ORIGINAL ARTICLE

Pregnancy Outcome in Women with Pulmonary Artery Hypertension: A Retrospective Time-bound Study in a Tertiary Care Institute in North Eastern India

Nalini Sharma[1], Ritisha Basu[2], Shweta Mishra[3], Kaushiki Singh[4], Sundaram S Priyan[5], Dimple Kharkongor[6], Aryan Sharma[7], Santa Singh[8]

Received on: 05 January 2024; *Accepted on:* 28 May 2024; *Published on:* 09 July 2024

Abstract

Background: Pregnancy complicated with pulmonary artery hypertension (PAH), lies at increased risk of maternal and neonatal complications. Although studies have reported mortality rates of up to 56% associated with pregnancy in PAH, however, with a multidisciplinary approach including obstetrics, anesthesia, and cardiology, care in women with PAH has improved. It is necessary to investigate if such a modern multidisciplinary approach has led to a reduction in maternal mortality and has improved maternal and fetal outcomes.

Aim: Our study evaluates maternal and fetal outcomes in pregnant women with PAH in a tertiary care setting in North Eastern India with a multidisciplinary approach.

Materials and methods: This retrospective, hospital-based, time-bound study was done on 54 pregnancies complicated by PAH, over one and a half years. Patients were evaluated for the development of any cardiac complications like arrhythmia, congestive cardiac failure, thromboembolism, and atrial fibrillation. Maternal obstetric complications were evaluated like postpartum hemorrhage, anemia, and pregnancy-induced hypertension. Gestational age at delivery and mode of delivery were also noted. Fetal complications like preterm delivery, fetal growth restriction, intrauterine fetal death, and congenital cardiac disease were noted.

Results: The mode of delivery was LSCS in the majority (77.7%), with the mean gestational age of delivery being 38 weeks and 5 days. On the assessment of PAH, the mild degree was seen in the majority of cases (55.6%), moderate PAH in around 29.6%, and a severe degree of PAH was seen in only 14.8% of cases. The majority of cardiac defects associated with PAH were congenital cardiac diseases in the form of ASD and VSD (68.5%). The majority of patients had spinal anesthesia (42.85%) during LSCS. General anesthesia was used in only 10 cases (23.8%). Preterm deliveries and fetal growth restriction were seen in around 14 and 33% of cases respectively, with no intrauterine fetal death. Cardiac complications occurred in 11% of cases and maternal obstetric complications occurred in 29.6% of cases. No maternal death was noted in the study group. On further analysis, it was seen that maternal complications were significantly higher among those with a higher degree of PAH ($p = 0.006$). Also, the baby's birth weight was significantly lower with an increase in the severity of PAH. On Bonferroni *post hoc* analysis, the association was between mild and severe PAH ($p < 0.01$) and between moderate and severe PAH ($p = 0.016$).

Conclusion: Our study has shown no maternal mortality over a group of 54 pregnant women. This study thereby appraises the contribution of a multidisciplinary approach in the management of these patients.

Keywords: Heart disease in pregnancy, Multidisciplinary approach, Pulmonary artery hypertension.

Journal of South Asian Federation of Obstetrics and Gynaecology (2024): 10.5005/jp-journals-10006-2454

Introduction

Pulmonary artery hypertension (PAH) is caused by the narrowing of pulmonary vasculature which can lead to right heart failure if not optimally managed. Pulmonary artery hypertension can be idiopathic or may be caused as a result of cardiac ailments like congenital heart disease, valvular heart disease, cardiomyopathy, chronic thromboembolic disease, or other systemic diseases.[1]

Pulmonary artery hypertension is often considered a contraindication in pregnancy because of the inability of a compromised right ventricle to adjust to the hemodynamic changes of pregnancy and labor.[2–5] Literature shows pregnancy complicated with PAH, is an increased risk of maternal and neonatal complications, sometimes leading to maternal death.[6] Pulmonary artery hypertension is more common in females and may sometimes be diagnosed first time in pregnancy.[7]

Women with pregnancies with accompanying PAH are on the rise. Although Studies have reported mortality rates of up to 56% associated with pregnancy in PAH, however with a multidisciplinary approach with obstetrics, anesthesia, and cardiology, care in women with PAH in modern times has improved.[8] Advancements in the management of such high-risk pregnancies have been

