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Epidemiology, lung mechanics and outcomes of ARDS: A comparison between pregnant and non-pregnant subjects

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ABSTRACT

Purpose: We describe the epidemiology, lung mechanics and outcomes of acute respiratory distress syndrome (ARDS) complicating pregnancy. We also compare the outcomes of ARDS in pregnant and non-pregnant females.
Methods: Retrospective observational study of all women admitted with ARDS.
Results: 211 women with ARDS were admitted, which included 27 (12.8%) pregnant subjects. All were ventilated with a low tidal volume strategy. Most pregnant females presented during the third trimester. There was no difference in the lung compliance, the applied PEEP and the plateau pressures across trimesters. The pregnant females had a lower median age (25 [22-28] vs. 32 [22–42] years, $p = 0.003$), higher proportion of severe ARDS (40.8% vs. 10.3%, $p < 0.0001$), and higher driving pressure (18.2 vs. 15.5 cm H_2O, $p = 0.03$) compared to non-pregnant females. The maternal (18.5%) and perinatal (37%) mortality was high. However, the mortality was not different between pregnant and non-pregnant subjects with ARDS. On a multivariate logistic regression analysis, the baseline APACHE II score, driving pressure and the delta SOFA score were independent predictors of mortality.
Conclusions: ARDS complicating pregnancy is severe and is associated with high perinatal mortality. However, the outcomes of ARDS in pregnant females were similar to non-pregnant females.

1. Introduction

Acute respiratory distress syndrome (ARDS) is a heterogeneous disorder that is characterized by the presence of acute onset hypoxemia, new-onset infiltrates on the chest radiograph and the exclusion of cardiogenic pulmonary edema [1]. Depending on the severity of ARDS, the hospital mortality varies between 35% and 46% [2]. Based on the mechanism of injury, ARDS has been classified as pulmonary (injury to the alveolar epithelium) or extrapulmonary (injury to the vascular endothelium) [3,4]. Although the mortality is similar in both forms of ARDS, they behave differently, with the latter responding better to higher positive end expiratory pressure (PEEP) [5].

ARDS can complicate pregnancy both due to causes unique to pregnancy (chorioamnionitis, septic abortions, amniotic fluid embolism, retained placental products and others), or otherwise (sepsis, pneumonia, multiple transfusions, pancreatitis and others). With improvements in ventilatory strategies (low-tidal volume strategy, prone position ventilation), survival in ARDS has improved dramatically [6,7]. However, in most clinical trials, pregnancy has been an exclusion criteria [6,7]. Although, the principles of mechanical ventilation during pregnancy should remain more or less similar, certain strategies such as prone position ventilation may be difficult during pregnancy, especially during the third trimester [8]. Also, the gravid uterus by increasing the abdominal pressure can alter the chest wall compliance and may cause difficulty in mechanical ventilation. All these factors may offer unique challenges while ventilating pregnant women with ARDS and could potentially impact the outcomes [9-11]. We hypothesized that the outcomes of ARDS complicating pregnancy should be different from non-pregnant females with ARDS. Herein, we describe our experience of ARDS complicating pregnancy. The fetal outcomes (perinatal mortality) are also presented. In addition, we compare the etiology, lung mechanics and the outcomes of ARDS in women with or without pregnancy.

2. Methods

We performed a retrospective analysis of women with ARDS admitted to the respiratory intensive care unit (RICU) of this institute, between 1st January 2009 and 31st October 2016. The diagnosis of acute lung injury (ALI) or ARDS was made using the American-European

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Consensus Conference (AECC) definition [12] before 2012, and later by the Berlin definition [1]. The Institute Ethics Committee approved the study protocol, and granted a consent waiver as it involved the retrospective use of anonymized patient data. We use a customized computer software to enter the daily data of patients. Data recorded at the time of admission to RICU and every 24 h were reviewed for this study. The worst value for each variable during the 24-h period was recorded in this database. The time interval from RICU admission to 8:00 AM the next day was defined as day 0. Acute Physiology and Chronic Health Evaluation (APACHE II) scores and Sequential Organ Failure Assessment (SOFA) scores were calculated using the values on day 0. Subsequent days were calendar days timed from 8:00 AM to 8:00 AM of the next day. Delta SOFA was calculated as a difference between the maximum SOFA score during the RICU stay and the baseline SOFA score [13,14].

