, we recommend a single

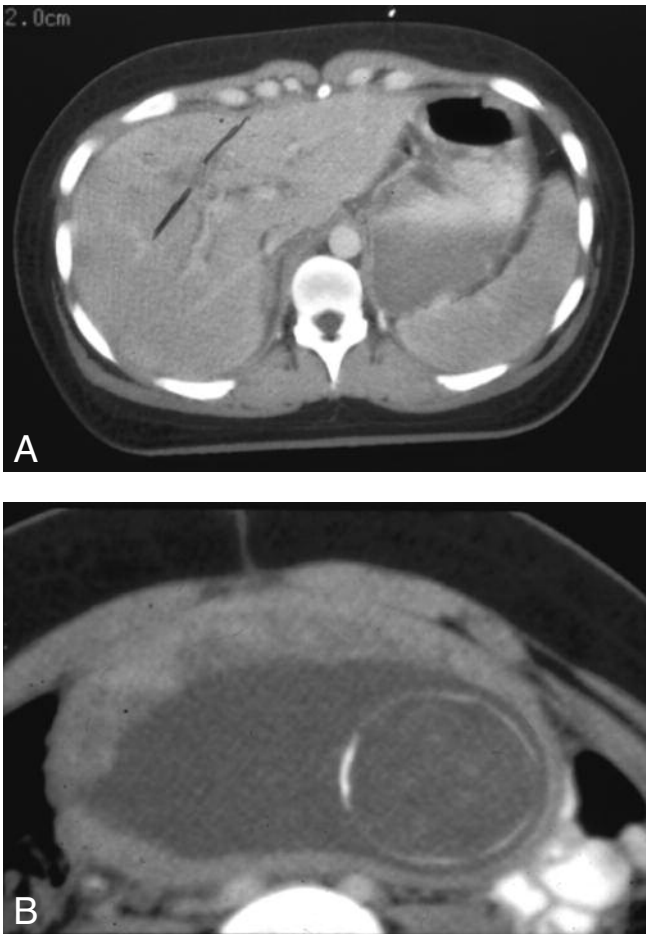


Fig. 6. — 24 yrs. old pregnant female in MVA.
A. Minor liver laceration
B. Image of fetus shows poor contrast uptake of placenta. This is a poor sign for fetal viability. Fetus was ultimately aborted.

