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The role of point-of-care ultrasound (POCUS) in maternal medicine

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A B S T R A C T

Point-of-care ultrasound (POCUS) is an increasingly valuable tool in maternal medicine, offering rapid, bedside evaluation of critically ill pregnant patients. This study explores the expanding role of POCUS in obstetric care, particularly its application in assessing different organ systems. POCUS enables timely, accurate diagnoses and interventions, crucial for preventing maternal morbidity and mortality. While POCUS is widely used in emergency and intensive care, its potential in obstetric settings remains underexplored. Maternal and Fetal Medicine specialists, who already possess substantial ultrasound expertise, can easily integrate POCUS in daily practice.

Point-of-care ultrasound (POCUS) is a goal-directed bedside ultrasound. It allows rapid assessment of different organs like the heart, lungs, abdominal organs, blood vessels or genitals, as an extension of the clinical exam to guide decision making. POCUS is increasingly utilized in acute clinical settings and is defined as modality serving procedural, diagnostic and monitoring purposes [1]. POCUS provides immediate answers to simple and focused medical questions, without the delay and the potential risks associated with the transportation of the patient to other hospital areas [2]. It is not a substitute for regular ultrasound practice, but is helpful in suboptimal and acute conditions for evaluation and directing care of acute or critical medical conditions at bedside. As such, it became popular in emergency and intensive care departments as well as in areas with limited health resources. Most young trainees in these specialties nowadays consider the basis of POCUS they learn in 3-day courses as an essential part of their clinical skills [3].

For a complete POCUS exam, curved (abdomen, lungs), phased array (heart, lungs) and linear (blood vessels, lungs) ultrasound probes are required, which can be installed on most existing mobile ultrasound devices. Alternatively, pocket size probes (pocket size ultrasound machine (PUM)), allow connection to mobile devices like smartphones. As such, PUM's became a real challenger to the traditional stethoscope in the white coat pocket of these medical professionals.

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1. POCUS in maternal medicine

The particularity of obstetrics is that two different patients, mother and fetus, form one unity. They both require optimal evaluation and treatment to assure their essentially interdependent wellbeing's. More women with chronic conditions become pregnant and maternal age rises with consequently more complicated pregnancies. The physiologic adaptations to pregnancy form a substantial challenge to all the organs of the maternal body. Approximately five percent of women will eventually need a form of intensive care support during the course of their pregnancy, due to deterioration of an underlying condition or complications like pre-eclampsia, pulmonary embolism, heart disease, sepsis, shock, trauma or domestic violence affecting these organs [4]. Several programs offer structured approaches (ABCDE-F), with focus on core organ systems (lungs, heart, blood vessels and abdominal organs) to manage these challenges and reduce their impact on maternal mortality and severe morbidity. Pregnant women with acute illnesses typically first present to their obstetric care provider. Immediate consultation of external specialist is often difficult and can cause unnecessary delay. By expanding their ultrasound expertise to the rapid assessment of the core maternal organs, obstetric care providers can then perform a more complete maternal bedside clinical assessment. Maternal POCUS then substantially facilitates the Maternal and Fetal Medicine specialists (MFMS) to efficiently organize the most appropriate multidisciplinary care for acutely ill pregnant women [5–7]. As mentioned, MFMS typically have access to advanced ultrasound equipment and a wealth of experience. Most ultrasound appearances of adult organs are very similar to those of fetal organs. Obstetricians are the primary experts on the unique (patho)physiology of acute illnesses in pregnancy. Maternal POCUS training is therefore of potential interest to MFMS. POCUS skills can be acquired in one of the many adult POCUS courses organized for internal medicine, emergency doctor, intensive care specialists or anesthesiologist. In the near future, the need for a dedicated maternal POCUS course needs to be discussed within the international obstetric community. Our manuscript describes the potential and broad applications of maternal POCUS in obstetric care. In the next chapters we will focus on assessment of the maternal heart, lungs, abdomen and blood vessels [8].

