Clinical and Experimental HEPATOLOGY

Clin Exp HEPATOL 2020; 6, 3: 176–184
DOI: https://doi.org/10.5114/ceh.2020.99508
Received: 10.03.2020, **Accepted:** 09.06.2020, **Published:** 30.09.2020

Review paper

Interventional radiological management of hepatobiliary disorders in pregnancy

Pratyaksha Rana[1], Pankaj Gupta[1], Sreedhara B Chaluvashetty[1], Ashima Mittal[2], Naveen Kalra[1], Usha Dutta[3], Manavjit Singh Sandhu[1]

[1]Department of Radiodiagnosis and Imaging, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India
[2]Department of Gynaecology and Obstetrics, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India
[3]Department of Gastroenterology, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India

Abstract

Hepatobiliary disorders are common in pregnancy and pose a management challenge. Minimally invasive interventional radiological (IR) techniques allow safe and effective management of these disorders. However, the available literature is scarce. Radiological interventions in this group of patients mandate a clear understanding of the risks of radiation to the fetus. The IR physician involved in the care of these patients should be aware of the measures to minimize the exposure to ionizing radiation. Additionally, the risk-benefit ratio should be clearly defined in a multidisciplinary discussion involving IR physicians, obstetricians, and gastroenterologists. This review is an effort to address issues related to the application of IR procedures for hepatobiliary disorders in pregnant patients.

Key words: interventional radiology, hepatobiliary, pregnancy, fetus.

Address for correspondence:

Dr. Pankaj Gupta, Assist. Prof., GE Radiology, Department of Radiodiagnosis and Imaging, PGIMER, Chandigarh, India, phone: +91-1722756602, e-mail: Pankajgupta959@gmail.com

Introduction

Hepatobiliary disorders are commonly encountered in pregnancy. They can be classified into hepatic disorders, biliary disorders, vascular disorders, infections, granulomatous disorders, and masses (Table 1). These diseases may be existing before pregnancy or predisposed by pregnancy [1, 2]. Early diagnosis and management are important because of associated maternal and fetal morbidities [3].

Hepatic disorders

Acute fatty liver of pregnancy and intrahepatic cholestasis of pregnancy are hepatic disorders specific to pregnancy with etiopathogenesis related to physiological changes of pregnancy [4, 5]. Certain conditions related to pregnancy such as hyperemesis gravidarum, preeclampsia syndrome, and HELLP syndrome (hemolysis, elevated liver enzyme and low platelet count) cause hepatic dysfunction although the exact etiopathogenesis remains unclear [6]. Other causes of hepatic dysfunction such as acute viral hepatitis, autoimmune hepatitis, and non-alcoholic steatohepatitis leading to jaundice are either preexistent or occur concurrently with pregnancy. Cirrhosis of the liver due to various causes generally has poor outcomes in pregnant patients both for the mother and the fetus. Common complications of cirrhosis in pregnancy include hepatic decompensation, variceal bleeding, spontaneous abortion, preterm delivery, fetal growth restriction, postpartum hemorrhage, and splenic artery aneurysm rupture [7]. Portal hypertension either due to intrahepatic (cirrhosis) or extrahepatic causes (extrahepatic portal venous obstruction and non-cirrhotic portal fibrosis) leads to the opening of portosystemic shunts, which can cause torrential bleeding in pregnancy [8, 9].

Table 1. Hepatobiliary disorders in pregnancy

Hepatobiliary disorders	
Hepatic disorders specific to pregnancy	Intrahepatic cholestasis of pregnancy, acute fatty liver of pregnancy, pre-eclampsia syndrome, hyperemesis gravidarum
Diffuse liver diseases and viral hepatitis	Autoimmune hepatitis, non-alcoholic fatty liver disease, viral hepatitis (acute or chronic – A, B, C, D, E, G)
Focal infective (non-viral) and granulomatous diseases	Liver abscess (pyogenic, amoebic), hydatid disease, tuberculosis, sarcoidosis, schistosomiasis
Biliary disorders	Cholelithiasis and its complications (choledocholithiasis, cholangitis, acute cholecystitis, and acute pancreatitis), choledochal cyst
Vascular disorders	Budd-Chiari syndrome, extrahepatic portal venous obstruction
Liver masses	Adenoma, hepatocellular carcinoma, hemangioma, simple hepatic cyst

Biliary disorders

Gallstone-related disorders are the most common biliary disorders encountered in pregnancy. Gallstone prevalence in pregnancy is 18.4-19.3% in multiparous women and 6.5-8.4% in nulliparous women [10]. Increased incidence of gallstones and biliary sludge in pregnancy is related to changes in hormonal levels. Increased estrogen and progesterone levels affect the composition of bile and gallbladder motility [1, 10]. There is an increase in gallbladder volume in the fasting state, as well as an increase in residual volume after emptying. Additionally, there is saturation of cholesterol in bile and a decrease in the circulating bile salt pool [11].