The following information was retrieved on a data extraction form: (a) demographic profile; (b) presence of co-morbid illness; (c) pregnant or non-pregnant; (d) baseline SOFA scores, delta SOFA, APACHE II scores; (e) type of respiratory support (non-invasive or invasive ventilation); (f) duration of mechanical ventilation (MV); (g) worst values of the following physiologic and ventilator parameters recorded daily (Pa_{O2}/Fi_{O2} ratio, PEEP, plateau pressure [Pplat], driving pressure [Pplat minus PEEP] and static compliance [Cstat]); (h) ICU and hospital length of stay (LOS); and, (i) the final outcome at discharge from hospital. The included subjects with ARDS were categorized as mild (200⟩ $Pa_{O2}:Fi_{O2}$ ratio ≤ 300), moderate (100⟩ $Pa_{O2}:Fi_{O2}$ ratio ≤ 200) and severe ARDS ($Pa_{O2}:Fi_{O2}$ ratio ≤ 100) [1].

Patients with ARDS complicating pregnancy were labeled as preg-ARDS while ARDS in non-pregnant females was labeled as ARDS-others. The following additional details were noted in pregnant subjects; duration of gestation, gestational age of the fetus, condition of the fetus at admission and at hospital discharge (alive or dead).

All subjects received the standard of care followed in RICU, including enteral feeding, deep venous thrombosis and stress-ulcer prophylaxis, unless contraindicated. Sedation and neuromuscular paralysis was used in all the subjects during the initial 24–48 h of mechanical ventilation [15]. In addition, pregnant subjects and their fetus(es) were monitored regularly by the obstetricians. Fetal assessment was done once daily using the ultrasound. We ventilated the subjects with volume-controlled mode using the low tidal volume strategy as per the ARDSnet protocol [6]. The target SpO_2 in pregnant females was kept at ≥95% while in non-pregnant females it was kept between 89 and 94% [16].

3. Endpoints

The primary objective was to describe the occurrence, epidemiology, and outcome of ARDS in pregnant subjects (and their fetus).

The secondary objectives were: (a) description of the epidemiology and outcomes of all women with ARDS; and (b) comparison of etiology, ventilator parameters, and final outcome of ARDS in subjects with and without pregnancy.

3.1. Statistical analysis

We used the commercial statistical package (IBM SPSS Statistics for windows, version 22.0. Armonk, NY: IBM Corp) for statistical analysis. Descriptive frequencies and categorical variables were expressed as median (interquartile range [IQR]), mean (standard deviation [SD]) or as percentages for the group, respectively. Differences between the categorical and continuous variables were compared using the Chi-square test and the Kruskal-Wallis, respectively. The repeated measure analysis was done using the mixed models using the 1st order Autoregressive, AR (1) structure. We performed multivariate logistic regression analysis to identify variables associated with mortality. Survival curves were constructed to study the effect of pregnancy in ARDS on ICU mortality for the RICU stay using Kaplan-Meier curves. Differences between the

Table 1
The clinical profile, etiology, severity and ventilator parameters of ARDS in women (pregnant and non-pregnant).

