

Low-dose Computed Tomography in a Pregnant Woman with a Ruptured Pseudoaneurysm of the Abdominal Aorta

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ABSTRACT

Imaging the pregnant patient presents a unique challenge to radiologist due to the risk of radiation to the conceptus (embryo/fetus). A rare case of a successfully recognized and treated pseudoaneurysm (PA) of the abdominal aorta is to be presented. The pseudoaneurysm occurred in the third trimester and had a favorable outcome for the mother and the baby. Emergent abdominal ultrasound (US) is the first modality in diagnostic algorithm for the rupture of aortic aneurysm in a pregnant woman. It provides the most rapid diagnostic information, although intestinal gas and abdominal tenderness may limit its accuracy. To confirm the findings, magnetic resonance angiography (MRA) or CT angiography (CTA) can be used. In our case, the diagnosis was established using a color Doppler ultrasonography of the abdomen and was later confirmed by a low dose CT scan of the abdominal aorta. MRA in such cases have some disadvantages. At many health centers, the monitoring of patients with acute ruptures is more difficult in the MR suite than at the CT scanner. MRA angiographic images are also subject to degradation by multiple artifacts and the visualization of the distal vasculature is suboptimal and inferior to the one done by CTA. Due to fetal movements, a small quantity of fresh blood can be overlooked by MR. MRA is often not available on a 24-hours basis, and the time required for making a diagnosis can preclude the use of MRA in an unstable patient. For this reason, we used a low dose CTA protocol to confirm the diagnosis. Low dose scanning protocols in CT can obtain sufficient diagnostic information while reducing the risk of radiation. A particular focus is put on the outline of new concepts for dose management and optimization. We used new approaches based on tube current modulation. The birth was induced by an urgent Caesarean section followed by a resection of a pseudoaneurysm and a reconstruction of the aorta with an end-to-end vascular prosthesis.

Key words: PSAN-pseudoaneurysm, AA-abdominal aorta, low dose protocol, CT-computed tomography, radiation risk, CTA-CT angiography, MRA-magnetic resonance angiography

Introduction

The term pseudoaneurysm (PA) refers to a blood filled cavity located between an artery and the overlying connective tissue which communicates with the arterial lumen¹. PA most commonly results from contained arterial rupture². It is a serious condition in which blood leaks from a damaged artery into the surrounding tissue³. More than a half of all ruptured arterial aneurysms in younger

women are pregnancy-related⁴. Although pregnancy is not associated with an increased incidence of PA formation, it is associated with a higher rate of rupture^{5,6}. Vascular and hemodynamic changes in pregnancy may predispose rupture of previously asymptomatic posttraumatic aneurysm^{7,8}. The increased blood flow, intra-abdominal pressure, and vessel wall changes due to the hormonal and metabolic changes associated with gestation are believed to be contributory. Most ruptures occur late in the preg-

nancy, usually in the third trimester³. Due to the fact that the rupture of abdominal PA (especially during pregnancy) is a life-threatening emergency, urgent diagnostic work-up and prompt treatment are imperative. For hemodynamically unstable patients with a presumed rupture, bed-side emergent US provides the most rapid diagnostic information, although intestinal gas and abdominal tenderness may limit its accuracy. If rupture is not suspected, CT angiography (CTA) or magnetic resonance angiography (MRA) can more precisely map the size and anatomy of PA^{9,10}. Low-dose CT scanning protocols can obtain sufficient diagnostic information with a reduced radiation risk. In most cases, vascular surgery has to be performed immediately or after Cesarean delivery^{11–13}.

In this paper, we present a rare case of successfully recognized and treated abdominal aortic PA with a specific diagnostic approach in a multiparous woman. In this case, a modified low dose CT was performed after the initial color Doppler examination. The approach was chosen for two reasons: Firstly, MRA was not available on a 24-hours basis, and the time required for diagnosis precluded the use of MRA in an unstable patient. Secondly, MRA angiographic images are subject to degradation by multiple artifacts, and visualization of the distal vasculature is suboptimal and inferior to CTA^{14–16}. Our approach was based on tube current modulation, and slice thickness reduction. Reducing tube current and slice thickness successfully reduced the radiation dose in the mother and the fetus. Research indicates that manually reducing the tube current from 160mA (standard tube current) to 30mA can reduce entrance-surface doses depending on the scan length and the protocol used^{12,17}.