Most gallstones are incidentally detected during pregnancy and are asymptomatic. They are diagnosed during the routine perinatal checkup and routine obstetric ultrasound scan. Biliary colic, cholecystitis, choledocholithiasis, obstructive jaundice, ascending cholangitis, hepatic abscess, and gallstone pancreatitis are the significant complications of gallstone disease in pregnancy [12]. Pregnancy, however, does not increase the severity or frequency of these complications [12]. The incidence of acute cholecystitis in pregnancy is reported to be 1 : 1000-1 : 10,000 [13, 14]. Obstruction of the cystic duct with superimposed bacterial infection is the etiological factor in 50-90% of cases. The incidence is similar in each trimester, although some studies report a higher rate in the third trimester [15]. Patients usually present with an acute abdomen with or without fever. Rarely, there may be gallbladder perforation [16]. Acute pancreatitis (AP) is most commonly associated with gallstone disease as in non-pregnant patients. However, other metabolic causes such as hyperlipidemia, hypertriglyceridemia, hyperparathyroidism, and drugs or toxins have also been implicated as etiological factors. Specific clinical and radiological parameters are used to determine the severity and outcome of patients with pancreatitis [17-19]. Pregnancy does not alter the course of AP.

Apart from cholelithiasis and choledocholithiasis, there can be a pre-existing biliary disorder in the pregnant patient, which can become symptomatic due to physiological changes of pregnancy.

Liver masses

Liver masses in pregnant women are rare; however, they pose a diagnostic and management challenge. They can be preexistent or can be first diagnosed during pregnancy. Increased use of routine obstetrical USG has led to an increased detection rate. The hepatic masses can be benign or malignant [20]. Most masses are asymptomatic, but because of hormonal changes in pregnancy may result in symptoms and increased complication rates. There can be compression on adjacent organs, bleeding, or rarely rupture into the peritoneal cavity, leading to catastrophic events for both mother and fetus.

Hepatic adenoma

Hepatic adenoma is a benign liver tumor of hepatocyte origin occurring in young females. It is thought to be hormone-sensitive because of the association with oral contraceptive pill use, glycogen storage disorders, androgenic steroids use and galactosemia. They are highly vascular tumors without a true fibrous capsule, which increases the risk of bleeding and rupture. Most patients are asymptomatic, and the estimated lifetime risk of bleeding is 27.2% and the rupture rate 15.8% [21]. The risk of hepatic adenoma rupture is highest in the third trimester, which has been attributed to high estrogen levels and increased vascularity of the liver due to hyperdynamic circulation. Fetal and maternal mortality is 38% and 48%, respectively, following acute hepatic rupture into the peritoneal cavity [22].

Hepatocellular carcinoma

Hepatocellular carcinoma (HCC) is rare in pregnancy with only isolated case reports [23]. However, cirrhosis and HCC are more frequently encountered in the Asian population due to high incidence of hepatitis B and C, which are important risk factors for the development of cirrhosis and HCC.

Liver abscess and hydatid cyst

Amoebic and pyogenic liver abscesses, and other atypical infections including visceral larva migrans and schistosomiasis are rarely reported have characteristics imaging features [24, 25]. The most common complications of liver abscesses include intraabdominal or intrathoracic rupture, thrombosis of the portal vein or inferior vena cava (IVC), hepatopulmonary fistula, and refractory ascites secondary to venous thrombosis [26]. The liver is the most common site for hydatid disease. It is mostly asymptomatic. A case report of hydatid cyst presenting with obstructive jaundice in pregnancy has been described [27].

Vascular disorders

Budd-Chiari syndrome (BCS) is characterized by obstruction to the hepatic venous outflow at the level of IVC or hepatic veins. Predisposing factors include hypercoagulable states, which can be both congenital and acquired [28]. Pregnancy itself is a risk factor for BCS, but additional risk factors are usually present [29]. In addition to the hypercoagulable state in pregnancy, volume expansion, hypoproteinemia, increased intraabdominal pressure, compression of IVC by the gravid uterus, and compression of the lymphatic system are other risk factors implicated in development or aggravation of BCS in pregnancy [30]. Merz *et al*. developed a classification system to classify BCS in pregnant women into WHO categories I-IV (Table 2) [30].

Diagnosis of hepatobiliary disorders

The diagnosis of hepatobiliary disorders in pregnancy can be challenging. A combination of medical history, physical examination, laboratory tests, and radiological investigations is usually required. Radiological studies are generally not helpful in cases of medical causes of jaundice, in which clinical and biochemical investigations play a role. Ultrasound is a safe and non-invasive examination to diagnose various hepatic and biliary disorders with no risk of ionizing radiation. It has a high diagnostic accuracy for gallbladder abnormalities [31]. However, its sensitivity and specificity for evaluation of other abnormalities such as choledocholithiasis and pancreatic diseases vary with the patient anatomy, and definitive diagnosis with ultrasound may not be possible. Moreover, ultrasound is operator dependent. Endoscopic ultrasound (EUS) has high sensitivity to diagnose biliary stones. However, it is an invasive investigation. Computed tomography (CT) is the investigation of choice for various hepatobiliary disorders in non-pregnant patients; however, due to the risk of radiation it is not employed in pregnant patients. Certain diseases such as acute pancreatitis require repeated investigation, and thus the cumulative radiation dose increases [32]. Magnetic resonance imaging (MRI) without gadolinium administration is considered safe during pregnancy and can be employed in equivocal evaluation with ultrasound. MRI with magnetic resonance cholangiopancreatography (MRCP) has high sensitivity in the evaluation of hepatic vascular and pancreaticobiliary diseases [33, 34].