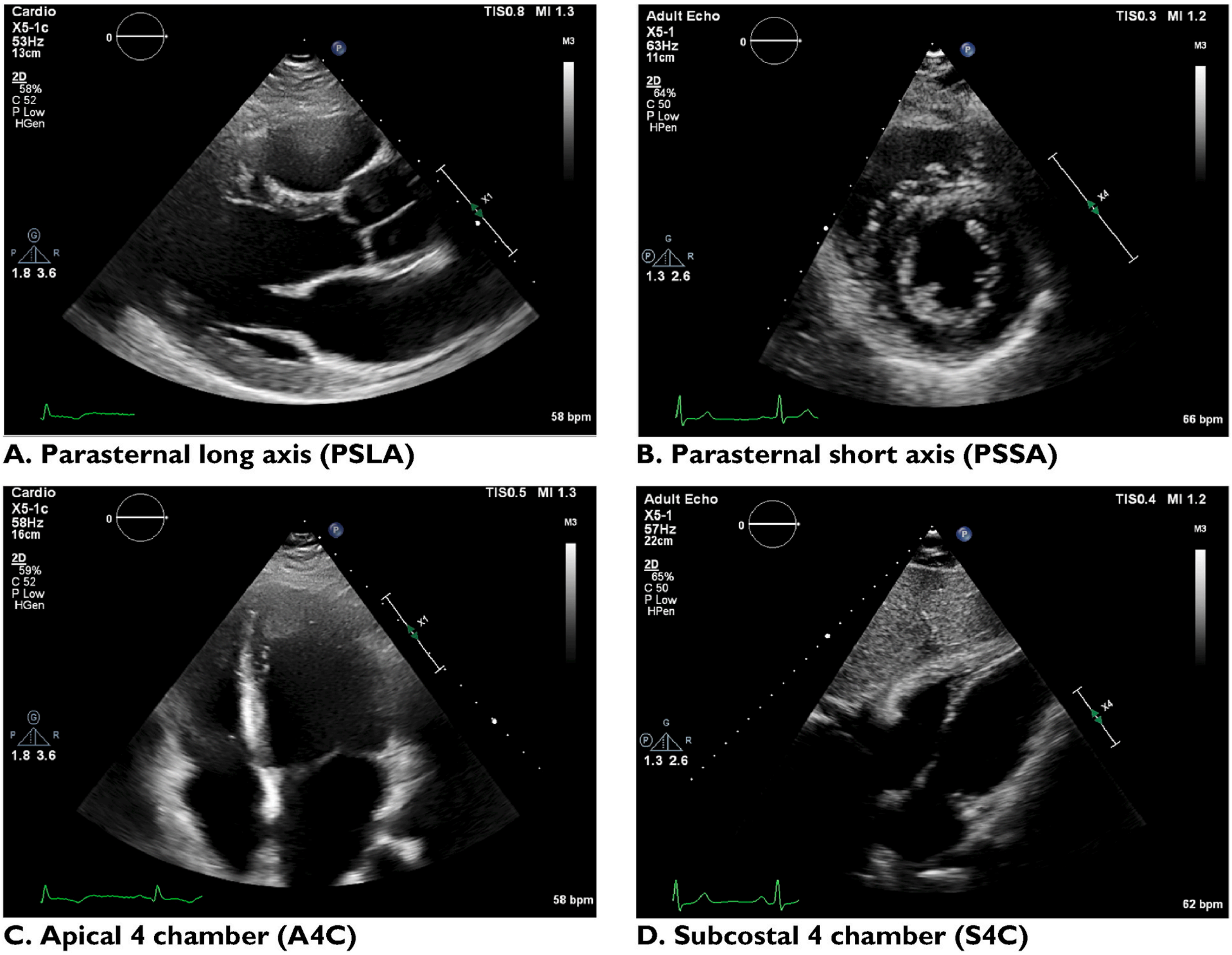


Fig. 1. Standard echocardiography views.

2. Maternal echocardiography

Pregnancy requires a profound cardiovascular adaptation to meet the increased metabolic demands of both the mother and the fetus. Total blood volume increases by 45% and cardiac output by 30–50% [9]. This leads to reversible structural changes like mild atrial dilatation and left ventricular hypertrophy [10,11]. The changes can substantially challenge the cardiovascular system of pregnant women, especially in case of (un)known cardiovascular disease. Cardiac disease remains the leading cause of maternal mortality in developed countries [12,13]. Cardiac function can also be substantially affected in other severe maternal complications like preeclampsia, pulmonary embolism or shock. Transthoracic echocardiography using a phased array probe is therefore an essential application of POCUS in maternal medicine, providing critical insights into these disruptions. A complete cardiac POCUS exam is performed at 3 sites (parasternal, apical and subcostal windows) from which 6 standard views are obtained: parasternal long axis-(PSLA), parasternal short axis-(PSSA), apical four chamber-(A4C), apical 5 chamber-(A5C), subcostal 4 chamber-(S4C) and subcostal inferior vena cava view, see Fig. 1 [14]. These views allow for the assessment of left ventricle (LV) and right ventricular (RV) function and size, detection of pericardial fluid, assessment of patient's fluid responsiveness or tolerance, and along with lung, abdominal and vascular POCUS, differentiate between various types of shock (hypovolemic, cardiogenic, obstructive, distributive). See Table 1.

2.1. Left ventricle assessment

To assess LV function during POCUS, the PSLA, PSSA, A4C and A5C views are most useful. To assess gross systolic function, a qualitative assessment is made with an "eyeballing" technique. In the PSLA view, one can observe a) myocardial thickening and b) excursion of the endocardial borders to the center of the ventricle during ventricular contraction as well as c) movement of the anterior leaflet of the mitral valve towards the intraventricular septum during early diastole. In the PSSA view, one can get a global look for wall motion abnormalities. A helpful technique is to place a finger in the middle of the ventricle at the mid-papillary level and observe if the walls are contracting evenly. If the left ventricular walls exhibit significant thickening of at least 40 % and show uniform inward movement during systole, and the tip of the anterior mitral leaflet moves within 10 mm the intraventricular septum, the patient is likely to have a normal ejection fraction (EF). On the other hand, minimal ventricular wall movement during systole and limited motion of the anterior leaflet of the mitral valve, suggest LV systolic dysfunction with reduced EF (<40%) [15,16]. Quantitative assessment of LV function can be achieved using several (advanced) methods. Fractional shortening (FS) and EF (Teicholz-formula) can easily be estimated by measuring the LV end diastolic diameter (LVEDD) and LV end systolic diameter (LVESD) using 2-D or M-mode in the PSLA or PSSA view. FS is around half of the EF [17]. Mitral annular plane systolic excursion (MAPSE) is another useful

Table 1
Shock evaluation with Point-of-Care Ultrasound.