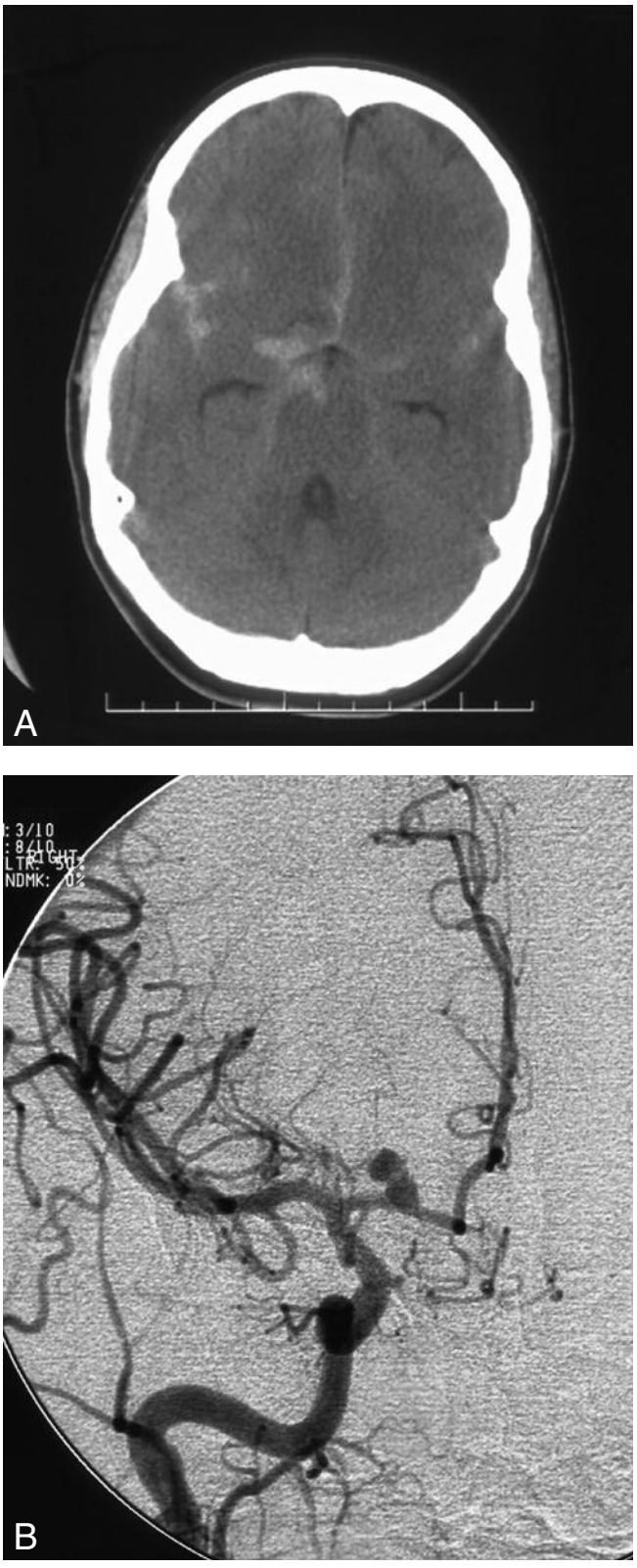


Fig. 7. — Anterior cerebral artery aneurysm bleed in 27 yr. old pregnant female with twins.
A. CT shows blood in ventricles and around frontal lobes.
B. Carotid angiogram reveals anterior cerebral aneurysm, which was successfully occluded initially. Patient was only to rebleed one week later and become decerebrate. Mother was kept artificially alive. The twins were delivered by C-section after being felt mature enough.

frontal projection first, and then making a decision about the necessity of taking a lateral chest.

It is claimed that pulmonary emboli occur in pregnancy in a frequency of .07 - .09/1000 (1/2000 deliveries) (17). Exactly where this number comes from is unknown to the authors. PE results from the hyper-coaguable state, increased venous stasis, 50% increase in plasma volume, etc. Controversy exists as to the best and safest method of diagnosis. The advocates of the use of Tc nuclear medicine scans claim less radiation exposure and cite the problem with false positive CT scans. There are clearly institutions that have had great success using nuclear medicine. However, we are among the advocates of the use of CTA for pulmonary embolus. In our initial research (13), we could find only one positive lung scan identifi-

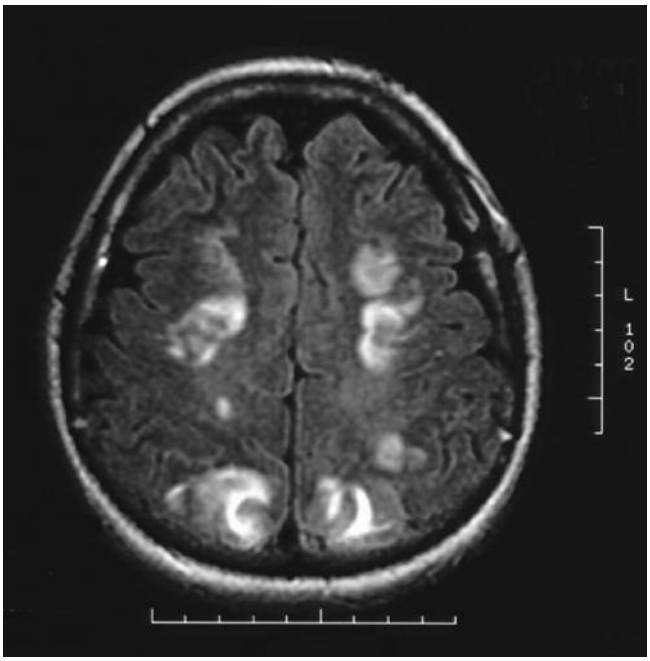


Fig. 8. — Classic case of Posterior Reversible Edema Syndrome on MRI (PRESS).