Challenges and role of interventional radiology in pregnancy

There is an expanding role of interventional radiology (IR) for diagnosis as well as treatment of various diseases in pregnancy. Minimally invasive biliary interventions such as percutaneous transhepatic biliary drainage (PTBD), percutaneous cholecystostomy (PCC), drainage of liver abscesses, hydatid cyst and pancreatic collections are being increasingly used to tide over the acute crisis as well as for curative purposes [35]. Vascular IR procedures such as transarterial chemoembolization (TACE) and radiofrequency ablation (RFA) for hepatic masses and transjugular intrahepatic portosystemic shunts (TIPS) are also less

Table 2. Classification of Budd-Chiari syndrome in pregnant patients

Classification of Budd-Chiari syndrome	
I	No increase in maternal mortality, no or only slight increase in maternal morbidity
II	Slight increase in maternal mortality, maternal morbidity moderately increased
III	Significant increase in maternal mortality, severe maternal morbidity
IV	Extremely high maternal mortality. Termination of pregnancy recommended

Modified from [30].

frequently utilized. For appropriate utilization of IR procedures, a multidisciplinary approach with the involvement of obstetricians, an interventional radiologist, anesthesiologist, and gastroenterologist or hepatologist is needed.

Key issues to be addressed during IR procedures in pregnant patients are the patient position, the use of medications, and radiation risk to the fetus. Patient positioning is vital in patients beyond 20 weeks of pregnancy, with the left lateral decubitus position being preferred to reduce the compression effect of the gravid uterus on the IVC. Because of the physiological changes of pregnancy and the presence of developing fetuses, selection of anesthesia and medication is more challenging than in non-pregnant patients. The dose must be adjusted and optimized depending on changes in the blood plasma volume, cardiac output, and glomerular filtration rate. Over-sedation can lead to fetal hypoxia and bradycardia and should be avoided. Continuous fetal monitoring for fetal wellbeing is needed during the procedures. In general, regional anesthesia is preferred over general anesthesia [36]. Fluoroscopy, ultrasound, and CT with or without fusion imaging are the conventional modalities for image guidance during IR procedures. Ultrasonography is the safest modality for mother and fetus due to a lack of ionizing radiation and should be employed whenever possible. When ultrasound is not feasible, and fluoroscopy or CT is needed, radiation minimizing maneuvers should be used.

Both stochastic (non-threshold probability dependent) effects and non-stochastic effects (deterministic, effects with defined threshold) are seen with exposure to ionizing radiation. However, most perinatal effects of radiation are deterministic and depend on the gestational age. Thus, radiologists should adhere to the principle of "as low as reasonably achievable" when using the ionizing radiation imaging modality in pregnant patients [37] (Table 3).

The National Council on Radiation Protection and Measurements (NCRP) has stated that the risk of all developmental abnormalities is negligible with exposure to 50 mGy or less of ionizing radiation. The risk of malformations is significantly increased at doses above 150 mGy. The NCRP concluded that the exposure of the fetus to radiation arising from maternal diagnostic procedures during pregnancy would very rarely be a reason, by itself, for terminating a pregnancy [37]. With IR procedures involving direct exposure to the maternal abdomen, there is a risk of significant fetal exposure; however, using radiation minimizing methods, exposures can be reduced to acceptable levels. The second trimester is considered the safest trimester for imaging.

Various methods have been described to reduce radiation dose to the fetus during fluoroscopy and CT procedures, including decrease imaging and fluoroscopy time, minimizing the field of view, shielding, increasing source-patient distance, collimation, pulsed fluoroscopy, increasing pitch and decreasing tube current or voltage in CT [38]. The total dose during each procedure should be monitored and recorded for assessment of possible effects on the fetus.

Management of hepatobiliary disorders

Biliary disorders

Traditionally, biliary colic has been managed non-operatively in a conservative manner with close observation, expectant management, and surgery in the postpartum period [39]. However, there has been a paradigm shift from conservative management to curative management with better maternal and fetal outcomes [40]. Othman *et al.*, in their study, reported better outcomes, less recurrence, and complication rates in patients treated with endoscopic retrograde cholangiopancreatography (ERCP) and laparoscopic cholecystectomy than in patients who were put on conservative management [41]. The American College of Gastroenterology clinical guidelines for the management of biliary disease in pregnancy strongly recommend ERCP to be performed in pregnant women presenting with biliary disease such as biliary pancreatitis, symptomatic choledocholithiasis and/or cholangitis that strongly necessitates intervention and strongly recommend early surgical intervention with laparoscopic cholecystectomy in symptomatic cholecystitis [42].

Table 3. Fetal effects from low-level radiation exposure

Effect	Most sensitive period after conception	Threshold dose (mGy) at which an effect was observed in human studies
Prenatal death	0-8	No data
Growth retardation	8-56	200
Organ malformation	14-56	250
Small head size	14-105	No threshold observed
Severe mental retardation	56-105	100
Reduction of IQ	56-105	100
Childhood cancer	0-77	No threshold observed

Modified from [37].

Both open and laparoscopic cholecystectomy is considered safe in all trimesters of pregnancy, although the second trimester of pregnancy is regarded as the safest. According to the Society of American Gastrointestinal and Endoscopic Surgeon guidelines, laparoscopic treatment for acute abdomen has the same benefit to pregnant and non-pregnant patients compared to laparotomy [43]. However, there have been reports of early contraction and premature birth or spontaneous abortion with laparoscopic cholecystectomy [44, 45].