[1,2,4–6,8]Department of Obstetrics and Gynaecology, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, Meghalaya, India

[3,7]Department of Obstetrics and Gynaecology, Rama Medical College and Research Center, Hapur, Uttar Pradesh, India

Corresponding Author: Ritisha Basu, Department of Obstetrics and Gynaecology, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, Meghalaya, India, Phone: +91 8910560163, e-mail: basu.ritisha312@gmail.com

How to cite this article: Sharma N, Basu R, Mishra S, *et al.* Pregnancy Outcome in Women with Pulmonary Artery Hypertension: A Retrospective Time-bound Study in a Tertiary Care Institute in North Eastern India. J South Asian Feder Obst Gynae 2024;16(4):383–387.

Source of support: Nil

Conflict of interest: None

due to the early identification of underlying conditions, in-depth knowledge of the cardiovascular system, modern obstetric care, and the following of newer comprehensive multidisciplinary protocols.

It is thereby important to study the effect of PAH on pregnancy in the present times where the development of novel cardiac medications has succeeded in controlling the disease. It is necessary to investigate if the multidisciplinary approach has translated into a reduction in maternal mortality and has improved outcomes.

Our study thus evaluates maternal and fetal outcomes in pregnant women with PAH in a tertiary referral care setting in North Eastern India with a multidisciplinary approach.

Materials and Methods

This retrospective, hospital-based, time-bound study was done in the Department of Obstetrics and Gynecology of a tertiary referral Institute in North Eastern India for one and a half years.

We included all the pregnant women with PAH who delivered during the period. The inclusion criteria were pregnant patients presenting with signs and symptoms of heart disease with PAH confirmed by Doppler echocardiography.[8] In the evaluation of PAH, echocardiographic measurements revealing a pulmonary artery systolic pressure of 35–55 mm Hg indicated mild PAH, while values of 56–75 mm Hg suggested moderate PAH. A pulmonary artery systolic pressure exceeding 75 mm Hg was indicative of severe PAH.[9]

The present study included 54 pregnant women and pregnancy outcomes were studied. Patients were evaluated for the development of any cardiac complications like arrhythmia, congestive cardiac failure, thromboembolism, and atrial fibrillation. Maternal obstetric complications were evaluated like postpartum hemorrhage, anemia, and pregnancy-induced hypertension. Gestational age at delivery and mode of delivery were noted. Fetal complications like preterm delivery, fetal growth restriction, intrauterine fetal death, and congenital cardiac disease were evaluated.

Statistical Analysis

Data was analyzed using SPSS version 21. Depending on the type of distribution, categorical variables were expressed as frequency and percentages, and continuous variables were expressed as mean or median (Interquantile range).

Chi-square test was used to determine the association between the severity of PAH and complications. The association between the severity of PAH and the baby's birth weight was determined using One-way ANOVA with the Bonferroni *post hoc* test. A *p*-value of < 0.05 was considered statistically significant.

Results

In this study, 54 pregnant women with PAH were studied for 1 and a half years. The average gestational age of delivery was 38 weeks and 5 days with 14.8% being preterm deliveries and 18% being postdated deliveries (Table 1).

The majority of cardiac defects associated with PAH were congenital cardiac diseases in the form of ASD and VSD (68.5%). Maternal obstetric complications occurred in 29.6% of cases (95% CI: 18.4–43.8%). The majority of patients with maternal obstetric complications had pregnancy-induced hypertension (10 patients, 18.51%). Four patients (7.4%) had severe anemia and 2 (3.7%) had a postpartum hemorrhage, both groups requiring blood transfusion.

