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Outcomes of Cardioversion During Pregnancy: A Retrospective Analysis of the National Inpatient Sample

Mohammad Al-Akchar[a, i], Mohamed Alhajji[b], Khalid Sawalha[c], Odalys Estefania Lara Garcia[d], Obada Tarabichi[e], Michael Buhnerkempe[f], Mukul Bhattarai[g], Yansoun Elmasry[h], Anushree Agarwal[a], Mohamed Labedi[g]

Abstract

Background: Rising incidence of cardiac arrhythmias among pregnant women is an increasing concern in the United States. Although pregnancy rates continue to decline in the United States, maternal morbidity and mortality remain on the rise. The purpose of this study was to investigate the relationship between the use of electric cardioversion for pregnant women and the potential maternal and fetal morbidity and mortality.

Methods: Patient data were obtained from the National Inpatient Sample (NIS) from 1993 to 2019. The data included patients that had an ICD-9 diagnosis with either a normal or high risk pregnancy. Patients were separated by whether they had a procedure to restore cardiac rhythm.

Results and conclusion: Our retrospective study showed that pregnant patients who underwent cardioversion did experience a higher rate of mortality (odds ratio = 6.40; 95% confidence interval: 1.95 - 20.96; P = 0.002), with no difference in perinatal outcomes. There was no difference in perinatal outcomes.

Keywords: Cardioversion; Pregnancy; Outcomes

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[a]Cardiovascular Division, University of California San Francisco, San Francisco, CA, USA
[b]Department of Internal Medicine, Augusta University/University of Georgia Medical Partnership, Athens, GA, USA
[c]Department of Internal Medicine, UMass Chan Medical School-Baystate Campus, Springfield, MA, USA
[d]Department of Internal Medicine, University of Mississippi, Oxford, MS, USA
[e]University of Sharjah College of Medicine, Sharjah, United Arab Emirates
[f]Department of Internal Medicine, Center for Clinical Research, Southern Illinois University School of Medicine, Springfield, IL, USA
[g]Cardiovascular Division, Southern Illinois University School of Medicine, Springfield, IL, USA
[h]Department of Internal Medicine, St. Luke's Hospital, Chesterfield, MS, USA
[i]Corresponding Author: Mohammad Al-Akchar, Cardiovascular Division, University of California San Francisco, San Francisco, CA, USA.
Email: alakchar.m@gmail.com

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Introduction

Pregnancy makes for numerous physiological changes in the mother such as hypercoagulability, cardiac remodeling, and decreased vascular resistance [1]. In 2009, the estimated number of pregnancies in the United States was 6,369,000 accounting for 4,131,000 live births, 1,152,000 induced abortions, and 1,087,000 fetal losses [2]. Even though pregnancy rates continue to drop in the United States, maternal morbidity and mortality remain on the rise [2-4]. Arrhythmia prevalence in pregnant females is also on the rise [3, 5]. Whether cardiac arrhythmias in pregnant patients play a role in the increase of maternal morbidity or mortality in the United States is at question.

Electrical cardioversion (ECV) is a procedure that is frequently utilized in clinical practices [6]. It is a valuable tool in the management of patients with new onset arrhythmias and/or refractory cases [7]. There is a substantial risk of complications in pregnant and non-pregnant patients undergoing ECV. This includes but is not limited to thromboembolic events, skin burn, cardiac arrest, and/or other abnormal rhythm [8]. Several case reports published from the 20th century describe the use of ECV in pregnancy [9, 10]. Most of these cases had limited pregnancy outcomes [11]. Thus, we sought to assess outcomes of ECV in pregnancy using a national representative sample of the US population.

Materials and Methods

Study population

We used data from the National Inpatient Sample (NIS) for the years 1993 to 2019. We included all pregnant patients who also were diagnosed with a cardiac arrhythmia. Pregnant patients were identified utilizing International Classification of Diseases, Ninth and Tenth Revision, and Clinical Modification (ICD 9-CM and ICD 10-CM) codes V22, V23, Z34, Z33.1, and O09. An ICD 9-CM code for cardiac dysrhythmias (427) and ICD 10-CM codes for paroxysmal tachycardia (I47), atrial fibrillation and flutter (I48), other cardiac arrhythmias (I49), and unspecified cause cardiac arrest (I46.9) were used to identify cardiac arrhythmias. Patients were separated by whether they had a

procedure to restore cardiac rhythm during their stay as specified by an ICD 9 or 10 Procedure Coding System (ICD 9- or 10-PCS) code of 99.61/99.62/99.69 or 5A2204Z, respectively. The following variables were included from the NIS data: age, sex, race, insurance type, hospital type, and hospital region. Additional comorbidities were identified using ICD 9- and 10-CM codes (Supplementary Material 1, www.jcgo.org).