Parameter	Preg-ARDS ($n = 27$)	ARDS-others ($n = 184$)	Total ($n = 211$)	p value
Clinical and laboratory parameters				
Age, years	25 (22–28)	32 (22–42)	30 (22–40)	**0.003**
Mean BP, mmHg	83.3 (70–91.3)	83.3 (74–92)	83.3 (74–92)	0.85
Vasopressor dependent shock, n (%)	3 (11.1)	35 (19.0)	38 (18)	0.43
Presence of co-morbid illness, n (%)	3 (11.1)	51 (27.7)	54 (25.6)	0.10
Serum Creatinine, mg/dL	0.8 (0.5–1.3)	0.8 (0.6–1.4)	0.8 (0.6–1.3)	0.81
Hemoglobin, g/dL	9.2 (7.5–11.3)	9.9 (8.6–12.3)	9.8 (8.4–12.1)	**0.04**
Total leukocyte count, per cu.mm	13,600 (9300–17,400)	9890 (8000–15,825)	10,800 (8000–16,000)	**0.03**
Platelet count, lakhs/cu.mm	2.7 (1.4–3)	2.1 (0.9–3)	2.5 (0.9–3)	0.48
Blood glucose, mg/dL	120 (105–156)	130.5 (96–164.8)	129 (98–164)	0.73
Serum albumin, mg/dL	2.6 (2.2–3.4)	2.6 (2–3)	2.6 (2–3.1)	0.42
ICU severity scores				
Baseline APACHE II score	20 (12–24)	17 (11–24.7)	17 (11–24)	0.82
Delta SOFA	0 (0–2)	1 (0–3)	1 (0–3)	0.13
Etiology of ARDS				**0.008**
Pulmonary ($n = 104$)				
Infective pneumonia	18 (66.7)	74 (40.2)	92 (43.6)	
Pulmonary tuberculosis	1 (3.7)	7 (3.8)	8 (3.8)	
Others[a]	0	4 (2.2)	4 (1.8)	
Extrapulmonary ($n = 107$)				
Sepsis	6 (22.2)	95 (51.6)	101 (47.9)	
Acute pancreatitis	1 (3.7)	4 (2.2)	5 (2.4)	
Others[b]	1 (3.7)	0	1 (0.5)	
Severity of ARDS, n (%)				**<0.0001**
Mild	9 (33.3)	69 (37.5)	78 (36.7)	
Moderate	7 (25.9)	96 (52.2)	103 (49)	
Severe	11 (40.8)	19 (10.3)	30 (14.3)	
Ventilator parameters				
Invasive MV, n (%)	26 (96.3)	174 (94.6)	200 (94.8)	0.29
Baseline $Pa_{O2}:Fi_{O2}$ ratio	108.8 (73.9–207.5)	173.3 (124–237.5)	169.1 (120–233.6)	**0.004**
Baseline Fi_{O2}	0.55 (0.41–0.68)	0.46 (0.43–0.49)	0.47 (0.44–0.50)	0.12
Baseline pH	7.31 (7.21–7.39)	7.38 (7.29–7.41)	7.37 (7.28–7.41)	0.052
Baseline Pa_{CO2}, mmHg	37.5 (30.4–48.8)	37.9 (31.5–44.9)	37.9 (31.4–45)	0.99
Baseline HCO_3, mEq/L	20.3 (17.5–23.1)	22 (22.1–22.8)	22 (21.2–22.8)	0.18
Pplat at ICU admission, cmH_2O	30 (27.3–31.8)	25 (21—30)	26 (21-30)	**0.008**
PEEP at ICU admission, cmH_2O	10 (6–14)	8 (5–12)	8.5 (5–12)	0.07
Cstat at ICU admission, mL/cmH_2O	17 (13–27.3)	20 (15.4–27.3)	20 (15–27)	0.16
Driving pressure, cmH_2O	18 (16–20)	16 (12.5–18)	19 (13–19)	**0.03**

Values are provided as median (interquartile range) unless otherwise specified.
APACHE: acute physiology and chronic health evaluation; ARDS: acute respiratory distress syndrome; BP: blood pressure; Cstat: static lung compliance; HCO_3: bicarbonate; ICU: intensive care unit; MV: mechanical ventilation;$Pa_{O2}:Fi_{O2}$ ratio: partial pressure of oxygen: fraction of inspired oxygen ratio; Pa_{CO2}: partial pressure of carbon dioxide; PEEP: positive end expiratory pressure; Pplat: plateau pressure; Preg-ARDS: pregnancy related ARDS; SOFA: sequential organ failure assessment. Bold represents statistically significant.
[a] Vasculitis, toxic inhalation, diesel aspiration, drowning, lung contusion.
[b] Unknown poisoning, unknown insect/animal bite, transfusion related.