Case Report

A 42 year-old female was admitted to a gynecological ward in the 30th week of her sixth pregnancy due to spastic right-loin pain irradiating to the right groin. The patient was subfebrile and normotensive, with the following laboratory results: white blood cells (WBC) $11.1 \times 10^9/L$, red blood cells (RBC) $5 \times 10^9/L$, Hb 101 g/L, Hct 0.30, Tr $200 \times 10^9/L$, CRP 14.3 mg/L; raised levels of alpha-amylase in the urine (AMS-U) 1001 U/L. The course of all previous pregnancies had been normal, with vaginal deliveries within a reasonable time of the due date. An obstetric examination performed when the patient was admitted revealed no abnormalities, with regular CTG. Gynecological US had shown a pregnancy in line with the gestation period, with normal flow inside the fetal blood vessels. Immediate consultations with a surgeon and an internist were requested.

Initial abdominal US showed no gross abnormalities except for a small amount of free liquid adjacent to the lower pole of the right kidney. Two days after the patient's admission, the laboratory signs of acute hemorrhage appeared (Hb decreased to 84 g/L, E to $2.89 \times 10^9/L$), and the CRP increased to 16.4 mg/L. The patient's state deteriorated over the next several days. A follow up abdominal US showed an oval, irregularly-shaped hypoechoic thick-

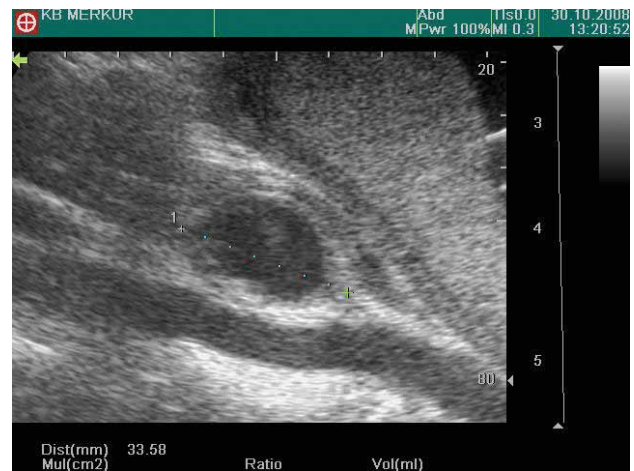


Fig. 1. B-mode US shows hypoechoic thick walled mass adjacent to abdominal aorta.

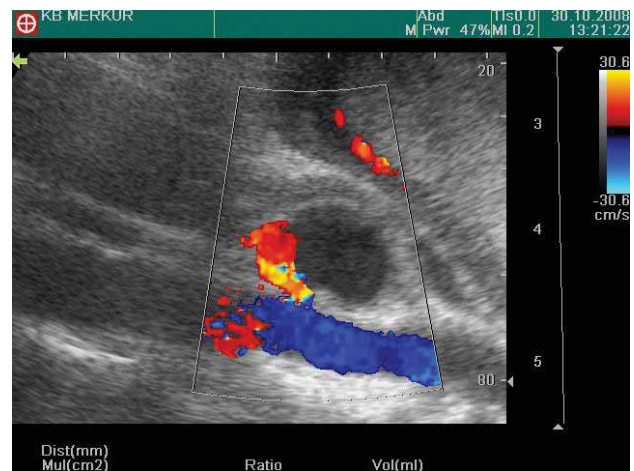


Fig. 2. CDFI shows narrow communication canal from aorta to the PA cavity.