No IRB was required since data were obtained from the NIS, which is de-identified public database. Ethical compliance is non-applicable given that the data were obtained from the NIS.

Outcome measures

Primary outcomes included in-hospital mortality, length of stay, and total hospital charges. Secondary outcomes were identified using ICD 9- and 10-CM/PCS codes (Supplementary Material 2, www.jcgo.org) and included: preterm labor (ICD 9-CM: 644 or ICD 10-CM: O47/O60), precipitate labor (661.3 or O62.3), cesarean delivery (669.7 or O82), permanent pacemaker implantation (Supplementary Material 2, www.jcgo.org), acute myocardial infarction (MI - 410 or I20), major bleeding (Supplementary Material 2, www.jcgo.org), vascular complications (Supplementary Material 2, www.jcgo.org), acute kidney injury (AKI - 584 or N17), and stroke (432/433/434 or I63).

Statistical analysis

All analyses were weighted using the sample weights for each admission per recommendations from the NIS [12]. Discharge weights allow users to make inferences regarding the overall population in the US with a goal of reducing the bias in inferences. Detailed information on the design of the NIS is available [13].

Univariate comparisons for all outcomes and patient characteristics between those who did and did not receive cardioversion were performed using survey weighted Chi-squared test for categorical variables and survey weighted *t*-tests and Wilcoxon rank-sum tests for normally and non-normally distributed continuous variables, respectively.

For outcomes found to be significant in univariate analysis, further exploration of potential confounding was done. Because cardioversion was not randomly assigned to patients and was likely to be influenced by patient factors, we used propensity score weighting methods, as described by Ridgeway et al [14, 15], to reduce confounding in outcome differences caused by treatment selection bias. Survey weighted logistic regression was used to calculate the probability that each admission received cardioversion (p_x) based on any patient factors found to be significantly different in univariate analyses (i.e., prosthetic valve, ventricular fibrillation, ventricular tachycardia, atrial fibrillation, atrial flutter, cardiac arrest, pre-existing cardiovascular disease, and congenital abnormalities of the heart). The propensity score weights were then defined as $1/p_x$ for those that received cardioversion and $1/(1 - p_x)$ for those that did not. The final weights that were applied to admissions and used in subsequent analyses were calculated by multiplying the sample weights by the propensity score weights. We assessed balance in all variables both before and after propensity score weighting to ensure balance between treatments was maintained or improved. For this, we used standardized differences (i.e., the difference in means or proportions divided by the standard error of the difference). Variables whose Kolmogorov-Smirnov (KS) test statistics were above 0.2 were considered unbalanced.

To determine if outcomes were associated with cardioversion, we used weighted regression analyses, where the weights for admission were the final weights described above and the variable included in the model was whether or not cardioversion was performed. Linear regression was used for continuous outcomes (i.e., total charges) and non-normal outcomes were log-transformed prior to analysis. Logistic regression was used for binary outcomes (i.e., mortality, pacemaker implantation, and acute MI).

For all analyses, statistical significance was set at $P < 0.05$. Analyses were performed using the "survey" [16] and "cobalt" [17] packages in R statistical software [18].

Results

After accounting for sample weights, we found 299 (2.9%) cases of cardioversion in pregnancy out of 10,343 diagnosed cases of cardiac arrhythmia in pregnancy.

Patient characteristics

Patient demographics and characteristics for patients who did and did not undergo cardioversion during pregnancy are summarized in Tables 1 and 2. Patients were more likely to undergo cardioversion at urban teaching hospitals than non-teaching and rural hospitals (Table 1). Patients undergoing cardioversion were also significantly more likely to have ventricular fibrillation, ventricular tachycardia, atrial fibrillation, atrial flutter, cardiac arrest, pre-existing cardiovascular disease, congenital heart abnormalities and a prosthetic valve (Table 2).