Table 2
Comparison of maternal and fetal outcomes across different trimesters of pregnancy, in subjects with ARDS.

Parameter	Ist trimester (n = 1)	IInd trimester (n = 9)	IIIrd trimester (n = 17)	Total (n = 27)	P value
Physiological parameters					
Severity of ARDS, n (%)					0.78
Mild	0	3 (33.3)	6 (35.3)	9 (33.3)	
Moderate	0	2 (22.3)	5 (29.4)	7 (25.9)	
Severe	1 (100)	4 (44.4)	6 (35.3)	11 (40.8)	
Baseline Pa_{O2}:Fi_{O2} ratio	44.7	142.7 (92.6)	143.1 (71.9)	139.3 (78.6)	0.49
Baseline PPlat, cmH_2O	35	29.4 (2.3)	28.1 (6.3)	28.9 (5.2)	0.44
Baseline PEEP, cmH_2O	14	9 (5.2)	11.5 (4.9)	10.9 (5)	0.46
Baseline Cstat, mL/cmH_2O	13.2	17.8 (6.6)	21.2 (8.7)	19.5 (7.8)	0.52
Outcome parameters					
Maternal mortality, n (%)	1 (100)	1 (11.1)	3 (17.6)	5 (18.5)	0.13
Fetal status at ICU admission, n (%)					
Alive	1 (100)	9 (100)	16 (94.1)	26 (96.3)	0.74
Dead	0	0	1 (5.9)	1 (3.7)	
Fetal outcome at ICU discharge, n (%)					
Alive	0	6 (66.7)	7 (41.2)	13 (48.1)	0.51
Dead	1 (100)	2 (22.2)	7 (41.2)	10 (37)	
Unknown	0	1 (11.1)	3 (17.6)	4 (14.9)	

Values are expressed as mean (standard deviation) unless otherwise mentioned.
ARDS: acute respiratory distress syndrome; Cstat: static lung compliance; ICU: intensive care unit; Pa_{O2}:Fi_{O2} ratio: partial pressure of oxygen:fraction of inspired oxygen ratio; PEEP: positive end expiratory pressure; Pplat: plateau pressure.

survival curves were analyzed using the log-rank test. A *p*-value < 0.05 was considered statistically significant.

4. Results

4.1. Occurrence and epidemiology of ARDS complicating pregnancy

During the study period, 211 women were admitted with ARDS (Table 1), which included 27 (12.8%) pregnant subjects. The median (IQR) age of the pregnant subjects was –significantly lesser than those without pregnancy (25 [22-28] vs. 32 [22–42] years, respectively; $p = 0.003$). The etiology of ARDS during pregnancy included community-acquired pneumonia ($n = 18$), pulmonary tuberculosis (n = 1), complicated malaria ($n = 1$), acute pancreatitis (n = 1) and transfusion-related lung injury (n = 1). Pregnancy-specific causes (including puerperal sepsis [$n = 4$] and hemolysis elevated liver enzymes with low platelet [HELLP] syndrome [n = 1]) of ARDS were seen in 5 subjects (18.5%). Invasive MV was required in 26 subjects (96.3%).

The pregnant subjects commonly presented in the third trimester of pregnancy ($n = 17$, 63%). One subject presented in the first trimester, while the remaining nine (33.3%) were in the second trimester of pregnancy. The baseline physiologic parameters and severity of ARDS was similar across all the trimesters (Table 2). The mean (SD) arterial Pa_{CO2} and pH after 48 h of MV were 34.3 (5) mm Hg and 7.39 (0.06), respectively.

4.2. Maternal and fetal outcomes

Maternal mortality in the preg-ARDS group was 18.5% ($n = 5/27$); there was no difference across the various trimesters (Table 2). Of the 27 pregnant subjects, 26 had a live fetus in-utero at admission; in one instance the fetus was not viable at admission. Four women delivered in the RICU, of which two were still births (one each in second and third trimesters). At the time of discharge, ten fetuses (37% mortality) did not suvive (Table 2). This included five instances of paired mortality (both the mother and the fetus) during ICU stay.