Table 1: Obstetric character of the study population ($n = 54$)

Variable	*Frequency*	*Percentage*
Age [Mean (SD)]		29.19 (5.103) years
Parity		
Primipara	16	29.6%
Multipara	38	70.4%
Mode of delivery		
LSCS	42	77.7%
Vaginal delivery	8	14.8%
Instrumental delivery	4	7.4%
Birth weight [Mean (SD)] in gms		2731.1 (559.26) gms

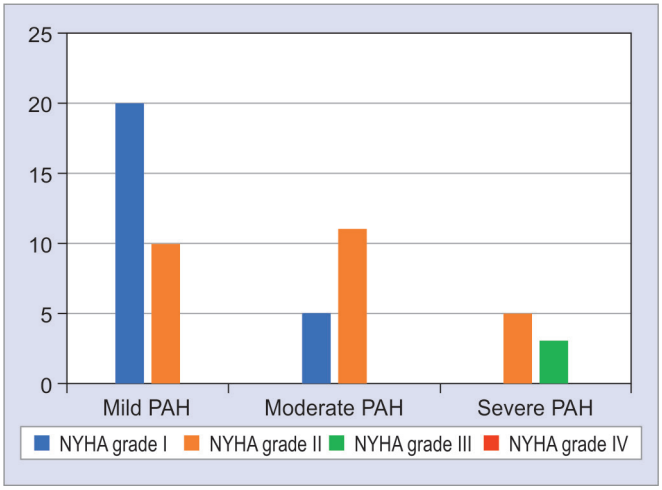

Fig. 1: Bar chart showing the percentage of NYHA grades in each category of PAH

Fetal complications occurred in 27.7% cases. Cardiac complications occurred in 11% of the study group—2 cases of right heart failure and 4 cases of arrhythmia.

In studying treatment used for the patients, tablet torsemide a diuretic was used in most cases followed by tablet/injection furosemide. The mean duration of stay in the hospital was 7.40 days, with the maximum duration being 14 days (Figs 1 and 2) (Tables 2 to 5).

Discussion

Maternal and Fetal Complications

In our study, preeclampsia was seen in 18.5% of cases. Maternal anemia was seen in 7.4% of cases and postpartum hemorrhage was seen in 3.7% of cases. Maternal complications were significantly higher among those with a higher degree of PAH ($p = 0.006$). Thomas et al., studied the National Inpatient Sample (NIS) from 2003 to 2012. The study found that women with PAH suffered more from eclampsia syndromes, preterm delivery, and intrauterine fetal demise ($p < 0.0001$ for all). Pulmonary artery hypertension subtype was significantly associated with maternal adverse events ($p < 0.001$).[10]

In our study, birth weight less than 2.5 kgs was seen in 33.33% of babies. There were no cases of intrauterine fetal demise, cardiac anomalies or early neonatal death. Also, the birth weight of the babies significantly reduced with an increase in the severity of PAH.

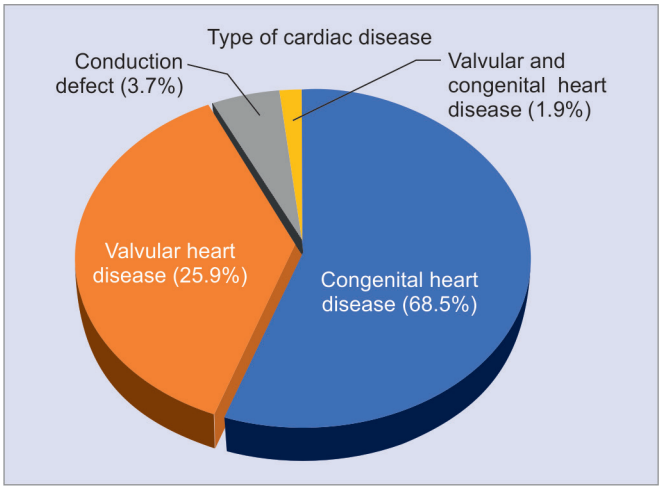

Fig. 2: Pie chart showing the distribution of cardiac disease in the population

Table 2: Clinical characters of the study population

Variable	*Frequency*	*Percentage*
Degree of pulmonary hypertension ($n = 54$)		
Mild	30	55.6%
Moderate	16	29.6%
Severe	8	14.8%
Complications		
Cardiac complications	6	11.1%
Cardiac arrhythmia–4 cases		
Right heart failure–2 cases		
Maternal obstetric complications	16	29.6%
Preeclampsia–18.5%		
Anemia–7.4%		
Postpartum hemorrhage–3.7%		
Fetal complications	15	27.7%
Low birth weight–33.3%		
Preterm delivery–14.1%		
Type of anesthesia used ($n = 42$)		
Spinal anesthesia	18	42.9%
Epidural anesthesia	14	33.3%
General anesthesia	10	23.8%