Before propensity score weighting, only atrial fibrillation was unbalanced between those undergoing and not undergoing cardioversion (KS = 0.21). After propensity score weighting, all variables were balanced with previously significant differences in ventricular fibrillation, ventricular tachycardia, atrial fibrillation, atrial flutter, cardiac arrest, pre-existing cardiovascular disease, congenital heart abnormalities, and presence of a prosthetic valve found to be eliminated (Table 3). All other variables continued to show no significant difference between those who did and did not undergo cardioversion during pregnancy after propensity score weighting (results not shown).

Outcomes

In univariate analyses, patients undergoing cardioversion in-

Table 1. Demographics of Patients Undergoing Cardioversion in Pregnancy

Characteristic	Cardioversion (n = 299)	No cardioversion (n = 10,044)	P
Age, years, mean (SD)	31.6 (6.4)	30.8 (7.1)	0.33
Race, n (%)			0.28
White	128 (49.1)	5,091 (57.3)	
Black	84 (32.2)	1,928 (21.7)	
Hispanic	35 (13.5)	1,113 (12.5)	
Other	14 (5.2)	757 (8.5)	
Insurance type, n (%)			0.48
Public (Medicare/Medicaid)	96 (32.1)	3,970 (39.5)	
Private	179 (59.8)	5,254 (52.4)	
Other	24 (8.1)	809 (8.1)	
Hospital region, n (%)			0.09
Northeast	62 (20.7)	2,119 (21.1)	
Midwest	44 (14.8)	2,194 (21.8)	
South	93 (31.2)	3,689 (36.7)	
West	99 (33.3)	2,042 (20.3)	
Hospital type, n (%)			< 0.001
Rural	35 (11.7)	981 (9.8)	
Urban nonteaching	35 (11.7)	3,047 (30.4)	
Urban teaching	229 (76.7)	5,998 (59.8)	

SD: standard deviation.

curred higher costs and were more likely to die or have acute MI during hospitalization than those not undergoing cardioversion (Table 2). Pacemaker implantation during hospitalization was less likely in those undergoing cardioversion (Table 2). There was no significant difference in rates of preterm labor, precipitate labor, C-section, major bleeding, vascular complications, AKI, or length of hospital stay (Table 2).

After propensity score weighting, total charges were still higher in those undergoing cardioversion (Table 4: mean difference = $1,580; 95% confidence interval = $1,110 - $2,240; P = 0.01). Cardioversion was also still associated with a higher risk of in-hospital mortality (Table 4: odds ratio = 6.40; 95% confidence interval: 1.95 - 20.96; P = 0.002). Rates of pacemaker implantation and acute MI were no longer found to be significantly different between those who did and did not undergo cardioversion (Table 4).

Discussion

In this large national database study (n = 10,044), 2.9% (n = 299) of pregnant women with cardiac arrhythmias underwent cardioversion. Those undergoing cardioversion were more likely to have pre-existing cardiac conditions, congenital heart abnormalities or prosthetic heart valves. Furthermore, those undergoing cardioversion had a higher cost of stay, and significantly higher odds of inpatient mortality (Table 4: odds ratio = 6.40; 95% confidence interval: 1.95 - 20.96; P = 0.002). Finally, ECV was more likely to occur in teaching hospitals.

Cardiac arrhythmias, though mostly asymptomatic, are common amongst pregnant women being reported in over 50% of this population on Holter monitoring [19]. Data however on the frequency or need for cardioversion are scarce. Similar to other studies, those with existing heart conditions or structural heart disease were more likely to need cardioversion [9, 19, 20]. In one study, 63% of those who underwent cardioversion had an existing heart condition [20].

The safety of cardioversion, both maternal and perinatal, remains the biggest question to answer, and in which our study aimed to highlight some data in relation to this. As previously mentioned, we found that patients who underwent cardioversion had higher odds of inpatient mortality. This is reported in other case series and studies which states that two maternal deaths occurred immediately after cardioversion [21]. On the other hand, several case reports and some studies report that cardioversion was safe and successful even in the presence of congenital heart disease [9, 22-24]. Perhaps the difference in this reported safety can be explained through what we found in our study which showed that pregnant women who underwent cardioversion were more likely sicker having a higher rate of ventricular arrhythmias, cardiac arrests, and pre-existing cardiovascular disease (CVD).