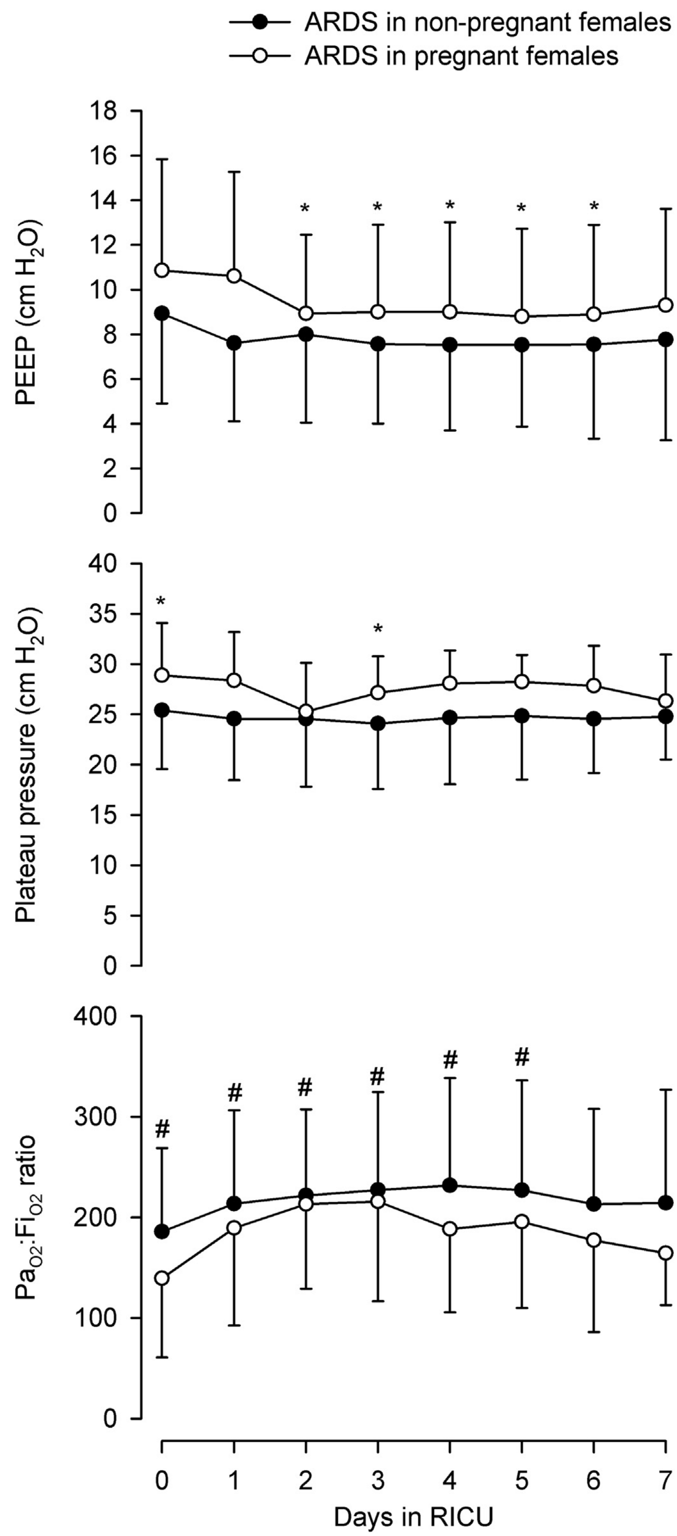

Fig. 1. Trends of applied PEEP, Pa_{O2}:Fi_{O2} ratio and Pplat levels from baseline to day 7 in female subjects with ARDS. There was significant difference between pregnant (white circles) and non-pregnant females (black circles) at baseline. Circles = mean values; error bar = SD. * significantly different between subjects; # significantly different between subjects and with-in subjects over time (mixed model technique of repeated measure analysis).

Table 3
Outcomes of ARDS in women with and without pregnancy, admitted to the intensive care unit (ICU).