	Cardiogenic shock	Distributive shock	Hypovolemic shock	Obstructive shock
Cardiac exam	Left ventricle: Dilated Severely reduced function Right ventricle: Possible dilated Valves: Possible severe MR, AR and/or AS	Left ventricle: *Early sepsis* Hyperdynamic with normal function *Late sepsis* Hypocontractile with reduced function	Left ventricle: Hyperdynamic (PLAX, PSAX) (kissing walls)	Left ventricle: *Tamponade* Hyperdynamic function Pericardial effusion with RA systolic and RV diastolic collapse Right ventricle: *Pulmonary embolism* Dilated, strained (A4C, S4C) D-shaped septum (PSAX)
Pulmonary exam	Lungs: B-line predominance Pleura: Possible bilateral pleural effusions	Lungs: *Pneumonia* Consolidation pattern or focal B-lines Pleura: Possible pleural effusion	Lungs: A-line predominance	Lungs: A-line predominance *Pneumothorax:* Absent lung sliding
Vascular exam	Distended IVC Reduced inspiratory collapse	Normal/collapsed IVC	Small to collapsed IVC	Distended IVC Reduced inspiratory collapse *Tamponade* Distended internal jugular vein *Pulmonary embolism* Deep vein thrombosis (compression ultrasonography)
Abdominal exam	*Chronic heart failure* Peritoneal fluid	*Peritonitis* Peritoneal fluid Hydronephrosis Cholecystitis Tubo-ovarian abscess	Intra-abdominal hemorrhage Extra-uterine pregnancy Subcapsular liver hematoma Liver adenoma Retroplacental hematoma	

Abbreviations: A4C, apical 4-chamber view; AR, aortic regurgitation; AS, aortic stenosis; IVC, internal vena cava; MR, mitral regurgitation; PLAX, parasternal long-axis view; PSAX, parasternal short-axis view; RA, right atrium; RV, right ventricle; S4C, subcostal 4-chamber view.
Modified by Nilam et al. Point of Care Ultrasound, 2nd Edition, page 196.

metric, which measures the mitral annular displacement distance towards the apex using M-mode in the A4C view. A reduced displacement of < 8 mm is associated with reduced LV EF [18]. Cardiac output (CO) can easily be calculated by measuring LV outflow tract (LVOT) diameter from the PSLV and LVOT velocity time integral (VTI) using pulsed wave (PW) Doppler from the A5C [19,20]. Diastolic function can be assessed by PW Doppler of the mitral inflow (normal E/A ratio is 0.75–1.5) and tissue Doppler imaging (TDI) of the mitral annulus (normal E/e' ratio $\leq$8) in the A4C.

LV systolic failure with low EF can be seen in different cardiomyopathies (e.g. peripartum cardiomyopathy) and several forms of shock [21,22]. The presence of regional wall motion abnormalities, such as hypokinesia or dyskinesia, on POCUS may raise suspicion for coronary artery disease. CO measurements can be used in hypertensive disorders of pregnancy to differentiate between hyperdynamic and hypodynamic phenotypes and select individualized antihypertensive treatment [23–25]. In preeclamptic women with pulmonary oedema, assessment of systolic and diastolic function helps to differentiate between iatrogenic (fluid overload) and heart failure as a cause.

2.2. Right ventricle assessment

The RV has a complex geometry, which makes echocardiography challenging. For qualitative assessment, look for the "D-sign" in the PSSA view. The "D-sign" refers to a D-shaped LV ventricle secondary to inward flattening of the septum as a consequence of RV pressure overload [26]. For quantitative measurements, use the A4C view, focused on the RV. Normally, RV size is around two third of that of the LV when measured at the base during end-diastole. A ratio of RV/LV size $\geq$1 suggests severe RV dilatation [27]. The