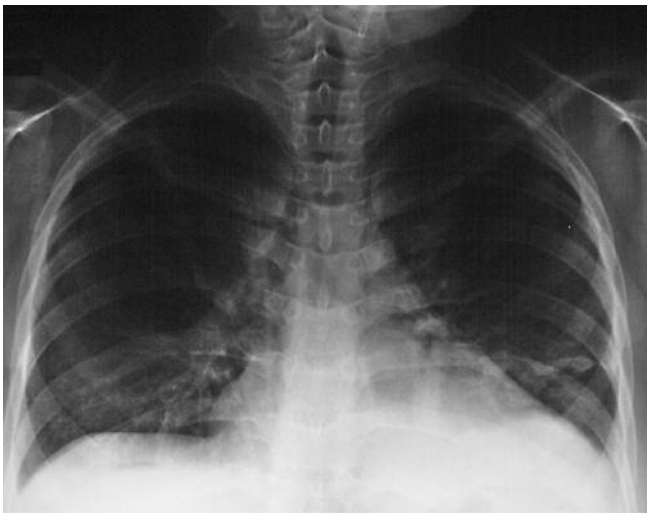


Fig. 9. — Cardiomyopathy of pregnancy diagnosed on chest X-ray in the peripartum period. Patient ultimately recovered.

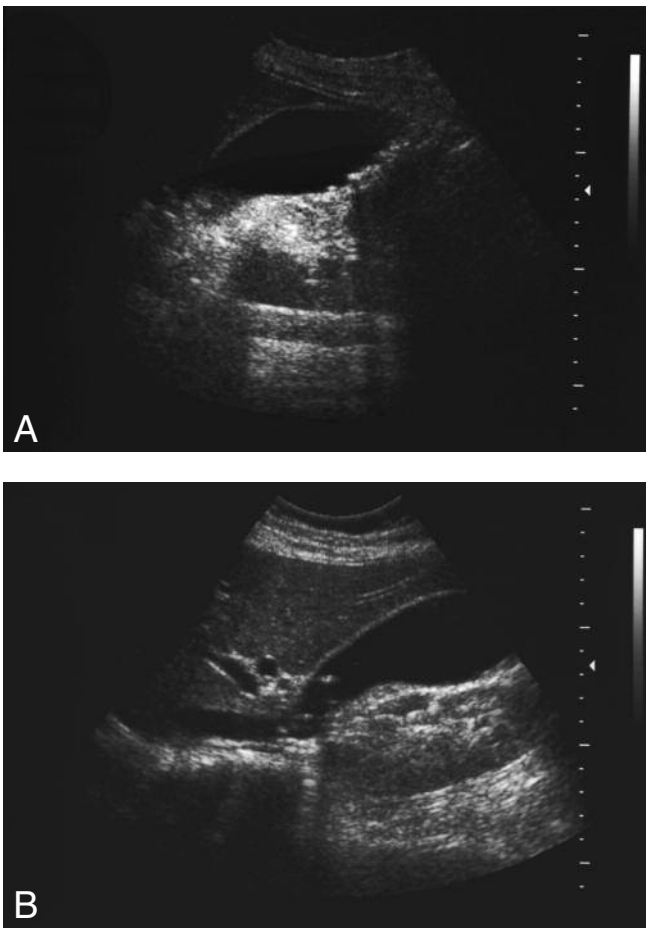


Fig. 10. — Gallstones in pregnancy diagnosed on US:
A. Gallstones seen lying along the posterior, dorsal wall of the gallbladder.
B. Study shows several of the stones in the orifice.

able in any of the major medical institutions in Houston, and calls to several well-known university hospitals outside Houston revealed similar results. Our experience in our affiliated institutions both during the study and to the present has been far from successful in obtaining high positivity on nuclear studies. The radiation dose to the lungs in a single pass CT is more than acceptable and will no doubt decrease in the future. One should be sure that the radiation exposure should not be decreased as to lose diagnostic accuracy and require yet another examination.