Poor fetal growth in one-third of our study group agrees with similar reports noted in pregnancy outcomes in heart disease patients, owing to the relation of uteroplacental insufficiency resulting from impaired cardiac output. In a study by Karen Sliwa et al., a cohort of 151 women with PAH was analyzed from the European Registry on Pregnancy and Heart Disease in 2007. Complications recorded were: miscarriage (5.6%), fetal mortality (2%), premature delivery (21.7%), low birth weight (19.0%), and neonatal mortality (0.7%). Early neonatal death occurred in 14 pregnancies (9.3%). Six neonates (4.0%) were reported to have cardiac anomalies.[11]

In our study, preterm delivery occurred in 14.1% of the patients. This agrees with a scientific statement from the American Heart Association, stating that the risk of preterm delivery is 10–12% in

Table 3: Treatment used with adjoining frequency and percentage

Treatment	*Frequency*	*Percentage*
Diuretics	25	46.29%
Sildenafil	18	33.33%
Calcium channel blocker	10	18.51%
Enoxaparin	16	29.62%
Digoxin	6	11.11%
Benzathine penicillin	6	11.11%
Vasopressors	2	3.70%

Table 4: Shows that maternal complications were significantly higher with the severity of PAH ($p = 0.006$)

	Maternal complications		
Severity of PAH	*Yes n (%)*	*No n (%)*	*p-value*
Mild	8 (26.1%)	22 (73.3%)	
Moderate	2 (12.5%)	14 (87.5%)	0.006
Severe	6 (75%)	2 (25%)	

Table 5: Shows that there was a significant association between the severity of PAH and decreased birth weight of the baby. On Bonferroni *post hoc* analysis, the association was between mild and severe PAH ($p < 0.01$) and between moderate and severe PAH ($p = 0.016$)

	Birth weight in gms		
Severity of PAH	*Mean*	*Standard deviation*	*p-value*
Mild PAH	2948.33	547.740	
Moderate PAH	2659.38	402.098	<0.001*
Severe PAH	2060.00	223.735	

*One way ANOVA

maternal congenital heart disease whereas, in complex congenital heart disease, the rate of preterm birth is as high as 22–65%.[2]

Mode of Delivery with Timing

The preferred method of delivery in PAH remains a topic of ongoing discussion. The process of normal vaginal delivery is linked to a 34% rise in cardiac output upon full cervical dilation.[12] The dynamics of labor and delivery introduce volume shifts heightening the risk of elevated pulmonary vascular pressure. This hemodynamic stress can induce hypercarbia and acidosis, leading to a sudden rise in pulmonary artery pressure thereby resulting in refractory right heart failure.[13] Therefore, a planned cesarean can be considered a safe mode of delivery, although vaginal delivery is not considered contraindicated.[3] Cesarean should be planned during daytime hours when input from seniors from departments of obstetrics, anesthesia, and cardiology can be reached.

In our study population, cesarean section was done in the majority 77.77% of cases with the majority being elective LSCS (78.57%). Jaïs et al. conducted a comprehensive examination of pregnancy outcomes across 13 pulmonary hypertension centers spanning Europe, the USA, and Australia during a 3-year interval from 2007 to 2010. Their findings revealed that a substantial 94% of deliveries were planned cesarean sections, typically taking place between the 31 and 38 weeks of pregnancy.[14] Similarly, Keily et al., in a study spanning six years and focusing on the management of pregnancies complicated by PAH, observed that 90% of women

underwent elective cesarean sections. This practice significantly contributed to the study's noteworthy maternal outcomes.[15]