Outcomes	Preg-ARDS (n = 27)	ARDS-others (n = 184)	Total (n = 211)	p value
Hospital Mortality, n (%)	5 (18.5)	38 (20.7)	43 (20.4)	1.0
ICU length of stay, days	10 (4–17)	7 (4–13)	7 (4–14)	0.20
Hospital length of stay, days	17 (7–27)	11 (6–19)	11 (6.8–19.3)	0.12
Duration of MV, days	6.5 (2–14.3)	5 (3−10)	5.5 (3−11)	0.06
Tracheostomized in ICU, n (%)	3 (11.1)	17 (9.2)	20 (9.5)	0.73

Values are provided as median (interquartile range) unless otherwise specified.
ARDS: acute respiratory distress syndrome; ICU – intensive care unit; MV: mechanical ventilation; Preg-ARDS: pregnancy related ARDS.

4.3. Comparison of preg-ARDS and ARDS-others

During the study period, 184 subjects were admitted with a diagnosis of ARDS-others. Pulmonary causes of ARDS were higher in pregnant females as compared to ARDS-others (70.4% vs. 46.2%, $p = 0.008$) (Table 1). The ARDS-others group had a higher median hemoglobin compared to pregnant subjects (Table 1). The proportion of subjects with severe ARDS was significantly higher during pregnancy (40.8% vs. 10.3% respectively, $p < 0.0001$). The driving pressure and Pplat at baseline were also significantly higher in the pregnant subjects. The static lung compliance was not different between the two groups (Table 1). Fig. 1 shows the trends of oxygenation (Pa_{O2}:Fi_{O2} ratio) and lung mechanics (PEEP and Pplat) over the course of the hospital stay (day 0 to day 7). The Pa_{O2}:Fi_{O2} ratio and Pplat were different between subjects at baseline and at day 3. The Pa_{O2}:Fi_{O2} ratio was also significantly different between and with-in subjects at days 1 through 5 when compared to baseline.

There were 43 (20.4%) deaths, and the mortality was similar (Table 3) in the preg-ARDS and the ARDS-others (18.5% vs. 20.7%, $p = 1.0$). On a multivariate logistic regression analysis, the baseline APACHE II score (aOR 1.11, 95% CI 1.02–1.21, $p = 0.02$), the driving pressure (aOR 1.19, 95% CI 1.02–1.40, $p = 0.027$) and the delta SOFA scores (aOR 1.55, 95% 1.18–2.03, $p = 0.002$) were independent predictors of mortality in women admitted with ARDS (Table 4). Pregnancy did not affect the survival in the study population. The time to ICU mortality was similar between the two groups (Fig. 2).

5. Discussion

The results of this study suggest that pregnancy with ARDS was an uncommon indication for ICU admission (13%). Pregnancy-specific causes of ARDS were encountered in 19% of these subjects, with puerperal sepsis being the most common etiology. The maternal (18.5%) and the perinatal (37%) mortality in ARDS complicating pregnancy was high. There was no difference in the severity of ARDS, physiologic parameters, maternal and fetal outcomes across the trimesters. Pregnant women had a higher proportion of severe ARDS requiring higher driving pressures for ventilation, as compared to ARDS-others. However, the mortality and other outcomes in the preg-ARDS group were similar to the ARDS-others. On a multivariate logistic regression analysis pregnancy did not influence the survival of women with ARDS.