There is a concern about the radiation dose to the female breast from CT. Some have recommended the use of radiation absorbing breast shields to be used on female patients. However, technologists must be trained on their use for each machine. The shields must be placed after the positioning radiographic acquisition on some scanners. In effect, they are an attempt to reduce dose by bypassing the scanners' normal operation. We recommend that faculties look into modifying their protocols to reduce the mAs per rotation by about 10%-20% and apply this to all patients, male and female. This will result in a more efficient method of risk reduction, it will protect the lungs and marrow of both sexes as well as the female breasts, and it will apply to all patients, resulting in a greater overall benefit to the patient population (19, 20, and 21).

Another serious chest emergency is the cardiomyopathy of pregnancy; or better described as the peripartum cardiomyopathy (17). This entity develops in the last trimester or even in the month postpartum. It is unclear as to whether the cause is an active myocarditis. Except for the chest x-ray, the diagnosis is made by the responsible clinicians using clinical and laboratory testing. This may include an echocardiogram. Fifty

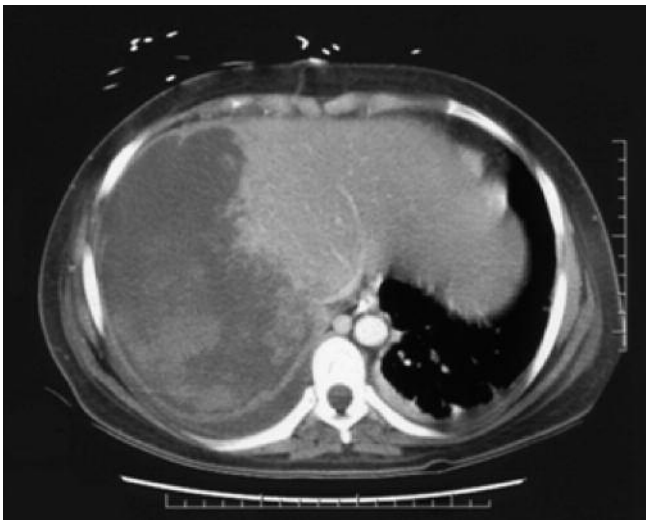


Fig. 11. — Hemolytic Anemia Elevated Liver Function and Low Platelets (HELLP) syndrome in 23 year old pregnant female on contrast enhanced CT. Note extensive necrosis of the (R) lobe of the liver.

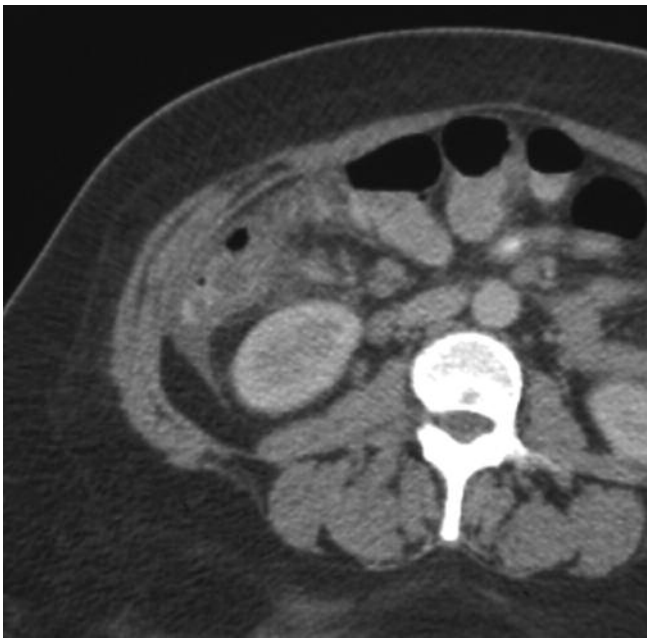


Fig. 12. — CT of a perforated appendix in a 33 yr. old pregnant female who developed RUQ pain with nausea and vomiting one week post partum. U.S. of RUQ showed gallstones. Pain shifted during the subsequent week with development of RLQ pain. A ruptured appendicitis was identified extending laterally and superiorly over the (R) kidney.