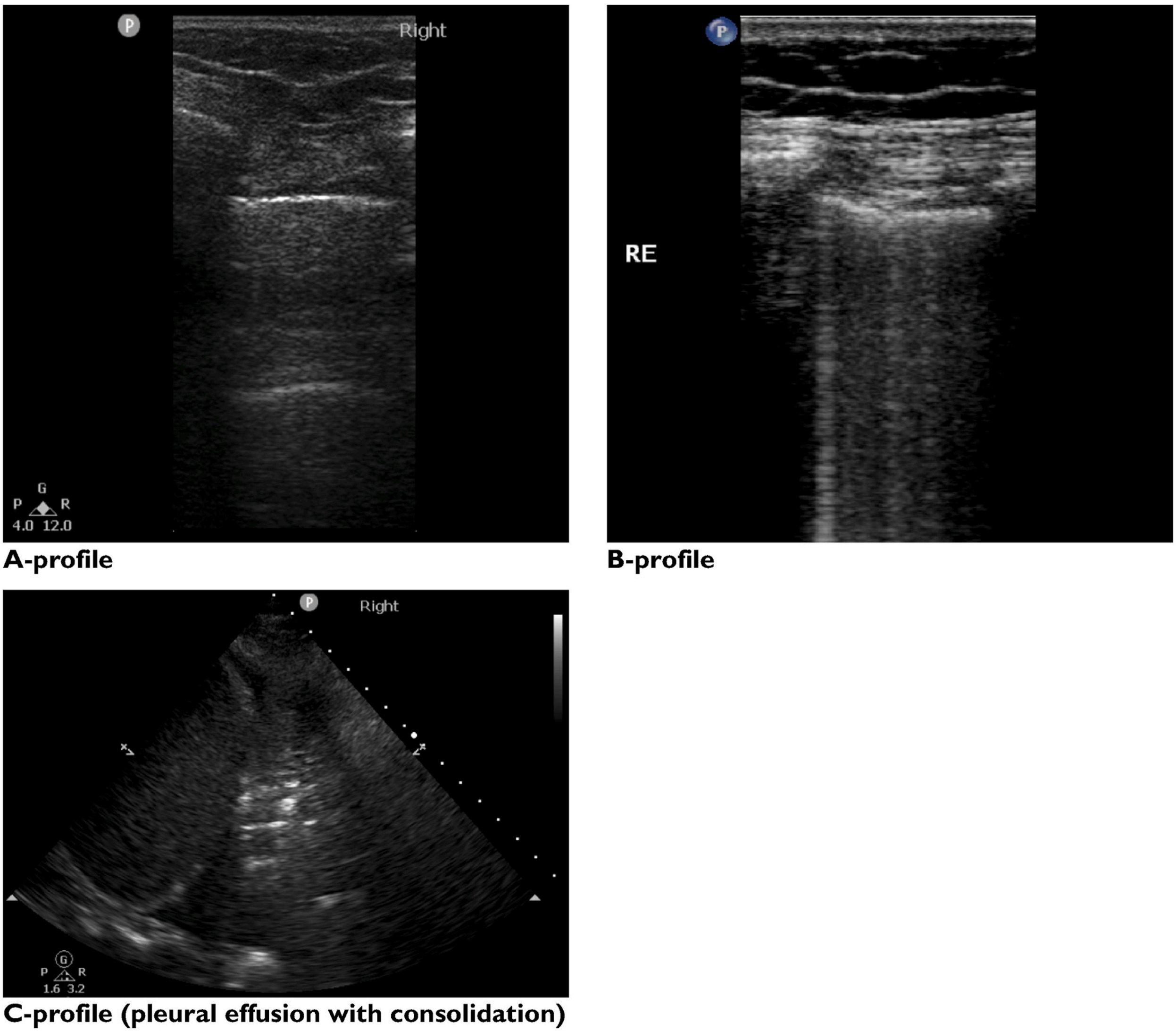


Fig. 2. Lung ultrasound profiles.

tricuspid annular plane systolic excursion (TAPSE) is a measurement for RV function. It measures the displacement of the lateral tricuspid annulus towards the apex using M-mode in a the A4C view. A TAPSE value of <17 mm is consistent with RV dysfunction [28]. Elevated pulmonary artery pressures can be suspected if the peak velocity of the tricuspid regurgitation measured with continuous wave (CW) Doppler exceeds 2.8 m/s.

Pulmonary embolism (PE), pulmonary hypertension and amniotic fluid embolism (AFE) are life-threatening conditions that precipitate acute RV failure. POCUS allows for rapid evaluation of the RV. In a pregnant women with shortness of breath, right ventricular dilatation and intraventricular flattening of the septum (D-sign) are typical ultrasound signs of massive pulmonary embolism.

2.3. Pericardial assessment (fluid, tamponade)

Pericardial effusion is best assessed in the PSLA and S4C views. Differentiating between pericardial effusion and pleural effusion can be challenging. In the PSLA view, pericardial effusion will appear anterior to the descending aorta, whereas pleural effusion will appear posterior to the descending aorta. The measurement of pericardial effusion should be performed during diastole. The effusion is classified based on the amount of fluid: small (<10 mm), moderate (10–20 mm), large (>20 mm), and very large (>25 mm) [29]. Small pericardial effusions are a common finding in the final stage of pregnancy, and usually resolve within 2 months after delivery [30,31]. In the absence of any signs of pericarditis (chest pain, pericardial friction rub, ECG changes) or tamponade (hypotension, muffled heart sounds, jugular venous distension), it should be considered as a physiological variant and echocardiographic follow-up is sufficient. Pericarditis requires further work-up and treatment. Cardiac tamponade is very rare and mainly seen in women with larger effusions, but given its life-threatening nature, immediate treatment is imperative [32].