Endoscopic retrograde cholangiopancreatography has the risk of exposure to ionizing radiation and anesthesia. However, it has been reported to be safe and effective during pregnancy with no associated maternal or fetal deaths, stillbirths, congenital malformation, or long-term complications [46, 47]. The risk of pancreatitis was, however, reported to be higher in pregnant patients as compared to the general population [45]. Ultrasound-guided ERCP with no exposure of radiation to the fetus has been described, with promising results [48, 49].

Percutaneous cholecystostomy is a minimally invasive procedure to decompress the gallbladder in cases of severe acute cholecystitis or GB perforation in patients who are not candidates for surgery [50, 51]. In most cases, PCC is feasible under ultrasound guidance, and hence there is no radiation risk to the fetus. Both transhepatic and transperitoneal approaches for placement of catheters can be used; however, the transperitoneal approach is preferred in patients at higher risk of bleeding [50]. Both trocar and Seldinger methods can be used, although the latter is preferred. The patient should be placed in the left lateral decubitus position. In a study by Chiappetta Porras *et al*., comprising 122 pregnant patients presenting with acute biliary tract disease, 69 patients did not respond to conservative medical management [52]. Out of the eight patients presenting in the first trimester, four underwent PCC for acute cholecystitis. Three underwent gallbladder aspiration for recurrent colic. All those presenting in the second trimester (n = 54) were successfully managed with laparoscopic cholecystectomy. Out of the seven patients who presented in the third trimester, four underwent gallbladder aspiration (three for recurrent colic and one for acute cholecystitis). Overall, ERCP was performed in four patients (one in the 1st trimester and three in the 3rd trimester). There was no fetal morbidity or mortality. A few other case series have shown the efficacy of PCC in the management of acute cholecystitis in pregnancy refractory to medical management with no adverse fetal outcome [51-54] (Table 4).

Percutaneous transhepatic biliary drainage involves percutaneous access to the bile ducts and placement of a catheter [55]. It is typically performed using fluoroscopy or a combined ultrasound and fluoroscopic approach, thus exposing the patient to ionizing radiation. However, few studies have reported ultrasound guided PTBD [56, 57]. There is no case series of the effectiveness and safety of PTBD in pregnancy. However, PTBD may be useful in pregnant patients with altered biliary anatomy, who have failure of ERCP or who fail to show resolution of jaundice or cholangitis following ERCP [58]. Following the principles of safe fluoroscopy, a PTBD may be internalized, allowing internal biliary drainage. An alternative to PTBD in failed ERCP is endoscopic ultrasound-guided drainage [59]. Although the initial access to the biliary system is performed via EUS guidance, fluoroscopy is required for wire manip-

Table 4. Studies of percutaneous cholecystostomy in pregnancy

Author	Number of patients	Details	Outcome
Allmendinger *et al.* [51]	One – 32 weeks – failed ERCP One – 30 weeks – recurrent cholecystitis	USG guided percutaneous cholecystostomy	Successful outcome for both fetus and mother
Chiappetta Porras *et al.* [52]	Eight – 1st trimester Fifty-four – 2nd trimester Seven – 3rd trimester	Recurrent gall bladder colic in 1st and 3rd trimester – percutaneous gallbladder aspiration Acute cholecystitis in 1st and 3rd trimester – percutaneous cholecystostomy Biliary obstruction in 1st and 3rd trimester – ERCP 2nd trimester – laparoscopic surgery	Laparoscopic surgery is safest in 2nd trimester; percutaneous procedures may be preferred in 1st and 3rd trimester
Caliskan [53]	Two – 1st trimester Four – 3rd trimester	USG-guided percutaneous cholecystostomy after failed medical therapy	Safe, alternative treatment for palliative purpose in patients with failed medical treatment, comorbid conditions making surgery risky and 3rd trimester of pregnancy
Eller *et al.* [54]	One – 36 weeks	USG-guided transhepatic gallbladder drainage	Biliary decompression followed by laparoscopy 3 months after delivery

ulation. However, EUS-biliary drainage is peformed in very specialized centers and entails a high cost [60-62].

Liver masses

Interventional management of liver masses requires consideration of the size of the lesion, abdominal symptoms, number and location of tumors, surgical and fetal risk, stage of pregnancy, and risk of bleeding [20]. Hepatocellular adenoma in a pregnant patient requires close follow-up to monitor the size and development of complications [63]. IR procedures can be used in emergent conditions such as rupture or bleeding or for definitive management [20, 64]. Transarterial embolization of the hepatic artery or the feeding branches to the tumors from the transfemoral route is less invasive than surgery. In acute bleeding episodes in hepatic adenoma, selective arterial embolization is usually the preferred first-line treatment [65]. It is generally followed by surgical resection; however, it can be used as definitive management in lesions < 5 cm in size [20]. Stoot *et al*. used selective arterial embolization in a term primigravida with features of rupture of liver adenoma [66]. Some authors advocate conservative management with close monitoring in patients with asymptomatic adenoma, especially those which are smaller, with less risk of rupture [67]. However, with increasing size or larger lesions at presentation, there is an increased risk of complications, and thus treatment becomes necessary either with IR techniques or surgery [20, 68]. RFA is a minimally invasive procedure and is considered safest in the 2nd trimester. Fujita *et al*. reported successful treatment of hepatic adenoma in a pregnant patient using RFA in the 18th week of gestation [69]. A multicentric prospective study is being undertaken to make a model for the management of adenoma during pregnancy [70].