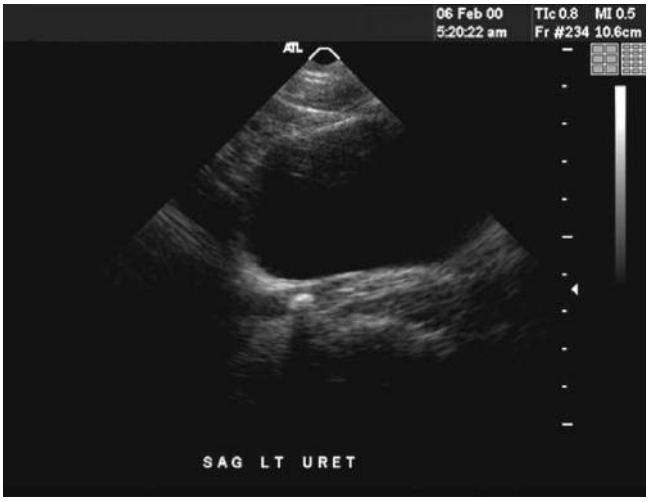


Fig. 13. — A UVJ stone shown 45 in a sagittal view of (L) ureter with classic shadowing on U/S. There was no jet in this case.

percent recover and 50% have a recurrence if they become subsequently pregnant (12).

Abdominal emergencies

Right upper quadrant emergencies

a. Gallbladder emergencies (.08 %).

These constitute the 2nd most common abdominal emergencies in pregnancy. U/S, of course, is the study of choice (17). MRI may be of value in select cases in evaluating the biliary collecting system, and sometimes Tc-HIDA. It is more common in pregnancy than other times, and reflects decreasing emptying, increased smooth muscle relaxation, the relaxant effect of progesterone, increased esterified and free blood cholesterol, decreased bile salt pool, etc. (12).

b. Pancreatitis

This is the 3rd most common cause of right upper quadrant emergencies (1/1000 – 1/1100) (17). Most often this occurs secondary to cholecystitis. Morbidity and mortality is higher in these patients. Other causes include tetracycline, pre-eclampsia, fatty liver and infection. Gray scan U/S usually will suffice; however, in the situation where complications of pancreatitis develop, MRI and/or enhanced CT may be necessary. In the latter however, again a single pass in the appropriate phase should be obtained.

c. Hemolytic Anemia Elevated Liver Function and Low Platelets syndrome (HELLP).

This most serious acute emergency in pregnancy is often associated with infection. Although one case has been reported as successfully evaluated using nuclear medicine, MRI or CT will best demonstrate the extensive hepatic necrosis (22).

d. Appendicitis (007 - .18%)

Appendicitis is the most common acute abdominal emergency in pregnancy (17). For diagnostic purposes, we use U/S first. However, especially in the middle and last trimester, the appendix is displaced from its normal position in the Rt. Lower quadrant superiorly, and is often very difficult to identify. Therefore,