2.4. Hypovolemia assessment (inferior vena cava)

Hypovolemia, such as that occurring with hypovolemic shock after postpartum hemorrhage, or vasodilation, as seen in sepsis, can be suspected when a hyperdynamic left ventricle is observed in any of the cardiac views. The endocardial excursion and myocardial thickening are increased and ventricular walls seem collapsing, nearly obliterating the LV cavity at the end of systole, a phenomenon referred to as "kissing walls". Ultrasound of the inferior vena cava (IVC) can be used to determine fluid responsiveness, estimate central venous pressure and guide fluid management [33]. The IVC diameter and collapse during inspiration is evaluated from the subcostal window at a point 2 cm before entering the right atrium. A distended IVC (>2.5 cm in pregnant women, 2.1 cm in non-pregnant) with minimal collapse (<50 % collapse in non-ventilated patients) suggests venous congestion, potentially caused by heart failure, obstructive causes (tamponade, pneumothorax) or a chronic cause (i.e. tricuspid regurgitation). Conversely, a narrow IVC (<1 cm) with large collapsibility (>50 % collapse) suggests hypovolemia and fluid responsiveness [34].

3. Lung ultrasound

Lung ultrasound is becoming a very popular method to assess and differentiate common pulmonary conditions at bedside in patients with shortness of breath. Ultrasound is superior to physical examination and chest X-ray, and has comparable sensitivity and specificity to computed tomography (CT) for most pulmonary pathologies [35,36]. In obstetrics, interest in maternal lung ultrasound emerged during the COVID pandemic [37]. Several protocols have been developed over time. The Bedside Lung Ultrasound in Emergency (BLUE) protocol is a systematic approach for using lung ultrasound in acute respiratory failure [38]. The BLUE protocol involves scanning specific lung zones to identify characteristic patterns (A-profile, B-profile, C-profile), thereby helping to quickly differentiate between various pulmonary pathologies, also in pregnant women with shortness of breath, see Fig. 2. Both convex and phased array probes are appropriate. A 6-point exam (3 points at each lung: 2–3 intercostal space midclavicular [upper anterior], 6–7 intercostal space mid axillary [nipple height lateral], 10–12 intercostal space posterior axillary line [posterior PLAPS- point]) is usually sufficient for bedside screening. The probe is vertically orientated between 2 ribs and depth should be set at 13–16 cm. Between the shadows of the rib (bat sign), superficial structures (skin, subcutaneous tissue, intercostal muscles), pleural lining (parietal and visceral pleura, a thin white echogenic line) and lung tissue can be discerned [39,40].

3.1. Pleural line

The bright pleural line is an important echogenic marker in lung ultrasound. Sliding of the parietal over the visceral pleura is observed during breathing, like sparkling or ants walking in line. While pneumothorax is a rare cause of dyspnoea in pregnant women, the presence or absence of lung sliding indicates the respective absence or presence of pneumothorax with near certainty [41,42]. Due to the echo lucent properties of fluids, hemothorax and/or pleural effusions are also easily observed at the PLAPS point [43].

3.2. Lung tissue

3.2.1. A-profile (air)

Air prevents normal conduction of ultrasound waves through lung tissue. During lung ultrasound, A-lines can be observed as bright repetitive horizontal reverberation artefacts (2–5 lines depending on depth) at equidistance from the pleural line (same distance between the skin and pleura). A-lines are thus the normal ultrasound appearance of air containing lung tissue observed in healthy pregnant women. Still, this pattern can also be observed in patients with shortness of breath with aerated lungs but other cause of dyspnea, like asthma, COPD (ventilation problem) or pulmonary embolism (perfusion problem) [38].

3.2.2. B-profile (fluid)

When interlobular septa become fluid filled and thickened, ultrasound waves can be conducted through lung tissue [44]. B-lines are then observed as bright vertical lines that originate at the pleural line and travel all the way to the bottom of the screen like ray-like comet stripes. While one or two B-lines can be normal in healthy lung tissue, three or more B-lines in a single view are considered abnormal and indicate interstitial syndrome. With increasing interstitial fluid, the number of B-lines increase and may appear confluent. The most common cause of interstitial syndrome with B-lines is pulmonary oedema as observed in preeclampsia or heart failure (cardiomyopathy). B-lines on lung ultrasound can often be observed before overt clinical signs of pulmonary oedema and are found superior and easier to interpret at bedside than bedside chest X-rays in pregnant women with engorged breast tissue. Other causes are acute respiratory distress syndrome (ARDS) as observed during infection (e.g. COVID-19), aspiration, or severe maternal illness (e.g. pancreatitis, sepsis, transfusion reaction) or pneumonia. POCUS of other maternal organ systems like the heart helps to differentiate between the causes of interstitial syndrome and dyspnea [45].