Hepatocellular carcinoma diagnosed during the first trimester can be treated as for non-pregnant patients after termination of pregnancy if the mother is willing. However, in advanced gestation and when continuation of the pregnancy is desired, a multidisciplinary approach is needed. Surgical resection, TACE, RFA, and systemic chemotherapy are treatment options. Surgical resection is considered the safest and best potential curative therapy. It is safest in the 2nd trimester when continuation of the pregnancy is desired [71]. IR treatment of HCC is safe; however, there are no specific guidelines [20].

Matsuo *et al*. reported a case of a 33-year-old woman who was hepatitis B positive, diagnosed with HCC at 17 weeks of gestation [72]. RFA was performed at 17 weeks of gestation, followed by resection in the postpartum period with a successful outcome.

Liver hemangiomas are managed conservatively when of size < 10 cm [22]. Intervention is usually needed in the presence of rapidly increasing volume, rupture, and bleeding, which is proposed to be more frequent in pregnancy due to hormonal changes. The preferred treatment for symptomatic hepatic hemangioma is surgical enucleation and resection [22]. However, selective arterial embolization may be advocated in cases where surgery is not feasible or contraindicated. A case report of the embolization of symptomatic liver hemangioma with intratumoral bleeding has been described [73]. The patient presented at 18 weeks of gestation with acute abdominal pain and a diagnosis of 9 cm sized hemangioma was made. The tumor was embolized, and the subsequent antenatal and postpartum period was uneventful.

Hydatid cyst

Medical management is usually advocated in cases of hydatid cyst. Albendazole is the drug of choice. It is considered teratogenic in the first trimester and hence contraindicated during this period. A larger cyst usually requires intervention due to the associated risk of rupture [74]. Surgical treatment in the later stages of pregnancy is associated with an increased risk of breach of the cyst and associated complications as well as precipitation of labor [75]. Ultrasound-guided puncture of the cyst, aspiration of cystic fluid, injection of scolicidal agent, and re-aspiration of solution (PAIR) may be utilized as an alternative to surgery. However, these cases are limited to a few case reports [27, 76, 77]. Ghosh *et al*. managed a 33-year-old multiparous female with Gharbi type II hydatid cyst presenting with obstructive jaundice in the third trimester with PAIR [27]. Hypertonic saline was used as the scolicidal agent. Ustunsoz *et al*. studied the long-term results of percutaneous treatment of hepatic hydatid cysts in pregnancy in 6 patients [76]. PAIR with hypertonic saline was performed. Five patients were successfully treated with a solid appearance of the cyst at 22 months. In one patient, cystobiliary fistula was suspected three months after delivery, which was managed with percutaneous catheter drainage of the residual cavity, and nasobiliary catheter within CBD followed by surgery.

Liver abscess

Early management is vital in cases of liver abscess caused by both bacterial and amebic etiology because of high perinatal mortality and maternal mortality re-

sulting from sepsis in untreated cases. Most amoebic liver abscesses respond well to medical management [78]. Metronidazole is the treatment of choice. It is considered safe in pregnancy [79]. Pyogenic liver abscesses, on the other hand, require drainage beside the institution of antibiotics. Ultrasound-guided aspiration of pus is safe and effective for smaller abscesses. However, abscesses with thicker pus and those larger than 5 cm require catheter drainage [80].

Budd-Chiari syndrome

Treatment of BCS includes systemic anticoagulants, interventional thrombolysis, interventional angioplasty, TIPS, surgical shunts, and liver transplantation [28].

TIPS is used to treat portal hypertension associated with BCS; however, its use in pregnant patients does not have specific guidelines. Ingraham *et al*., in their series of 5 pregnant patients with BCS, used TIPS to treat the complications of portal hypertension (prevention of variceal bleeding in four patients and refractory ascites in one patient) [81]. All the five patients had successful pregnancy outcomes for both mother (no bleeding or paracentesis for refractory ascites) and fetus (despite prematurity) with acceptable fetal radiation dose. Several other case reports have been published describing TIPS procedure in pregnant patients with emergent situations and recurrent variceal bleeding despite medical and/or endoscopic therapy [82-84]. The risk of radiation with TIPS despite being low is still a concern for the developing fetus. Now performing TIPS only under USG guidance has been advocated; however, no studies are available on pregnant patients [85, 86].

In conclusion, hepatobiliary disorders are prevalent in pregnancy and need a multidisciplinary approach for diagnosis and management. Fetal radiation dose and physiological changes of pregnancy are critical considerations in management. Minimally invasive radiological procedures allow safe and effective management of various hepatobiliary disorders in pregnancy.

Disclosure

The authors declare no conflict of interest.