Similar to maternal outcomes, the data on perinatal safety on ECV was also scarce yet controversial. One study reported that in 22 pregnant women who underwent cardioversion two had preterm delivery and two needed an emergent C-section

Table 2. Health Characteristics and Outcomes in Patients Undergoing Cardioversion During Pregnancy

Health characteristic/outcome, n (%), unless otherwise noted	Cardioversion (n = 299)	No cardioversion (n = 10,044)	P
Length of stay, days, median (IQR)	3 (1, 4)	2 (1, 4)	0.71
Total charges, thousands of dollars, median (IQR)	16.6 (11.7, 36.7)	12.6 (5.3, 25.1)	< 0.001
Death	20 (6.7)	198 (2.0)	0.01
Preterm labor	-[a]	495 (4.9)	0.58
Precipitate labor	0 (0)	20 (0.2)	0.73
C-section	0 (0)	90 (0.9)	0.45
Pacemaker implant	-[a]	16 (0.2)	0.01
Acute myocardial infarction	-[a]	43 (0.4)	0.004
Major bleeding	-[a]	498 (5.0)	0.57
Vascular complication	0 (0)	13 (0.1)	0.74
Acute kidney injury	0 (0)	120 (1.2)	0.40
Thromboembolism	0 (0)	20 (02)	0.73
Ventricular fibrillation	19 (6.4)	59 (0.6)	< 0.001
Ventricular flutter	0 (0)	0 (0)	-
Supraventricular tachycardia	70 (23.5)	2,295 (22.8)	0.91
Ventricular tachycardia	39 (13.0)	623 (6.2)	0.03
Paroxysmal tachycardia	0 (0)	78 (0.8)	0.49
Atrial fibrillation	100 (33.4)	1,285 (12.8)	< 0.001
Atrial flutter	51 (16.9)	184 (1.8)	< 0.001
Cardiac arrest	39 (13.0)	258 (2.6)	< 0.001
Presence of cardiac resynchronization therapy	-[a]	144 (1.4)	0.88
Pre-existing CVD	90 (30.1)	1,600 (15.9)	0.004
Ischemic cardiomyopathy	0 (0)	25 (0.2)	0.70
Peripartum cardiomyopathy	0 (0)	65 (0.7)	0.53
Ventricular hypertrophy	0 (0)	41 (0.4)	0.63
Cardiovascular collapse	0 (0)	405 (4.0)	0.11
Cardiogenic shock	-[a]	35 (0.3)	0.10
Hypertrophic subaortic stenosis	0 (0)	-[a]	0.86
Non-rheumatic valve disorders	21 (6.9)	594 (5.9)	0.75
Endocarditis	0 (0)	11 (0.1)	0.81
Valve disease	-[a]	132 (1.3)	0.17
Presence of prosthetic valve	13 (4.5)	36 (0.4)	< 0.001
Congenital abnormalities of the heart	20 (6.6)	139 (1.4)	0.001
Pulmonary artery stenosis	0 (0)	20 (0.2)	0.73
Mild to moderate pre-eclampsia	0 (0)	129 (1.3)	0.37
Severe pre-eclampsia	-[a]	120 (1.2)	0.74
Pre-existing hypertension with pre-eclampsia	0 (0)	115 (1.1)	0.41
Transient cerebral ischemic attack	0 (0)	15 (0.1)	0.77
Multiple gestation	-[a]	235 (2.3)	0.61
Thyroid gland disorder	0 (0)	34 (0.3)	0.65
Hypothyroidism	15 (5.0)	369 (3.7)	0.59
Thyrotoxicosis/hyperthyroidism	-[a]	120 (1.2)	0.74
Diabetes mellitus	20 (6.7)	712 (7.1)	0.91
Gestational diabetes mellitus	15 (5.0)	261 (2.6)	0.25
Premature separation of placenta	-[a]	85 (0.8)	0.50
Blood clotting disorder	-[a]	147 (1.5)	0.89

[a]Cell count is censored according to NIS guidelines (i.e., cell count ≤ 10). IQR: interquartile range; CVD: cardiovascular disease.

