



The Combined Influence of Maternal Medical Conditions on the Risk of Primary Cesarean Delivery

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Abstract

Background Common maternal medical comorbidities such as hypertensive disorders, diabetes, tobacco use, and extremes of maternal age, body mass index, and gestational weight gain are known individually to influence the rate of cesarean delivery. Numerous studies have estimated the risk of individual conditions on cesarean delivery.

Objective To examine the risk for primary cesarean delivery in women with multiple maternal medical comorbidities to determine the cumulative risk they pose on mode of delivery.

Study Design In this population-based retrospective cohort study, we analyzed data from Ohio live birth records from 2006 to 2015 to estimate the influence of individual and combinations of maternal comorbidities on rates of singleton primary cesarean delivery. The exposures were individual and combinations of maternal medical conditions (chronic hypertension [CHTN], gestational hypertension, pregestational diabetes, gestational diabetes, tobacco use, advanced maternal age, and maternal obesity) and outcomes were rates and adjusted relative risk (aRR) of primary cesarean delivery.

Results There were 1,463,506 live births in Ohio during the study period, of which 882,423 (60.3%) had one or more maternal medical condition, and of those 243,112 (27.6%) had primary cesarean delivery. The range of rates and aRR range of primary cesarean delivery were 13.9 to 29.3% (aRR 0.78–1.68) in singleton pregnancies with a single medical condition, and this increased to 21.9 to 48.6% (aRR 1.34–3.87) in pregnancies complicated by multiple medical comorbidities. The highest risk for primary cesarean occurred in advanced maternal age, obese women with pregestational diabetes, and CHTN.

Conclusion A greater number of maternal medical comorbidities during pregnancy is associated with increasing cumulative risk of primary cesarean delivery. These data may be useful in counseling patients on risk of cesarean during pregnancy.

Keywords

- ▶ advanced maternal age
- ▶ chronic hypertension
- ▶ gestational hypertension
- ▶ obesity
- ▶ multiple
- ▶ pregestational diabetes
- ▶ primary cesarean delivery
- ▶ vaginal delivery
- ▶ tobacco use

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Cesarean delivery is one of the most common surgical procedures performed in the United States.¹ Although very commonly performed, it is not without risk when compared with vaginal delivery.^{1,2} The most substantial increase in the U.S. cesarean rate was from 1996 when the rate was 20.7% and reached the highest rate in 2009 of 32.9% of which approximately 60% were primary cesareans.³ In 2017, after 4 years of seeing gradual improvement in the rate of cesarean delivery in the United States, there was plateau in the rate from 31.9% in 2016 to 32.0%. The same trend was noted in primary cesarean rate from 21.8 to 21.9%.⁴

There are many common maternal medical conditions that increase a woman's individual risk of cesarean delivery. Common maternal medical comorbidities such as hypertensive disorders, diabetes, tobacco use, and extremes of maternal age, body mass index (BMI), and gestational weight gain are known individually to influence the rate of cesarean delivery. Numerous studies have analyzed the individual influence of these maternal medical conditions on cesarean delivery risk; however, there is a paucity of data quantifying the impact of multiple medical maternal conditions coexisting in the same parturient on her individual risk of primary cesarean delivery. Therefore, in this study, we aim to examine the rate and risk of primary cesarean delivery in women with multiple combinations of coexisting maternal medical comorbidities to determine the cumulative risk they pose on mode of delivery.

Methods

We performed a population-based cohort study of all live births in Ohio over a 10-year period, 2006 to 2015, utilizing U.S. live birth records from the state of Ohio. The protocol for this study was approved, and a deidentified dataset was provided by the Ohio Department of Health. This study was exempt from review by the Institutional Review Board at the University of Cincinnati, Cincinnati, OH. The primary outcome for this study was primary cesarean delivery. The referent group for comparison was composed of vaginal births.

We examined singleton pregnancies with exposure variables containing both individual and combinations of maternal medical conditions (chronic hypertension [CHTN], gestational hypertension, pregestational diabetes, gestational diabetes, tobacco use, advanced maternal age, and obesity). These were all recorded on the birth certificates based on data obtained from the obstetric medical records. Data collected and recorded on the U.S. birth certificate are abstracted from the medical record per detailed instructions outlined by the National Center for Health Statistics System Guide for completing the facility worksheets for the certificate of live birth in the United States.^{5,6} BMI was calculated using prepregnancy weight and height, as recorded in the medical record and categorized by the World Health Organization.⁷ Obesity was defined as prepregnancy maternal BMI of 30 or higher. All birth records included in this analysis utilized the most recent, 2003 version, of the U.S. birth certificate.⁵

Differences in baseline maternal demographic, medical, and pregnancy characteristics were compared. The frequency of maternal characteristics among women when underwent primary cesarean delivery were compared with women who delivered vaginally to identify factors associated with having primary cesarean delivery. Women with history of prior cesarean delivery were not included in this outcome group. Statistical comparisons were performed using Student's *t*-test and chi-square test for continuous and categorical data, respectively. To quantify the effect of maternal medical comorbidities on the dichotomous outcomes of primary cesarean delivery, we used a log-binomial model, generalized linear model, with log link. This linear regression model approach for estimating relative risk is well suited for dichotomous outcomes. Adjusted relative risk (aRR) values and 95% confidence intervals (CIs) were calculated to estimate the risk of maternal medical comorbidities on primary cesarean delivery after adjustment for the confounding influences of maternal race, marital status, and parity. Significant differences were defined as comparisons with probability value of less than 0.05 and 95% CI not inclusive of the null value of 1.0. Statistical analyses were performed using STATA Release 15 software (StataCorp, College Station, TX).