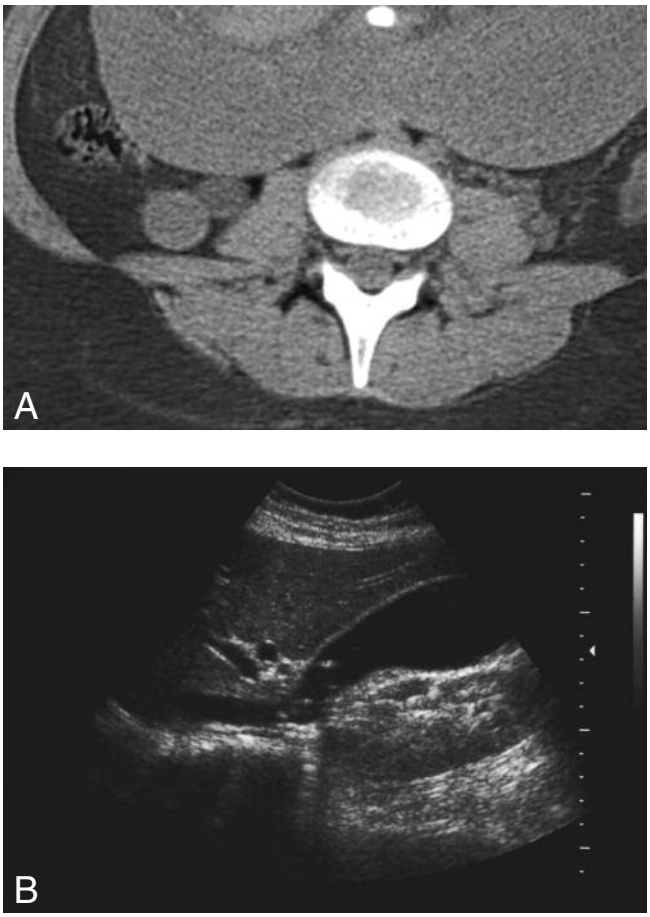


Fig. 14. — Two CT cases being performed to evaluate for a ureteral stone.

A. Case 1 shows a dilated ureter behind the enlarged uterus. The (R) ureteral stone had passed.

B. A (R) ureteral stones is clearly seen at the right UVJ at the trigone.

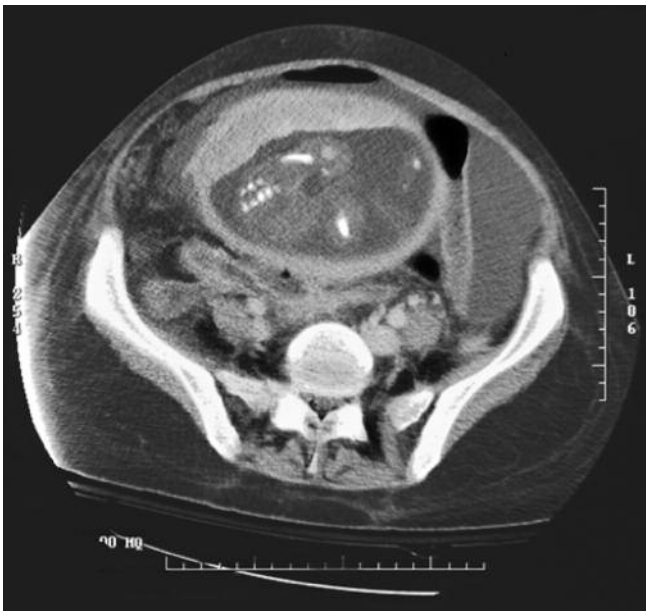


Fig. 15. — 32 yr. old pregnant Crohn's patient seen for severe pain at an outside hospital 50 miles away. Emergency CT with oral contrast shows free air above the uterus and fluid tracking (L) abdominal gutter. The bowel loops to the (L) and also behind the uterus are thickened. After surgery, a perforated ileum was found and resected.

our personal results with U/S have been less than satisfactory. MRI, ideally, is the next technique of choice (23, 24, and 25). However, our experience is that MRI is often unavailable after hours and obtaining an emergency MRI is difficult during the busy daytime schedule. If either US or MRI is unavailable, a CT is appropriate in these emergency situations. This is especially true when the diagnosis is confusing and may not be due to appendicitis. Therefore, in our experience, we have found CT to be a very useful modality in diagnosing appendicitis.

e. Urinary tract pathology

Urinary tract problems in pregnancy consist of the normal hydronephrosis of pregnancy, acute renal calculi, acute pyelonephritis and abscess (17). The diagnosis of pyelonephritis can usually be made clinically. In obscure cases, power Doppler U/S, MRI (24) and contrast enhanced CT are diagnostic. Which is used depends on the clinical situation. These are especially necessary if there is any question of a renal abscess. Nuclear Medicine is very sensitive, but unfortunately, extremely no-specific and, in our experience, not very helpful.