3.2.3. C-profile (consolidation)

When parts of lung become increasingly filled with fluid, its ultrasound appearance becomes consolidated, with an appearance of liver tissue (hepatization of lung). Due to gravity, consolidations are usually observed first at the PLAPS point. Consolidations can be observed with pneumonia or atelectasis. Consolidations can be accompanied by static or dynamic air bronchograms. Static air bronchograms are air bubbles trapped behind an obstruction that do not move during respiration, typically seen in atelectasis. Dynamic air bronchograms involve a mixture of fluid and air moving within up and down the bronchi during respiration and are commonly observed in pneumonia [46].

4. Pelvic and transabdominal POCUS

In obstetrics, ultrasound is commonly used to monitor the course of pregnancy from early gestation to term. Transvaginal

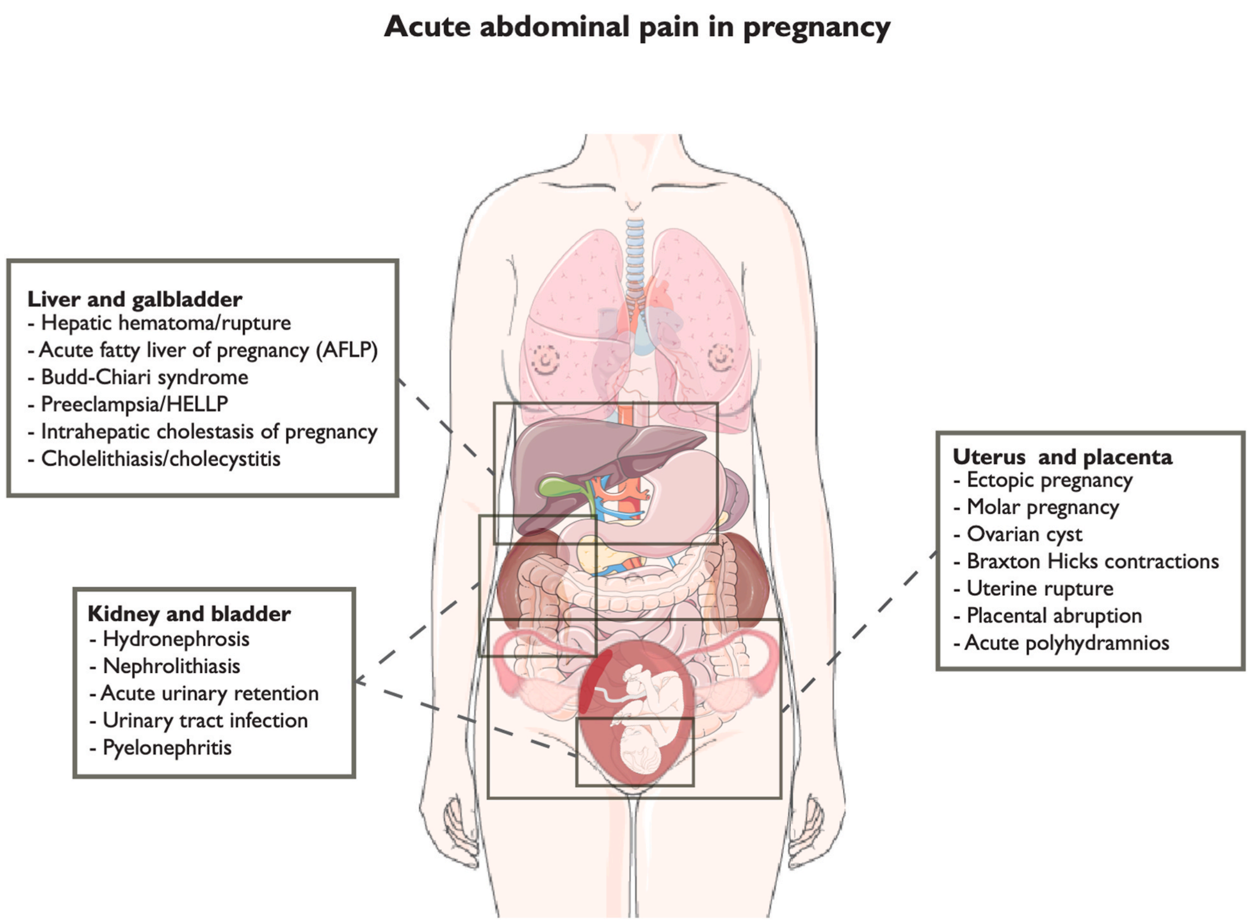


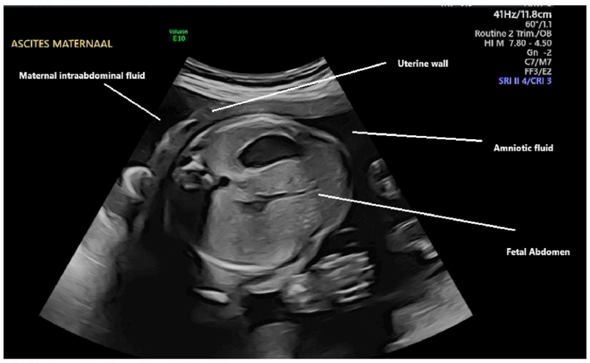
Fig. 3. Differential diagnosis of acute abdominal pain in pregnancy stratified by organ system.