Table 3. Distribution of Health Characteristics Undergoing Cardioversion During Pregnancy After Applying Propensity Score Weights

Health characteristic/outcome, n (%), unless otherwise noted	Cardioversion (n = 9,468)	No cardioversion (n = 10,346)	P
Ventricular fibrillation	59 (0.6)	74 (0.7)	0.83
Ventricular tachycardia	681 (7.2)	665 (6.4)	0.81
Atrial fibrillation	1,550 (16.4)	1,389 (13.4)	0.48
Atrial flutter	295 (3.1)	231 (2.2)	0.44
Cardiac arrest	306 (3.2)	292 (2.8)	0.77
Pre-existing CVD	2,025 (21.4)	1,691 (16.3)	0.36
Presence of prosthetic valve	80 (0.8)	54 (0.5)	0.56
Congenital abnormalities of the heart	90 (1.0)	167 (1.6)	0.34

CVD: cardiovascular disease.

due to fetal distress after cardioversion [9]. The authors attributed this to hypertonic uterus as a result of ECV [9]. Adamson and peers reported that these outcomes are likely related to hypotension and poor placental perfusion and supported this by one case of stillbirth after an ICD shock in a hemodynamically unstable patient [19]. The American Heart Association's statement on cardiac arrest in pregnancy states that cardioversion is safe to perform, as minimal energy is delivered to the fetus. Our study, similar to others too, found that ECV had no direct adverse effect on perinatal outcomes [23, 24]. This supports the explanation of Adamson and peers that support the idea that ECV itself has no direct effects on the uterus [25].

Limitations

This study has several limitations. NIS is a validated database that is large and nationally representative. However, there are several limitations to our study related to the use of collected electronic healthcare data. The sample size of those undergoing cardioversion during pregnancy, while adequate for the present analysis, is relatively small impacting potential generalization. Being a retrospective study, the possibility of unmeasured confounders is present. Specifically, ejection fraction, single ventricle physiology, or pulmonary hypertension could play a role and were not measured here. We used propensity score weighting to account for non-random assignment of treatment related to underlying conditions. It is known that individuals undergoing cardioversion for conditions like ventricular fibrillation, congenital heart disease, or cardiac arrest would be more likely to have the primary outcome. Although these conditions and others were adjusted for in the propensity score analysis and showed balance between treatment groups, it is possible that residual confounding in these and other conditions may impact outcomes. Additionally, we did not have information around hemodynamic parameters during the procedure, vasopressor use or hemodynamic compromise. Finally, the analysis was limited to in-hospital outcomes and no long-term outcomes and complications after discharge were studied.

Conclusion

Our study showed pregnant patients who underwent cardioversion appeared to have more significant arrhythmias that led to higher rates of inpatient mortality. These patients were more likely to have existing heart conditions and structural heart disease. Finally, there was no difference in perinatal outcomes in patients receiving ECV versus not.

Supplementary Material

Suppl 1. A full list of comorbidities and associated codes.

Suppl 884-001. Suppl 2. A full list of secondary outcomes and associated codes.

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Table 4. Propensity Score Weighted Differences in Outcomes Between Those Who Did and Did Not Undergo Cardioversion

Outcome	Mean difference/OR	95% CI		P
		Lower bound	Upper bound	
Total charges, thousands of dollars	1.58	1.11	2.24	0.01
Death	6.40	1.95	20.96	0.002
Pacemaker implant	0.35	0.04	3.45	0.37
Acute myocardial infarction	5.18	0.79	33.99	0.09

OR: odds ratio; CI: confidence interval.

Financial Disclosure

None to declare.

Conflict of Interest

None to declare.

Informed Consent

Non-applicable.

Author Contributions

M. Alakchar, and KS participated in the idea of the manuscript and in the manuscript writing. M. Buhnerkempe and M. Bhattarai performed the Data analysis. M. Alhajji, OG, and OT, participated in manuscript writing. AA, and ML performed the manuscript reviewing. YE, helped in formulating methodology and obtaining ICD codes.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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