ARDS complicating pregnancy may be expected to behave differently with the need for a higher PEEP as the effect of gravid uterus increases the abdominal pressures and displaces the diaphragm upwards, thereby reducing the chest wall compliance. This was seen in the current study, where the level of required PEEP was significantly higher in pregnant women during the first week of ventilation compared to non-pregnant subjects (Fig. 1). Despite ventilating all the pregnant subjects with a low tidal volume strategy, we were able to maintain the Pa_{CO2} levels and pH (mean [SD] Pa_{CO2} and pH after 48 h of ventilation, 34.3 [5] mm Hg and 7.39 [0.06], respectively). This suggests that the low tidal volume strategy could be used in pregnant females and maintain the Pa_{CO2} and pH in the acceptable range. Unlike previous studies of ARDS complicating pregnancy, non-obstetrical causes were more common in causing ARDS in our cohort [9,17,18]. This is likely due to regional differences in the case-mix. In a previous study comparing the profile of pregnant women across two ICUs from India and US, tropical infections were more commonly seen in the Indian scenario [19]. The overall mortality in our cohort was 20%, which is lesser than the previous reports on ARDS [2]. This could be due to the inclusion of only women in the current study. Female sex steroids have an anti-inflammatory effect and possibly modulates the immunity and response to therapy in ARDS [20]. Pregnant females were significantly younger than the ARDS-others group; however, this is unlikely to impact the outcomes as the difference in age was probably not clinically significant. Finally, pregnant females had a higher proportion of severe ARDS, which is likely due to mechanical factors (upward displacement of diaphragm, basal atelectasis) and the difference in the etiology of ARDS. However, despite these differences we could not find any difference in the ICU and hospital outcomes between the two groups.

Critical illness during pregnancy is associated with increased perinatal mortality and complications including premature labor and low birth weight [11,21,22]. The perinatal mortality in critically ill pregnant patients has been reported to be up to 35%, similar to our study [11,23-25]. Impaired maternal oxygenation causes fetal distress, which may result in premature labor and stillbirth. Also, due to the acuity of illness, only a small window period is available both for assessing the fetus and imparting corrective measures. The use of sedatives and neuromuscular blocking agents for facilitating ventilation may also adversely affect the fetal outcomes [26].

We reviewed the literature for studies describing the management and outcomes of pregnant women with ARDS, published in the last 10 years (Supplemental table 1). Six studies described respiratory failure secondary to H1N1 infection and did not provide information on

Table 4
Predictors of mortality in women with ARDS admitted to the intensive care unit (ICU) using multivariate logistic regression analysis.

Parameter	Survivors ($n = 168$)	Non-survivors ($n = 43$)	aOR (95% CI)	p value
Preg-ARDS, n (%)	22 (13.1)	5 (11.6)	1.11 (0.21–6.06)	0.90
Severe ARDS, n (%)	18 (10.7%)	12 (27.9%)	0.58 (0.14–2.35)	0.45
Baseline APACHE II score[a]	15 (10–23.7)	24 (17–28)	1.11 (1.02–1.21)	**0.02**
Delta SOFA[a]	0 (0–2.7)	2 (0–4)	1.55 (1.18–2.03)	**0.002**
Baseline driving pressure[a], cm H_2O	16 (12–18)	17 (15–20)	1.19 (1.02–1.40)	**0.027**

APACHE: acute physiology and chronic health evaluation; ARDS: acute respiratory distress syndrome; CI: confidence interval; aOR: adjusted odds ratio; Preg-ARDS: pregnancy related ARDS; SOFA: sequential organ failure assessment. Bold represents statistically significant.
[a] Values are presented as median (interquartile range) unless mentioned otherwise.