References

1. Lata I. Hepatobiliary diseases during pregnancy and their management: An update. Int J Crit Illn Inj Sci 2013; 3: 175-182.
2. Lee NM, Brady CW. Liver disease in pregnancy. World J Gastroenterol 2009; 15: 897-906.
3. Tripti N, Agarwal S. Fetomaternal outcome in jaundice during pregnancy. Obstet Gynecol India 2005; 10: 424-427.
4. Kondrackiene J, Kupcinskas L. Liver diseases unique to pregnancy. Medicina (Kaunas) 2008; 44: 337-345.
5. Mikolasevic I, Filipec-Kanizaj T, Jakopcic I, et al. Liver disease during pregnancy: challenging clinical issue. Med Sci Monit 2018; 24: 4080-4090.
6. Goel A, Jamwal KD, Ramachandran A, et al. Pregnancy-related liver disorders. J Clin Exp Hepatol 2014; 4: 151-162.
7. Tan J, Surti B, Saab S. Pregnancy and cirrhosis. Liver Transpl 2008; 14: 1081-1091.
8. Zakharia K, Tabibian A, Lindor KD, Tabibian JH. Complications, symptoms, quality of life and pregnancy in cholestatic liver disease. Liver Int 2018; 38: 399-411.
9. Westbrook RH, Dusheiko G, Williamson C. Pregnancy and liver disease. J Hepatol 2016; 64: 933-945.
10. Gilat T, Konikoff F. Pregnancy and the biliary tract. Can J Gastroenterol 2000; 14 Suppl D: 55D-59D.
11. Kern F Jr, Everson GT, DeMark B, et al. Biliary lipids, bile acids, and gallbladder function in the human female. Effects of pregnancy and the ovulatory cycle. J Clin Invest 1981; 68: 1229-1242.
12. Davis A, Katz VL, Cox R. Gallbladder disease in pregnancy. J Reprod Med 1995; 40: 759-762.
13. Friley MD, Douglas G. Acute cholecystitis in pregnancy and the puerperium. Am Surg 1972; 38: 314-317.
14. Landers D, Carmona R, Crombleholme W, Lira R. Acute cholecystitis in pregnancy. Obstet Gynecol 1987; 69: 131-133.
15. Baillie J, Cairns SR, Putman WS, Cotton PB. Endoscopic management of choledocholithiasis during pregnancy. Surg Gynecol Obstet 1990; 171: 14.
16. Petrozza JC, Mastrobattista JM, Monga M. Gallbladder perforation in pregnancy. Am J Perinatol 1995; 12: 339-341.
17. Blathazar EJ. Acute pancreatitis: assessment of severity with clinical and CT evaluation. Radiology 2002; 223: 603-613.
18. Gupta P, Rana P, Bellam BL, et al. Site and size of extrapancreatic necrosis are associated with clinical outcomes in patients with acute necrotizing pancreatitis. Pancreatology 2020; 20: 9-15.
19. Gupta P, Dawra S, Chandel K, et al. Fat-modified computed tomography severity index (CTSI) is a better predictor of severity and outcome in patients with acute pancreatitis compared with modified CTSI. Abdom Radiol (NY) 2020; 45: 1350-1358.
20. James M, Black M, Ahmed I, et al. Diagnosis and management of liver masses in pregnancy. Obstet Gynaecol 2016; 18: 43-51.
21. Van Aalten SM, de Man RA, IJzermans JN, Terkivatan T. Systematic review of haemorrhage and rupture of hepatocellular adenomas. Br J Surg 2012; 99: 911-916.
22. Cobey FC, Salem RR. A review of hepatic masses in pregnancy and a proposed algorithm for diagnosis and management. Am J Surg 2004; 187: 181-191.
23. Lau WY, Leung WT, Ho S, et al. Hepatocellular carcinoma during pregnancy and its comparison with other pregnancy-associated malignancies. Cancer 1995; 75: 2669-2676.
24. Kalantri A, Gupta P, Sharma V, et al. Hepatic infections: a comprehensive imaging review. J Gastrointestinal Infect 2019; 9: 38-49.
25. Gupta P, Sinha SK, Malik S, et al. Hepatic visceral larva migrans: a diagnostic enigma. Trop Doct 2018; 48: 345-347.
26. Athanassiou AM, Craigo SD. Liver masses in pregnancy. Semin Perinatol 1998; 22: 166-177.
27. Ghosh JK, Goyal SK, Behera MK, et al. Hydatid cyst of liver presented as obstructive jaundice in pregnancy; managed by PAIR. J Clin Exp Hepatol 2014; 4: 366-369.