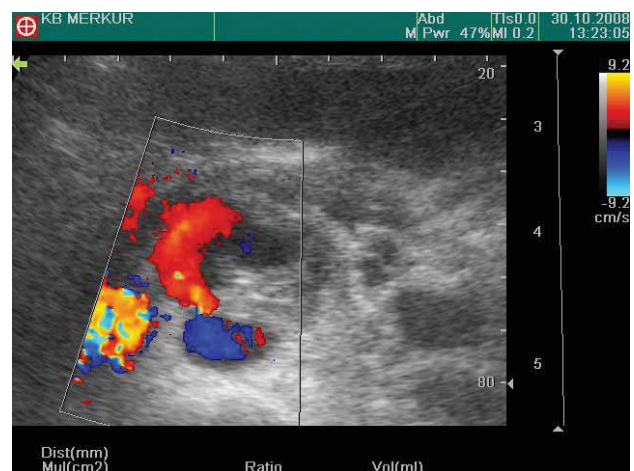


Fig. 3. Transversal CDFI scan shows communication between aorta and PA.



Fig. 4. CT shows hyperdense area adjacent to aorta in the left retroperitoneum at the level of renal vessels.

walled mass, 45×40×30 mm in size, anterior to the infra-renal part of the abdominal aorta, 4–5 cm above the aortic bifurcation. The aortic wall was irregular only in a small portion, and the appearance of the aorta was otherwise normal (Figure 1). PA of the abdominal aorta was suspected.

The value of the CRP rose to 103 mg/L. Upon consulting the surgeon and the internist, the penicillin and a colitis diet were introduced into the treatment. The patient became afebrile in response antibiotics. CRP values decreased to 43 mg/L. The patient complained of the constant pain of the spasmodic type in the right loin initiated by body movements. After a proper preparation, she was admitted to the color Doppler US. B-mode US showed a hypochoic thick-walled mass adjacent to the abdominal aorta and a narrow communication canal from the aorta to the PA cavity. A typical »to-and-fro« color pattern was detected inside the cavity of the suspected PA on color Doppler flow imaging (CDFI). A narrow communication canal from aorta to the cavity consistently showed flow in alternating directions (Figures 2 and 3). The vascular surgeon ordered additional tests in order to confirm that it was pseudoaneurysm of the abdominal aorta, as well as to see whether the pseudoaneurysm was ruptured or not.

We performed a CT with 7/7mm collimation and a »low-dose protocol«: 120kV/30 mA, pitch 1.5 instead of standard conditions: 120kV/160mA and pitch 1.5. We performed twenty-two sections and thus successfully reduced mAs with the aim of reducing the dose at the irradiated region.

A hyperdense area (density of 62.1 HU) on the CT scan adjacent to the aorta in the left retroperitoneum at the level of renal vessels indicated fresh blood. A distraction of the left psoas muscle was also found. The CT indicated asymmetry in the psoas muscles and a blurred left psoas, as well as a reticular formation of perirenal fasciae and a

blurred perirenal fat tissue. The CT confirmed the diagnosis of the ruptured aortic PA (Figures 4, 5, 6 and 7).

Subsequently, the patient was transferred to the department of vascular surgery. After adequate preparations and due to the mother and conceptus' vital indications, the birth was induced in the 32nd week by a Caesarean section. A live, premature male child weighing 1850 g, 44 cm long, Apgar score 9/9 was born.

The operation continued with a surgical resection of the pseudoaneurysm of the abdominal aorta, followed by

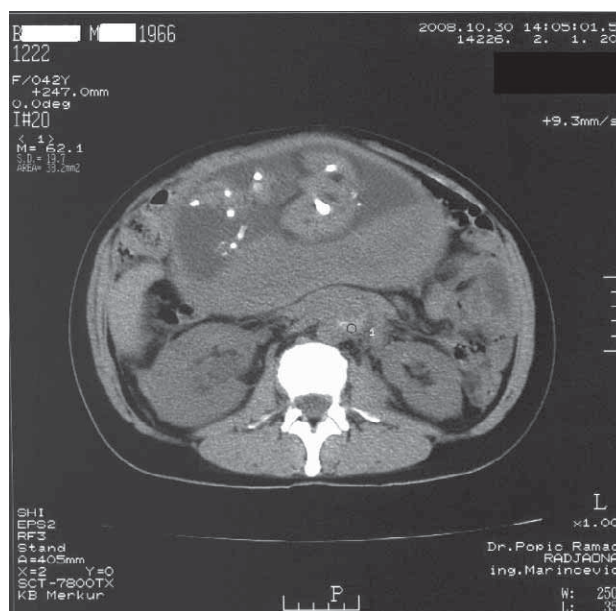


Fig. 5. A density of 62.1 HU on CT scan adjacent to aorta in the left retroperitoneum indicates fresh blood.