The most common problem clinically is the separation between the normal physiological hydronephrosis of pregnancy and a pregnant female who has a urinary tract stone. We try U/S first. One of the difficulties is that the stone may be obscured by the large fetus and its limbs. If U/S is to be used, it is imperative that the operator look for obstructive stones at the UVJ transvaginally. Without it a negative US study is incomplete. MRI has been advocated, but in our experience, has been less than ideal. We tend to go immediately to a non-contrast CT if the U/S fails; as it readily separates a dilated physiological ureter from an obstructed or non-obstructed ureter with a concurrent stone.

f. Obstetrical and gynecological emergencies

These include independent torsion of the fallopian tube, rupture of torsion of adnexal masses, ectopic pregnancies, degenerating myomas, abruptio placenta (Ref. Wei), uterine rupture, etc. Adnexal torsion occurs in 10-15% of ovarian masses during pregnancies (as high as 60%) and usually occurs in early pregnancy or the peripartum. Two to five percent of masses rupture during pregnancy. In most cases, U/S will be the study used first. MRI certainly can be used as needed (24, 25). CT should be reserved for use when the diagnosis is obscure and when MRI is unavailable as the backup choice.

g. Bowel emergencies

These include development of ulcers, Crohn's disease, ulcerative colitis, toxic megacolon, pseudomembranous colitis, ischemic bowel, etc. Of these, Crohn's disease is a serious threat to both fetus and mother. Although pregnancies have

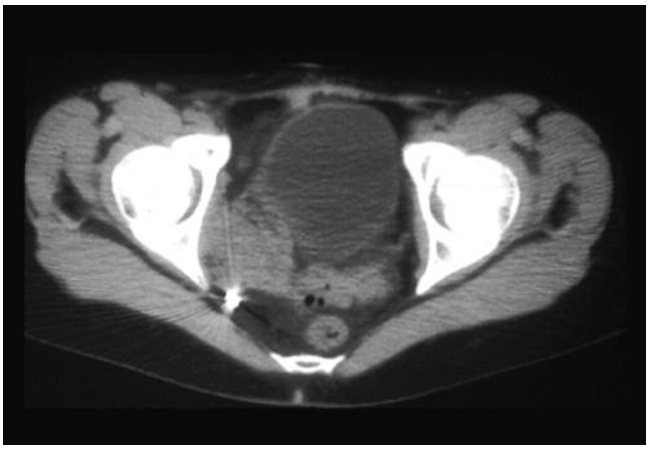


Fig. 16. — A retroperitoneal desmoid was identified in a 28 year old pregnant female on CT. These tend to grow during pregnancy. Patient underwent a successful partial resection.

successfully reached term, exacerbation of the Crohn's itself, is well documented and may lead to bowel perforation and/or fetal demise. The diagnosis of ulcer disease is best made clinically, i.e. via` endoscopy. Ideally, MRI would be the choice of study for any of the GI emergencies in pregnancy (25, 26). Again, CT will be diagnostic when MRI is unavailable or where the comfort zone of the physician using MRI is low.

h. Abdominal tumors

Growing angiomyolipomas, adrenal pheochromocytomas, renal carcinomas, etc. can occur in pregnancy, both symptomatic and asymptomatic. In our experience, some of these lesions are actually picked up on a routine U/S during a normal pregnancy, or on an US performed in the emergency room for other reasons (16). MRI or CT, obviously are often needed in the appropriate diagnosis and staging of these patients and in determining whether termination of the pregnancy should be considered. If one is unsure as to whether the pregnancy should be terminated, then MRI would be the study of choice. However, if MRI is felt to be incapable of staging accurately the tumor that has been found, or if it is clear that the pregnancy will be terminated; and then a CT should be performed. In appropriate situations, a PET scan may in fact be preferable to a CT alone.

Conclusions

This paper presents what we believe is a reasonable approach to the use of radiation in pregnancy. As per international criteria, imaging radiation should be performed when it is the most efficient, logical method of obtaining a diagnosis. In cases where imaging is needed outside the abdomen, it should be performed as required since there is no practical risk to offset the benefit. In the abdomen, more selective imaging should be performed as appropriate. Key to treating trauma patients who are/or may be pregnant is to remember that maternal survival is sin non of fetal survival. Further, there is no correlation between the severity of trauma and fetal survival.

A second major area discussed in this paper is the non-traumatic emergencies. The rationale of our approach to the imaging evaluation for possible pulmonary embolus, cholecystitis, various liver diseases seen in pregnancy, appendicitis, urinary tract infection and stones, adnexal problems, etc. is described.

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