ultrasound offers most resolution in early pregnancy and deep pelvic structures (cervix, pouch of Douglas), a curved probe offers sufficient dept and resolution to allow abdominal scanning for uteroplacental, and fetal evaluation as well as the possibility to assess other abdominal organs [47]. During obstetric POCUS, findings that are relatively easy to assess include the presence and location of the gestational sac, fetal viability, number of fetuses, placental location and amniotic fluid [1,48]. Ultrasound can help to discern obstetric causes of acute abdominal pain in early pregnancy like miscarriage (absence of fetal heartbeat, abnormal gestational sac), ectopic pregnancies (absence of intrauterine gestational sac, ectopic mass, tubal ring, ring of fire, free fluid in pouch of Douglas), ovarian torsion (enlarged ovary with peripheral cysts, with or without mass, free fluid, absence of color flow) or PID (adnexal mass, free fluid) as well as later in pregnancy like threatening preterm labor (cervical shortening), placental abruption (retroplacental hematoma can sometimes be observed along with signs of fetal distress) or (threatening) uterine rupture (very thin (<3 mm) or dehiscence of uterine wall, free abdominal fluid, fetal parts outside the uterus, fetal distress). In pregnant women with abdominal pain, maternal POCUS can be used to rapidly assess other abdominal organs like the liver, gallbladder, spleen, appendix, kidneys, bladder, ovaries and peritoneal cavity as potential cause and effectively direct further work-up and management [49]. POCUS findings must be interpreted within the clinical state of the pregnant woman. The differential diagnosis of acute abdominal pain in pregnant women stratified by organ system is presented in Fig. 3.

4.1. Urinary tract

Maternal POCUS can easily be used to evaluate maternal kidneys. Hydronephrosis is easily be observed as an anechogenic fluid collection with the normally hyperechogenic (due to fat content) renal sinus, see Fig. 4A. It is classified as mild, moderate or severe. Up to 90 % of pregnant women have some degree of hydronephrosis, especially of the right kidney, due to mechanical compression of the ureter between the gravid uterus and iliopsoas muscle, and higher levels of progesterone causing smooth muscle relaxation of the ureters [50]. However, it can be pathological in combination with signs of infection (pyelonephritis) or signs of obstruction (flank pain or suspected ureteric obstruction or damage after obstetric surgery, bladder atony). Renal cysts and masses can be incidental benign findings but warrant further investigation. Renal venous Dopplers can be used to assess the risk of developing preeclampsia [51]. Ultrasound of the bladder can be convenient to evaluate urinary retention (bladder volume [ml)] = 0.75 x width [cm], length [cm] x height [cm]), proper catheter placement or bladder integrity (filling to exclude suspected bladder lesion after obstetric surgery). The visualization of regular bilateral ureteral jets using power Doppler (every 20 s lasting 1 s) in the bladder excludes significant ureteric obstruction (stones, sutures) or damage.

A. Hydronephrosis



B. Intraabdominal fluid

Fig. 4. Abdominal ultrasound.

4.2. Free peritoneal fluid

Both abdominal and vaginal ultrasound can be used to assess free abdominal fluid. The fluid can be located retroperitoneally or intraperitoneally, ultrasound is most sensitive for intraperitoneal fluid. When limited amounts are present, vaginal ultrasound can me more sensitive as the fluid tends to accumulate in the pouch of Douglas. Differentiation between the type of fluid like blood (hemoperitoneum e.g. ruptured ectopic, uterine rupture, spontaneous hemoperitoneum in pregnancy, liver rupture, abdominal aneurysm rupture, postsurgical hemorrhage), ascites (preeclampsia, Budd-Chiari syndrome: hepatic vein thrombosis causing pain, ascites and hepatomegaly), urine (bladder or ureteric damage) is not possible solely based on ultrasound characteristics. The presence and significance of free abdominal fluid must be interpreted in the context of the clinical circumstances. Ultrasound guidance increases the procedural success rate of paracentesis when further exams on the fluids are deemed necessary. In women with certain connective tissue diseases (e.g. Loeys-Dietz, vascular Ehlers Danlos), the risk of abdominal (aortic or other [e.g. splenic]) aneurysm rupture is increased during pregnancy, while rare, fetal and maternal mortality are extremely high and rapid assessment can be lifesaving. Peritoneal fluids (intra- or retroperitoneal) with signs of rupture (shock) are then highly suggestive. The abdominal aorta can also be evaluated. An aortic abdominal diameter >3 cm is considered as an aneurysm and warrant follow-up, but ruptures are unusual <4.5 cm. Evaluation should be done in 15 % left lateral tilt to reduce the effects of aortocaval compression by the pregnant uterus. See Fig. 4B for an example of intraabdominal fluid.

4.3. Liver and gallbladder pathology

Up to 3 % of all pregnancies are complicated by liver disease [52]. With POCUS, the presence of liver masses as a cause of hemorrhagic shock (intrahepatic hematoma, liver adenoma) or cholecystitis in case of right upper quadrant pain can be suspected.