Anesthesia

Earlier research has indicated unfavorable results for women undergoing emergency cesarean sections under general anesthesia, revealing an elevated mortality risk in the immediate postpartum phase. The heightened maternal mortality associated with general anesthesia can be attributed to various mechanisms, including the increase in peripheral vascular resistance induced by general anesthesia. This rise is facilitated by factors such as heightened sympathetic stimulation during tracheal intubation, the impact of anesthesia-related medications, elevated airway plateau pressure resulting from positive-pressure mechanical ventilation, and pulmonary vasoconstriction triggered by alveolar hypoxia.[16–19] In a research investigation led by Jaïs X et al., 62% of pregnancies complicated by PAH were successfully carried to term. Regrettably, three individuals, constituting 12% of the cohort, experienced fatalities in the early postpartum period due to right heart failure. Notably, all of these women had severe PAH and had general anesthesia during delivery.[14]

In our study, general anesthesia was used only in around 23% of cases. 2 cases of postpartum right heart failure were suffering from severe PAH and received general anesthesia during cesarean section. Thereby, it can be commented that the excellent outcome of our study can be attributed to the restricted use of general anesthesia.

Type of Treatment Received

The majority of women in our study were treated with diuretics followed by sildenafil and calcium channel blockers as advised by the hospital's cardiology team.

In Bédard et al. systematic review on maternal and fetal outcomes in PAH, 32 and 20% of patients who received nitric oxide and prostacyclin analog, died in due course.[6] However, the advanced therapies were commenced in severely morbid patients, when patients had already developed heart failure and were hemodynamically unstable. Therefore, advanced therapy must be instituted early in treatment with PAH. In our study, sildenafil-phosphodiesterase type V inhibitor was used in almost one-third of all cases.

No universally established thromboprophylaxis protocol exists for PAH in pregnancy.[20] While our study does not provide specific insights into the recommended type and scope of thromboprophylaxis, it underscores the importance of promptly considering and implementing such measures in collaboration with a multidisciplinary team.

Cardiac Complications and Maternal Mortality

Cardiac complications were seen in around 11% (6 patients) of our study group. Cardiac arrhythmia was seen in 4 patients. The arrhythmia was seen in 1 case of mild PAH and 3 cases of moderate PAH. One out of 4 patients developed arrhythmia in the antenatal period and the rest developed arrhythmia post-delivery after cesarean section.

Two instances of right heart failure were observed, manifesting in the postpartum period after cesarean sections conducted under general anesthesia. This underscores the persistent difficulty faced by patients with PAH in adapting to the hemodynamic alterations by acute changes during delivery and the postpartum phase. Notably, all cases of right heart failure were identified in individuals with severe PAH categorized as NYHA grade III, necessitating intensive care management under cardiology supervision.

Our study was conducted on 54 pregnant women with PAH and no maternal death was noted. This shows an evolving result in the management of women with PAH where a multidisciplinary approach can be taken as the cornerstone of such maternal outcomes. Besides efficient follow-up and management, a cause of low maternal death in our study can also be attributable to the fact that most women in our study group had mild PAH (55.6%) with the majority being in NYHA grade I and grade II signifying a good control. Severe PAH was seen only in 8 cases, signifying only 14.8% of the cases. Bonnin et al. had reviewed 15 consecutive cases of pregnancies complicated by severe PAH and found a mortality rate as high as 36%.[21]

Another subject of interest in our study is that most of the cardiac ailment associated with PAH was congenital heart disease. It might have a role in the good outcome as the condition was probably known to the patient pre-pregnancy and was well controlled. Serious cardiac condition like Eisenmenger syndrome, a significant contributor to maternal mortality, was seen only in 3 cases.[22] One case of Eisenmenger was complicated by severe preeclampsia and was delivered by cesarean section by epidural anesthesia.

Bédard et al. conducted a systematic review of all published reports on pregnancies in women with PAH from 1997 to 2007.[6] A comparative analysis of the findings was done with the results from the Weiss et al. study, which reported on late pregnancy outcomes in PAH patients spanning from 1978 to 1996.[23] Upon comparing the two study cohorts over two consecutive decades, a noteworthy reduction in mortality was evident across all three subgroups. Specifically, mortality rates decreased from 30 to 17% in idiopathic PAH, 36 to 28% in PAH associated with congenital heart disease, and 56 to 33% in PAH stemming from other causes. When compared, the results of our study can be supported by the modern PAH-targeted therapies available and an increase in experience in successfully handling PAH cases. Also in our study population, multigravida comprised 75% of the population. This observation indicates that multigravida tolerates the stress of pregnancy and delivery better, leading to high success in maternal outcomes. These findings are consistent with the study by Bédard et al., which showed primigravidae were at higher mortality risk.[6]

Currently, US And European guidelines state that, in PAH, pregnancy should be terminated in the early period of gestation.[9,24] Our study strengthens that, this recommendation remains strong in poorly controlled PAH, however, in women with the well-controlled condition, individualization in management with multidisciplinary input should be offered as with modern therapies.