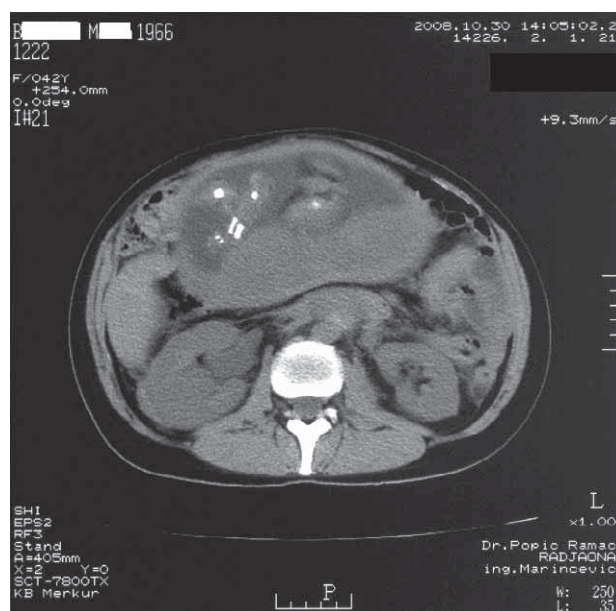


Fig. 6. Asymmetry in psoas muscles and blurred left psoas.



Fig. 7. Reticular formation of perirenal fasciae and blurred perirenal fat tissue.

a reconstruction of the aorta by the termino-terminal prosthesis Gelsoft Plus, 10 mm in diameter. The postoperative course was normal with an antibiotic protection. The patient was discharged from the hospital in good health conditions.

A histological examination of the resected part of the abdominal aorta confirmed that it was a part of the arterial wall with a sustained tunica media and an adventitia. At one location, the intima was thinner and partly missing (biopsy no. 07644/ 08). The content of the aneurysm was sent to the bacteriological aerobic and anaerobic analysis. The analyzed culture proved to be sterile. The microscopic examination did not find polymorphonuclear leucocytes or microorganisms. A PHD confirmed the diagnosis.

Discussion

The pseudoaneurysm of the abdominal aorta is a rare occurrence appearing in only 1% of all abdominal aneurysms⁴. Visceral or renal (pseudo) aneurysms recognized during pregnancy are also relatively infrequent. Nevertheless, these can be severe and potentially life-threatening condition for the mother and the fetus, thereby presenting a high-priority medical emergency^{7,8–11}. On the other hand, more than a half of all ruptured arterial aneurysms in younger women are pregnancy-related, and are associated with high a maternal mortality rate^{4–6}. We found reports of the rupture of cerebral and renal artery aneurysms during pregnancy¹². Aortic and coronary dissections in pregnant women have been reported, particularly ones with coexisting media layer degeneration, such as in Marfan syndrom^{18–20}. In most cases, vascular surgery had to be preformed immediately or after the Cesar-

ean delivery^{9,10}. We did not find any recent literature data on ruptured pseudoaneurysms of AA during pregnancy. The mortality of ruptured pseudoaneurysms is quite high in locations other than AA and in other (non-pregnant) patients.

Most patients who reach the emergency department are frequently referred to CT in order to confirm or exclude the suspected diagnosis. But radiation doses are frequently neglected in these patients. Dealing with pregnant women, one should consider the fetal radiation dose and possible radiation injuries to the embryo which can increase the risk of teratogenesis in early pregnancy and the onset of childhood leukemia. The radiobiological rule ALARA says that an »as low as reasonably achievable« amount of radiation should be used to reach the diagnosis. Whenever possible, we should use the low dose protocols in CT in order to reduce radiation risk to the fetus and the mother to the minimum while obtaining sufficient diagnostic information.