Hepatic hemorrhage is a rare but life-threatening pregnancy complication. It can occur spontaneously but most often as a result of severe hemolysis, elevated liver enzymes, low platelets (HELLP) syndrome or in rapidly growing hormone sensitive liver adenomas in pregnant women [53]. Women presents with complaints of right upper quadrant or epigastric pain, shoulder pain and hypovolemic shock. In case of capsular rupture, intraperitoneal fluid may be present [54]. Hematomas are most frequently present in the right hepatic lobe (77 %) [55]. Ultrasound appearance may be variable with acute subcapsular hematoma as a crescent-shaped collection of echogenic fluid just beneath the liver capsule that progressively become hypodense over time. Unruptured adenomas are generally well demarcated heterogenous hyper- or hypoechogenic masses [54].

Pregnant women are at risk to develop gall stones because of higher cholesterol levels and delayed gallbladder emptying due to increased estrogen and progesterone levels [56]. POCUS is helpful in diagnosing cholecystitis (i.e. inflammation or infection of the gallbladder due to obstruction of the gallbladder's drainage ducts) in case of acute upper quadrant pain. Sonographic Murphy sign is the most sensitive POCUS finding for cholecystitis and refers to maximal tenderness at the point where the ultrasound probe is positioned to visualize the gallbladder compared to other regions of the right upper quadrant [57]. Its presence or absence in combination with gallstones, seen as hyperechoic collections with posterior shadowing within the gallbladder lumen [58], and/or gallbladder wall thickening (>3 mm) and/or pericholecystic fluid [59], have high potential to rule in or rule out acute cholecystitis [57].

5. Vascular POCUS

5.1. Deep vein thrombosis

The risk of deep vein thrombosis (DVT) and subsequent pulmonary embolism, is increased in pregnancy due to hypercoagulability, venous stasis and endothelial injury. In pregnancy, DVT are more often iliofemoral and on the left side. Prompt diagnosis is crucial to start adequate treatment with anticoagulant agents and prevent pulmonary embolism. Overlap between normal physiological changes in pregnancy and symptoms of DVT and/or pulmonary embolism (leg swelling, pain, rising D-dimer) makes it more difficult to distinguish on clinical grounds. POCUS using simple compression ultrasonography with high resolution linear probes of the femoral and popliteal veins can be used to accurately rule in or out DVT. The patient is placed in a supine position with leg externally rotated and knee slightly flexed (frog position). The veins and corresponding arteries (lateral to the vein) are visualized at the upper leg at the level of the common femoral vein, junction of the common femoral vein and saphenous vein, and eventually at lower levels (deep femoral vein and popliteal vein). Pressure is applied with the ultrasound probe. In normal circumstances, the vein can be compressed completely and the artery only slightly. In case of DVT, a non-compressible vein is observed. Occasionally, an echogenic cloth can be visualized inside the vein. Iliofemoral thrombosis might require more detailed triplex ultrasound examination and remains the expertise of dedicated vascular ultrasound specialists [60]. Algorithms that combine clinical signs, D-dimers levels and simple compression ultrasound reduce the need for additional advanced ultrasound and pulmonary CT angiography to safely rule in or out DVT and pulmonary embolism in pregnant women [61].

5.2. Vascular access

Similar to amniocentesis and CVS, ultrasound guidance can substantially facilitate the placement of peripheral venous, arterial or central lines. In pregnant women where placement can be complicated due to increased BMI, oedema or shock, ultrasound guidance improves the success rate. A linear probe is used with a transverse or longitudinal approach.

6. Conclusion

POCUS of the maternal heart, lungs, abdomen and veins allows rapid bedside assessment of acute problems in pregnant women by MFMS. This technique extends the clinical examination and enables more efficient guidance for appropriate further care. Obstetric care providers already possess significant ultrasound skills and equipment; enhancing their expertise with maternal POCUS can significantly improve outcomes for critically ill mothers and their fetuses.

CRediT authorship contribution statement

J.A. van der Zande: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Project administration, Visualization. **K. Rijs:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Project administration, Visualization. **A.A. Shamshirsaz:** Writing – review & editing. **H. Soliman:** Writing – review & editing. **A. Franx:** Writing – review & editing. **R.M. Kauling:** Writing – review & editing. **J.W. Roos-Hesselink:** Writing – review & editing. **C. D. van der Marel:** Writing – review & editing. **K. Verdonk:** Writing – review & editing. **J.M.J. Cornette:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Practice points

- POCUS should be integrated into obstetric care for rapid diagnosis in critical cases.
- Maternal POCUS allows evaluation of different organ systems.
- Training in POCUS enhances the clinical skills of Maternal and Fetal Medicine specialists.

Research agenda

- Develop specialized maternal POCUS training programs tailored for obstetric care providers.
- Investigate the impact of POCUS on maternal and fetal outcomes.
- Explore the integration of pocket ultrasound devices in low-resource obstetric environments.

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Conflicts of interest

The authors have no conflicts of interest.

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