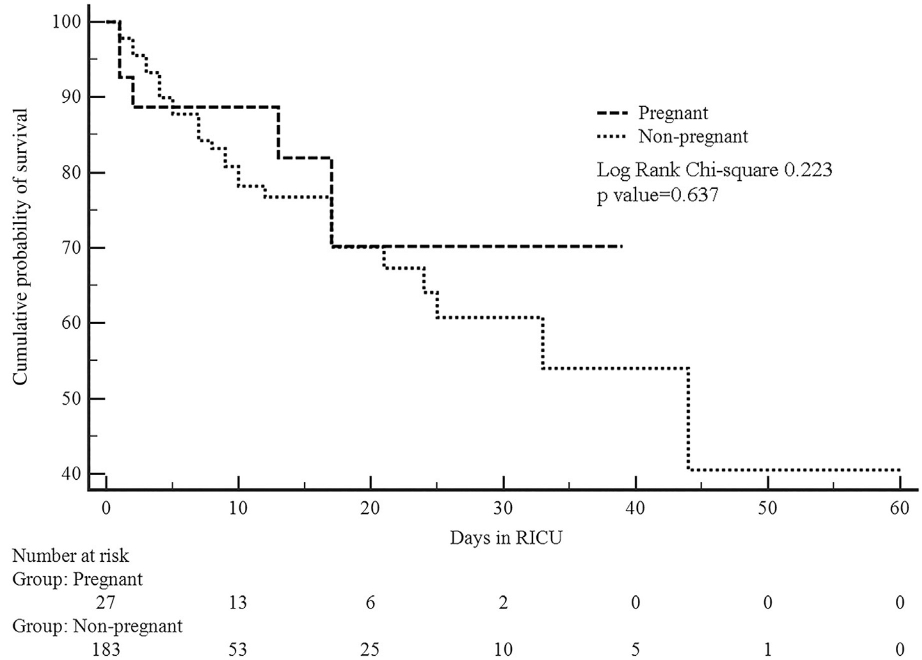

Fig. 2. Kaplan Meier survival curves comparing cumulative probability of mortality in pregnant and non-pregnant women with acute respiratory distress syndrome (ARDS) during the respiratory intensive care unit (RICU) stay.

the ventilatory strategy [23,27-31]. One study included 29 critically ill pregnant subjects who required mechanical ventilation. The subjects were ventilated at a higher tidal volume (7.7 ± 1.5 mL/Kg ideal body weight) with a PEEP of 10.2 ± 4 cmH_20 [32]. However, this study also included subjects without ARDS (with relatively normal lung) and did not have a comparator arm [32]. Another study described maternal mortality in a nationwide inpatient analysis of patients discharged with a diagnosis of ARDS [10]. But this study did not describe the lung mechanics and ventilatory strategies involved in the management of ARDS complicating pregnancy. None of these studies have exclusively described the outcomes in pregnant women with ARDS. To our knowledge, no previous study has compared the outcomes, etiology and lung mechanics of ARDS in pregnant and non-pregnant females.

Finally, our study has a few limitations. It is limited by its small sample size and the retrospective study design. We also did not measure transpulmonary pressures that would have enabled compartmentalization of the respiratory system compliance. As a policy in our ICU, we did not prone pregnant females during ventilation and thus the results of this study do not provide information about prone position ventilation for managing severe ARDS during pregnancy. We believe that proning may hinder fetal monitoring because at least 16 h of prone position is required for improved survival [7]. We did not study the impact of delivery on the lung mechanics and maternal outcomes; however, previous studies have documented only a moderate impact on the maternal respiratory functions following delivery [32,33]. Targeting a higher SpO_2 in the preg-ARDS group could have influenced certain ventilator parameters and outcomes and is a limitation. We also do not have long term follow-up details of mothers with ARDS and the neurological status of their children. Finally, the results of this study cannot be extrapolated to pregnant females without ARDS.

In conclusion, ARDS complicating pregnancy is more severe than ARDS in non-pregnant females, however their outcomes are similar. The development of ARDS during pregnancy is associated with a high perinatal mortality.

Author contributions

VM- involved in patient care, collected data, drafted and revised the manuscript.

RA- provided intellectual content to the manuscript, drafted and revised the manuscript.

SD- drafted and revised the manuscript.

KTP- drafted and revised the manuscript.

ANA- performed statistical analysis, drafted and revised the manuscript.

VS- involved in patient care, and revised the manuscript.

ISS- conceived the idea, performed statistical analysis, drafted and revised the manuscript.

ISS: guarantor of the paper, takes responsibility for the integrity of the work as a whole, from inception to published article.

Conflict of interest

VM- Conflicts of Interest- none, financial disclosures- none
RA- Conflicts of Interest- none, financial disclosures- none
SD- Conflicts of Interest- none, financial disclosures- none
KTP- Conflicts of Interest- none, financial disclosures- none
ANA- Conflicts of Interest- none, financial disclosures- none
VS- Conflicts of Interest- none, financial disclosures- none
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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2018.12.006.

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