The potential effects of radiation on the conceptus include: prenatal death, intrauterine growth restriction, small head size, severe mental retardation, reduced intelligence quotient, and organ malformation and childhood cancer²¹. The probability of any of the above effects depends on the radiation dose to the conceptus, as well as its gestational age. Common indications for CT scanning in pregnant patients include a suspected appendicitis, pulmonary embolism and urinary tract calculi^{21–24}. To minimize radiation exposure to the fetus, it is important to determine if the necessary diagnostic information can be obtained from an alternative non-radiation based imaging modality. For scanning body regions outside the abdomen and pelvis, such as the chest CT for suspected pulmonary embolism, the dose that reaches the fetus is very low (<0.1 mSv) because the scattered radiation levels decrease quickly away from the scan volume²⁵. In the case of CT for renal calculi in pregnant patients, the fetal dose can be reduced with the use of low mAs (mili Amper seconds), a high pitch and a limited scan range without compromising the study quality^{24,26}. For the abdominal-pelvic CT, which directly irradiates the fetus, scan parameters, such as wider beam collimation, higher pitch, and lower mAs, kV and scan range, can be selected to reduce the fetal dose to approximately 23 mGy per scan phase^{19,27}. For CT in pregnant patient with suspected appendicitis, the scan volume should be restricted to the necessary anatomy, and dual-pass studies should be avoided, if possible^{29,29}. Thus, even for a routine dose-level, such as the bi-phase CT exam of the abdomen and the pelvis, the probability of birthing a healthy baby decreases by only 0.5%²⁴. As a typical CT dose for pregnant women has not been standardized yet, especially for specific trimesters; low on dose protocols in this case were derived from practices cited in literature. Our chosen dose was based a phantom study (using the same CT equipment) in which 10 low dose protocols were tested³⁰.

For non-acute symptoms, radiologist and physicians must also decide if immediate CT scanning is required or if CT scanning can be postponed until after the delivery.

Sonography is unreliable in cases such as suspected abdominal aortic ruptures¹⁹. Small periaortic hematomas may not be detected, thus posing the threat of a faulty diagnosis. MR imaging is also not recommended, as freshly hemorrhaged blood may not be appropriately identified with standard imaging sequences²⁸. At many health centers, the monitoring of patients with acute rupture more difficult in an MR suite than at the CT scanner²⁹. MRA, typically employing the 3D time-of flight technique, performed at high field strength (≥ 1.5 T) with image segmentation, is reported to be approximately 95% sensitive to detecting cerebral aneurysms measuring at least 3 mm. MRA angiographic images are, however, subject to degradation by multiple artifacts, and visualization of the distal vasculature is suboptimal and inferior to CTA (31). MR visualization of small amounts of freshly hemorrhaged blood near the abdominal aorta is difficult due to fetal movement artifacts. It is worth mentioning that MRA is often not available on a 24-hours basis, and the time required for establishing a diagnosis can preclude the use of MRA in an unstable patient. Both techniques (CTA and MRA) need dynamic contrast enhancement, which is a factor to be considered in pregnancy. Gadolinium has not been proven to be teratogenic, but the American College of Radiologists' white paper on MR safety³¹ and product information suggests that it is not advisable to use Gadolinium in pregnancy unless there is no suitable alternative. Gadolinium is excreted into the fetal bladder and the amniotic fluid, and it recirculates, which contributes to a much longer half-life and its long term effects are not yet clearly known. Iodinated contrast for CTA also involves the risk of inducing fetal hypothyroidism. In this case, we decided to perform a »low-dose« CT of the abdominal aorta. The CT was performed with lower milliamp values, higher pitch, and a reduced scan range. These parameters are important in lowering the exposition dose, which directly lowers the fetal dose⁴. Usually, freshly hemorrhaged blood is easily identified in the retroperitoneum because of its characteristic appearance. It has higher attenuation values and dissects between fascial planes, resulting in fingerlike projections³², which we detected in our case, although not very specific. An additional sign was an asymmetry of the psoases: a thicker left psoas with indistinct contours in comparison with the right one.