28. Bansal V, Gupta P, Sinha S, et al. Budd-Chiari syndrome: imaging review. Br J Radiol 2018; 91: 20180441.
29. Rautou PE, Plessier A, Bernuau J, et al. Pregnancy: a risk factor for Budd-Chiari syndrome? Gut 2009; 58: 606-608.
30. Merz WM, Rüland AM, Hippe V, et al. Pregnancy in Budd-Chiari syndrome: case report and proposed risk score. Medicine (Baltimore) 2016; 95: e3817.
31. Gupta P, Kumar M, Sharma V, et al. Evaluation of gallbladder wall thickening: a multimodality imaging approach. Expert Rev Gastroenterol Hepatol 2020; 14: 463-473.
32. Gupta P, Jain R, Koshi S, et al. Radiation dose from computed tomography in patients with acute pancreatitis: an audit from a tertiary care referral hospital. Abdom Radiol (NY) 2020; 45: 1517-1523.
33. Gupta P, Bansal V, Kumar MP, et al. Diagnostic accuracy of Doppler ultrasound, CT and MRI in Budd Chiari syndrome: systematic review and meta-analysis. Br J Radiol 2020; 93: 20190847.
34. Kamat R, Gupta P, Rana S. Imaging in chronic pancreatitis: state of the art review. Indian J Radiol Imaging 2019; 29: 201-210.
35. Gupta P, Gupta J, Kumar C, et al. Aggressive percutaneous catheter drainage protocol for necrotic pancreatic collections. Dig Dis Sci 2020; doi:10.1007/s10620-020-06116-6.
36. Moon EK, Wang W, Newman JS, et al. Challenges in interventional radiology: the pregnant patient. Semin Intervent Radiol 2013; 30: 394-402.
37. Medical radiation exposure of pregnant and potentially pregnant women. NCRP report no. 54. National Council on Radiation Protection and Measurements; 1977; http://www.ncrppublications.org/Reports/054 [Accessed 18 March 2013].
38. Thabet A, Kalva SP, Liu B, et al. Interventional radiology in pregnancy complications: indications, technique, and methods for minimizing radiation exposure. Radiographics 2012; 32: 255-274.
39. Date RS, Kaushal M, Ramesh A. A review of the management of gallstone disease and its complications in pregnancy. Am J Surg 2008; 196: 599-608.
40. Lu EJ, Curet MJ, El-Sayed YY, et al. Medical versus surgical management of biliary tract disease in pregnancy. Am J Surg 2004; 188: 755-759.
41. Othman MO, Stone E, Hashimi M, et al. Conservative management of cholelithiasis and its complications in pregnancy is associated with recurrent symptoms and more emergency department visits. Gastrointest Endosc 2012; 76: 564-569.
42. Tran TT, Ahn J, Reau NS. ACG clinical guideline: liver disease and pregnancy. Am J Gastroenterol 2016; 111: 176-194.
43. Pearl J, Price R, Richardson W, Fanelli R. Guidelines for diagnosis, treatment, and use of laparoscopy for surgical problems during pregnancy. Surg Endosc 2011; 25: 3479-3492.
44. Graham G, Baxi L, Tharakan T. Laparoscopic cholecystectomy during pregnancy: A case series and review of the literature. Obstet Gynecol Surv 1998; 53: 566-574.
45. Barone JE, Bears S, Chen S, et al. Outcome study of cholecystectomy during pregnancy. Am J Surg 1999; 177: 232-236.
46. Tang SJ, Mayo MJ, Rodriguez-Frias E, et al. Safety and utility of ERCP during pregnancy. Gastrointest Endosc 2009; 69 (3 Pt 1): 453-461.
47. Cappell MS. The fetal safety and clinical efficacy of gastrointestinal endoscopy during pregnancy. Gastroenterol Clin North Am 2003; 32: 123-179.
48. Meves V, Pohl J. Trans-abdominal ultrasound guided ERC in a pregnant woman with bile duct stones. Video J Encyclopedia GI Endoscopy 2014; 2: 9-11.
49. Shelton J, Linder JD, Rivera-Alsina ME, Tarnasky PR. Commitment, confirmation, and clearance: new techniques for non-radiation ERCP during pregnancy (with videos). Gastrointest Endosc 2008; 67: 364-368.
50. Little MW, Briggs JH, Tapping CR, et al. Percutaneous cholecystostomy: the radiologist's role in treating acute cholecystitis. Clin Radiol 2013; 68: 654-660.
51. Allmendinger N, Hallisey MJ, Ohki SK, Straub JJ. Percutaneous cholecystostomy treatment of acute cholecystitis in pregnancy. Obstet Gynecol 1995; 86: 653-654.
52. Chiappetta Porras LT, Nápoli ED, et al. Minimally invasive management of acute biliary tract disease during pregnancy. HPB Surg 2009; 2009: 829020.
53. Caliskan K. The use of percutaneous cholecystostomy in the treatment of acute cholecystitis during pregnancy. Clin Exp Obstet Gynecol 2017; 44: 11-13.
54. Eller A, Shim S, Sigvardt L, et al. Treatment of acute cholecystitis in a third-trimester pregnant women. Ugeskr Laeger 2016; 178: V12150954.
55. Gupta P, Gupta J, Kumar MP. Imaging in obstructive jaundice: what a radiologist needs to know before doing a percutaneous transhepatic biliary drainage. J Clin Radiol ISVIR 2020; 4: 31-37.
56. Nennstiel S, Treiber M, Faber A, et al. Comparison of ultrasound and fluoroscopically guided percutaneous transhepatic biliary drainage. Dig Dis 2019; 37: 77-86.
57. Miyazaki M, Shibuya K, Tokue H, Tsushima Y. Percutaneous transhepatic biliary drainage assisted by real-time virtual sonography: a retrospective study. BMC Gastroenterol 2013; 13: 127.
58. Gupta P, Maralakunte M, Rathee S, et al. Percutaneous transhepatic biliary drainage in patients at higher risk for adverse events: experience from a tertiary care referral center. Abdom Radiol (NY) 2019. doi: 10.1007/s00261-019-02344-1.
59. Lee JJ, Lee SK, Kim SH, et al. Efficacy and safety of pancreatobiliary endoscopic procedures during pregnancy. Gut Liver 2015; 9: 672-678.
60. Singla V, Arora A, Tyagi P, et al. Failed common bile duct cannulation during pregnancy: Rescue with endoscopic ultrasound guided rendezvous procedure. Endosc Ultrasound 2016; 5: 201-205.
61. Girotra M, Jani N. Role of endoscopic ultrasound/Spyscope in diagnosis and treatment of choledocholithiasis in pregnancy. World J Gastroenterol 2010; 16: 3601-3602.
62. Chong VH. EUS complements ERCP during pregnancy. Gastrointest Endosc 2009; 70: 1285-1286.
63. Chong VH, Jalihal A. Endoscopic management of biliary disorders during pregnancy. Hepatobiliary Pancreat Dis Int 2010; 9: 180-185.
64. European Assosiation for the study of the Liver (EASL). EASL clinical practice guidelines on the management of bengin liver tumours. J Hepatol 2016; 65: 386-398.
65. Dokmak S, Paradis V, Vilgrain V, et al. A single-centre surgical experience of 122 patients with single and multiple hepatocellular adenomas. Gastroenterology 2009; 137: 1698-1705.
66. Stoot JH, van Roosmalen J, Terpstra OT, Schaapherder AF. Life-threatening hemorrhage from adenomas in the liver during pregnancy. Dig Surg 2006; 23: 155.
67. Noels JE, van Aalten SM, van der Windt DJ, et al. Management of hepatocellular adenoma during pregnancy. J Hepatol 2011; 54: 553-558.
68. Thomeer MG, Broker M, Verheij J, et al. Hepatocellular adenoma: when and how to treat? Update of current evidence. Therap Adv Gastroenterol 2016; 9: 898-912.