Duration of Stay

The average duration of hospital stay in our study was 7.4 days. A stay of one week postpartum not only warrants close monitoring for primary and secondary postpartum hemorrhage but also helps in monitoring early postpartum cardiac complications. However, the effects of pregnancy on the cardiovascular system persist for several months after delivery.[25] Therefore, a follow-up till 6 months after delivery is justified.

Limitation

Maternal death in PAH cases can occur even beyond 6 months postpartum as the effects of pregnancy on the hemodynamic

changes can last for several months after delivery.[3] Late maternal follow-up was not included in our study, which contributes to one of the limitations. Future studies can be done on this subject, where late maternal follow-up is also included.

Conclusion

Our study has shown no maternal mortality over a group of 54 pregnant women with PAH. This study thereby appraises the contribution of a multidisciplinary approach and the contribution of elective cesarean under regional anesthesia. However, it is important to note that most women in our study group had mild to moderate pulmonary hypertension.

It should be emphasized that as PAH pregnancies are extremely high risk, contraception, and preconception counseling is of utmost importance, especially in women with severe and poorly controlled PAH.

Orcid

Nalini Sharma https://orcid.org/0000-0001-5462-3017

References

1. Siu SC, Sermer M, Colman JM, et al. Cardiac disease in pregnancy (CARPREG) investigators. Prospective multi-center study of pregnancy outcomes in women with heart disease. Circulation 2001;104(5):515–521. DOI: 10.1161/hc3001.093437.
2. Canobbio MM, Warnes CA, Aboulhosn J, et al. Management of pregnancy in patients with complex congenital heart disease: A scientific statement for healthcare professionals from the American Heart Association. Circulation 2017;135(8):e50–e87. DOI: 10.1161/CIR.0000000000000458.
3. European Society of Gynecology (ESG), Association for European Paediatric Cardiology (AEPC), German Society for Gender Medicine (DGesGM), et al. ESC Guidelines on the management of cardiovascular diseases during pregnancy: The task force on the management of cardiovascular diseases during pregnancy of the European Society of Cardiology (ESC). Eur Heart J 2011;32(24):3147–3197. DOI: 10.1093/eurheartj/ehr218.
4. Hemnes AR, Kiely DG, Cockrill BA, et al. Statement on pregnancy in pulmonary hypertension from the Pulmonary Vascular Research Institute. Pulm Circ 2015;5(3):435–465. DOI: 10.1086/682230.
5. Pieper PG, Hoendermis ES. Pregnancy in women with pulmonary hypertension. Neth Heart J 2011;19(12):504–508. DOI: 10.1007/s12471-011-0219-9.
6. Bédard E, Dimopoulos K, Gatzoulis MA. Has there been any progress made on pregnancy outcomes among women with pulmonary arterial hypertension? Eur Heart J 2009;30(3):256–265. DOI: 10.1093/eurheartj/ehn597.
7. Humbert M, Sitbon O, Chaouat A, et al. Pulmonary arterial hypertension in France: Results from a national registry. Am J Respir Crit Care Med 2006;173(9):1023–1030. DOI: 10.1164/rccm.200510-1668OC.
8. Oh JK. Echo Manual, Chapter 9, 3rd edition. Wolters Kluwer; 2017. pp. 145–153.
9. Galiè N, Hoeper MM, Humbert M, et al. Guidelines for the diagnosis and treatment of pulmonary hypertension: The task force for the diagnosis and treatment of pulmonary hypertension of the European society of cardiology (ESC) and the European Respiratory Society (ERS), endorsed by the International Society of heart and lung transplantation (ISHLT). Eur Heart J 2009;30(20):2493–2537. DOI: 10.1093/eurheartj/ehp297.