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Availability, cost and noninvasiveness, combined with accuracy in detection and measurement, make color Doppler sonography ideal for the detection and follow-up of uncomplicated aneurysms^{18,19}. Moreover, the lack of ionizing radiation makes it the method of choice.

However, the CT scan and MR provide more precise data, and surpass US in objectivity and reproducibility^{20,28}. They demonstrate the size and extent of the PA better than US visualize the retroperitoneum, detect an aneurismal leak, urethral obstruction, perianeurysmal fibrosis, or other unsuspected causes of abdominal pain. Spiral CT scanning, especially using MSCT offers rapid scanning without respiratory motion artifacts. In urgent cases, it is the method of choice. Spiral CT scanning is especially helpful when evaluating juxtarenal AAAs³².

Conclusion

Emergent abdominal ultrasound (US) or computed tomography (CT) scans tend to be the first imaging methods performed when dealing with a suspected rupture of the abdominal aortic PSAN. Symptomatic patients should be scanned as soon as possible, in order to reach the diagnosis before a catastrophic rupture. For hemodynamically unstable patients with presumed rupture, bed-side emergent US provides the most rapid diagnostic information, although intestinal gas and abdominal tenderness may limit its accuracy. CT angiography (CTA) or magnetic resonance angiography (MRA) can depict more precisely the size and anatomy of PA^{9,10}.

For pregnant women, low dose scanning protocols which can obtain sufficient diagnostic information with a reduced radiation risk, are available in CT. In our case, we performed CT with reduced tube current and reduced slice thickness. These parameters are critical in reducing the exposure of the patient and the fetus. Neither excluding the fetus from the scanning volume nor covering the patient with a lead apron (which would produce artifacts on the image and possibly lead to repeated scanning) was possible.

Despite the limited diagnostic possibilities, the pseudoaneurysm of the abdominal aorta was clinically suspected and diagnosed with minimal delay, and then successfully treated.

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NISKODOZNI PROTOKOL KOMPJUTORIZIRANE TOMOGRAFIJE KOD TRUDNICE S RUPTUROM PSEUDOANEURIZME ABDOMINALNE AORTE

SAŽETAK

Izbor metode oslikavanja kod trudnica zahtjeva poseban pristup radiologa ponajprije zbog mogućeg rizika izlaganja embrija/fetusa zračenju. Prikazat ćemo rijedak slučaj uspješno prepoznate i liječene pseudoaneurizme abdominalne aorte kod trudnice. Pseudoaneurizma je nastala u trećem trimestru trudnoće a ishod je bio povoljan za majku i dijete. Dijagnoza je postavljena color Doppler ultrazvukom trbuha i potvrđena kompjutoriziranom tomografijom abdominalne aorte, uporabom niskodoznoga protokola. Niskodozni protokoli kompjutorizirane tomografije daju dovoljnu dijagnostičku informaciju uz znatno manji rizik od štetnih učinaka zračenja. U ovom smo slučaju upotrijebili promjenu jakosti struje grijanja katode i manju debljinu slojeva, u skladu s novim smjericama, za smanjenje doze zračenja prilikom CT. Trudnoća je dovršena hitnim carskim rezom, nakon kojeg je slijedila rekonstrukcija aorte s postavljanjem endoproteze. Ultrazvuk je metoda izbora u ovakvim slučajevima jer daje brzu dijagnostičku informaciju o abdominalnoj aorti. Pregled mogu ograničiti zrak u crijevima i defans trbušnih mišića kod akutnih stanja u trbuhu. CT angiografija (CTA) ili magnetska angiografija (MRA) najtočnije određuju veličinu i anatomske odnose pseudoaneurizme. Prema podacima iz literature prikaz akutnih stanja je teži magnetskom rezonancijom (MR) nego kompjutoriziranom tomografijom. MR snimke su ometane brojnim artefaktima, pa je vizualizacija distalnih krvnih žila lošija nego CT-om. MRA je često dostupna u roku od 24 sata, a vrijeme potrebno za dijagnozu ovog akutnog stanja je iznimno dragocjeno.