69. Fujita S, Kushihata F, Herrmann GE, et al. Combined hepatic resection and radiofrequency ablation for multiple hepatic adenomas. J Gastroenterol Hepatol 2006; 21: 1351-1354.
70. Van Aalten SM, Bröker ME, Busschbach JJ, et al. Pregnancy and liver adenoma management: PALM-study. BMC Gastroenterol 2012; 12: 82.
71. Li AJ, Zhou WP, Lu JH, et al. Surgery for pregnancy-associated primary hepatocellular carcinoma: Report of four cases. Int J Surg Case Rep 2014; 5: 882-885.
72. Matsuo M, Furukawa K, Shimizu H, et al. Novel treatment strategy with radiofrequency ablation and surgery for pregnant patients with hepatocellular carcinoma: a case report. Surg Case Rep 2018; 4: 43.
73. Graham E, Cohen AW, Soulen M, Faye R. Symptomatic liver hemangioma with intra-tumor hemorrhage treated by angiography and embolization during pregnancy. Obstet Gynecol 1993; 81 (5 Pt 2): 813-816.
74. Gupta P, Debi U, Sinha SK, Prasad KK. Role of endoscopic retrograde cholangiography in ruptured hepatic hydatid. Trop Gastroenterol 2015; 36: 21-24.
75. Malhotra N, Chanana C, Kumar S. Hydatid disease of the liver during pregnancy: a case report and review of literature. Int J Gynecol Obstet 2006; 7: 1-4.
76. Ustunsoz B, Ugurel MS, Uzar AI, Duru NK. Percutaneous treatment of hepatic hydatid cyst in pregnancy: long-term results. Arch Gynecol Obstet 2008; 277: 547-550.
77. Musaev GK, Sharipov RK, Fatyanova AS, et al. Echinococcosis and pregnancy: approaches to the treatment. Khirurgiia (Mosk) 2019; 5: 38-41.
78. Read KM, Kennedy-Andrews S, Gordon DL. Amoebic liver abscess in pregnancy. Aust N Z J Obstet Gynaecol 2001; 41: 236-237.
79. Koss CA, Baras DC, Lane SD, et al. Investigation of metronidazole use during pregnancy and adverse birth outcomes. Antimicrob Agents Chemother 2012; 56: 4800-4805.
80. Yüksel B, Seven A, Kucur S, et al. Presentation and management of pyogenic liver abscess in a 23-week pregnant woman. Case Rep Obstet Gynecol 2013; 2013: 845215.
81. Ingraham CR, Padia SA, Johnson GE, et al. Transjugular intrahepatic portosystemic shunt placement during pregnancy: a case series of five patients. Cardiovasc Intervent Radiol 2015; 38: 1205-1210.
82. Wildberger JE, Vorwerk D, Winograd R, et al. New TIPS placement in pregnancy in recurrent esophageal varices hemorrhage – assessment of fetal radiation exposure. Rofo 1998; 169: 429-431.
83. Savage C, Patel J, Lepe MR, et al. Transjugular intrahepatic portosystemic shunt creation for recurrent gastrointestinal bleeding during pregnancy. J Vasc Interv Radiol 2007; 18: 902-904.
84. Lodato F, Cappelli A, Montagnani M, et al. Transjugular intrahepatic portosystemic shunt: a case report of rescue management of unrestrainable variceal bleeding in a pregnant woman. Dig Liver Dis 2008; 40: 387-390.
85. Liang HL, Liu WC, Huang JS, et al. TIPS in patients with cranial porta hepatis: ultrasound-guided transhepatic portohepatic-portocaval puncture in single needle pass. AJR Am J Roentgenol 2011; 196: 914-918.
86. Raza SA, Walser E, Hernandez A, et al. Transhepatic puncture of portal and hepatic veins for TIPS using a single-needle pass under sonographic guidance. Am J Roentgenol AJR 2006; 187: W87-W91.