10. Thomas E, Yang J, Xu J, et al. Pulmonary hypertension and pregnancy outcomes: Insights from the national inpatient sample. J Am Heart Assoc 2017;6(10):e006144. DOI: 10.1161/JAHA.117.006144.
11. Sliwa K, van Hagen IM, Budts W, et al. Pulmonary hypertension and pregnancy outcomes: Data from the Registry of Pregnancy and Cardiac Disease (ROPAC) of the European Society of Cardiology. Eur J Heart Fail 2016;18(9):1119–1128. DOI: 10.1002/ejhf.594.
12. Hunter S, Robson SC. Adaptation of the maternal heart in pregnancy. Br Heart J 1992;68(6):540–543. DOI: 10.1136/hrt.68.12.540.
13. Weiss BM, Hess OM. Pulmonary vascular disease and pregnancy: Current controversies, management strategies, and perspectives. Eur Heart J 2000;21(2):104–115. DOI: 10.1053/EUHJ.1999.1701.
14. Jaïs X, Olsson KM, Barbera JA, et al. Pregnancy outcomes in pulmonary arterial hypertension in the modern management era. Eur Respir J 2012;40(4):881–885. DOI: 10.1183/09031936.00141211.
15. Kiely DG, Condliffe R, Webster V, et al. Improved survival in pregnancy and pulmonary hypertension using a multiprofessional approach. BJOG 2010;117(5):565–574. DOI: 10.1111/j.1471-0528.2009.02492.x.
16. Hickey PR, Retzack SM. Acute right ventricular failure after pulmonary hypertensive responses to airway instrumentation: Effect of fentanyl dose. Anesthesiology 1993;78(2):372–376. DOI: 10.1097/00000542-199302000-00025.
17. Kerbaul F, Rondelet B, Motte S, et al. Isoflurane and desflurane impair right ventricular-pulmonary arterial coupling in dogs. Anesthesiology 2004;101(6):1357–1362. DOI: 10.1097/00000542-200412000-00016.
18. Blaise G, Langleben D, Hubert B. Pulmonary arterial hypertension: Pathophysiology and anesthetic approach. Anesthesiology 2003;99(6):1415–1432. DOI: 10.1097/00000542-200312000-00027.
19. Moudgil R, Michelakis ED, Archer SL. Hypoxic pulmonary vasoconstriction. J Appl Physiol 2005;98(1):390–403. DOI: 10.1152/japplphysiol.00733.2004.
20. Pitts JA, Crosby WM, Basta LL. Eisenmenger's syndrome in pregnancy: Does heparin prophylaxis improve the maternal mortality rate? Am Heart J 1977;93(3):321–326. DOI: 10.1016/s0002-8703(77)80251-2.
21. Bonnin M, Mercier FJ, Sitbon O, et al. Severe pulmonary hypertension during pregnancy: Mode of delivery and anesthetic management of 15 consecutive cases. Anesthesiology 2005;102(6):1133–1137; discussion 5A–6A. DOI: 10.1097/00000542-200506000-00012.
22. Balint OH, Siu SC, Mason J, et al. Cardiac outcomes after pregnancy in women with congenital heart disease. Heart 2010;96(20):1656–1661. DOI: 10.1136/hrt.2010.202838.
23. Weiss BM, Zemp L, Seifert B, et al. Outcome of pulmonary vascular disease in pregnancy: A systematic overview from 1978 through 1996. J Am Coll Cardiol 1998;31(7):1650–1657. DOI: 10.1016/s0735-1097(98)00162-4.
24. McLaughlin VV, Archer SL, Badesch DB, et al. ACCF/AHA 2009 expert consensus document on pulmonary hypertension a report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents and the American Heart Association developed in collaboration with the American College of Chest Physicians; American Thoracic Society, Inc.; and the Pulmonary Hypertension Association. J Am Coll Cardiol 2009;53(17):1573–1619. DOI: 10.1016/j.jacc.2009.01.004.
25. Clapp JF 3rd, Capeless E. Cardiovascular function before, during, and after the first and subsequent pregnancies. Am J Cardiol 1997;80(11):1469–1473. DOI: 10.1016/s0002-9149(97)00738-8.