Results

There were 1,463,506 live births in Ohio during the study period, of which 882,423 (60.3%) had one or more maternal medical condition, and of those 243,112 (27.6%) had primary cesarean delivery. Differences in baseline maternal socio-demographic characteristics between births delivered by primary cesarean versus the referent group are displayed in ►Table 1. Among primary cesarean births, women were more likely to be primiparous, of nonHispanic black race (17.4 vs. 16.1%), have a high school equivalent education or higher (87.9 vs. 82.9%), and have a private medical insurance carrier (57.1 vs. 50.9%). Women who delivered by primary cesarean were also less likely to be married, 55.2 versus 56.5% (for all demographic categories *p*-values < 0.001).

The range of rates and aRR range of primary cesarean delivery were 13.9 to 29.3% (aRR 0.78–1.68) in pregnancies with a single medical condition and this increased to 21.9 to 48.6% (aRR 1.34–3.87) in pregnancies complicated by multiple medical comorbidities. The highest rate and risk for primary cesarean occurred in women who were obese, with comorbid pregestational diabetes and gestational hypertension and women who had pregestational diabetes and gestational hypertension (46.6 and 48.6%) (►Table 2). Women without any medical conditions had a primary cesarean delivery rate of 15.2% (95% CI 15.1–15.3%). In women who utilized tobacco as their only medical comorbidity, the risk for primary cesarean delivery was lower compared with the reference group with no medical conditions, 0.78 (0.77–0.79). However, when tobacco use occurred in combination with other maternal conditions, the cesarean risk increased. The other single maternal medical conditions examined including CHTN, gestational hypertension, obesity, advanced maternal age, and pregestational diabetes were associated

Table 1 Maternal demographic characteristics of the study population, stratified by cesarean status

Characteristic	Vaginal delivery	Primary cesarean section
Maternal age, y	27.38 ± 5.86	27.88 ± 6.16
Gravidity	2 (1–3)	2 (1–3)
Parity	1 (0–2)	0 (0–1)
Race/ethnicity		
Non-Hispanic white	764,704 (75.8%)	217,194 (75.4%)
Non-Hispanic black	161,915 (16.1%)	48,767 (17.5%)
Hispanic	48,111 (4.8%)	10,624 (3.8%)
Native American	2,001 (0.2%)	543 (0.2%)
Asian	25,353 (2.6%)	7,081 (2.6%)
Education level		
Less than HS diploma	171,023 (17.1%)	33,712 (12.2%)
HS diploma or above	830,461 (82.9%)	243,829 (87.9%)
Marital status		
Married	569,725 (56.5%)	154,311 (55.2%)
Not married	439,215 (43.5%)	125,135 (44.8%)
Insurance		
Private	486,759 (50.9%)	151,222 (57.1%)
Medicaid/Medicare	382,730 (40.1%)	98,624 (37.2%)
Self-pay	56,485 (5.9%)	7,972 (3.0%)
Other	46,884 (4.8%)	11,539 (4.3%)

Abbreviation: HS, high school.

Notes: All characteristics differed significantly, with $p < 0.01$. Dichotomous comparisons presented as number (%); continuous variable comparisons presented as mean (\pm standard deviation) or median (interquartile range).

with increased relative risk for having a primary cesarean delivery, even after adjustment for coexisting risk factors for cesarean, see **Table 2**.

Pregnancies complicated by an increasing number of maternal medical conditions had higher rates and relative risks of primary cesarean delivery (**Figs. 1 and 2**). In women who have two medical conditions in pregnancy, the rates and aRR for primary cesarean delivery were 21.9 to 48.6% (aRR 1.24–2.84). In women who have three medical conditions in pregnancy, the rates and aRR for primary cesarean delivery were 24.0 to 46.6% (aRR 1.64–3.08), and for pregnancies of women with four medical conditions, the rates and aRR for primary cesarean delivery were 33.1 to 39.8% (aRR 2.13–3.87). The highest percentage rate for primary cesarean delivery occurred in women who had pregestational diabetes and gestational hypertension, with rate of 48.6% (95% CI 44.8, 52.4%) and aRR 2.63 (95% CI 2.40, 2.88). The women with the highest aRR for primary cesarean delivery were women who were advanced maternal age, obese, had pregestational diabetes, and CHTN, aRR 3.87 (95% CI 3.48, 4.26).

Discussion

In this study, we identified an increasing rate and risk of primary cesarean delivery in patients as their number of medical conditions increased compared with the rate of

primary cesarean delivery in the general population.^{1,8,9} Over the 10-year study period, having multiple medical conditions was associated with as high as a 40.9 to 48.6% risk of having a cesarean delivery.

While our results demonstrate higher rates of primary cesarean delivery with as few as two maternal medical conditions, the risk did not appear to be additive with increasing number of comorbid conditions. Rather, the increase in rate and risk of primary cesarean appeared more closely related to the specific risk factors that coexisted together rather than just the number of conditions. For example, patients with multiple comorbidities that included either obesity, diabetes, or gestational hypertension appeared to have more notable primary cesarean risk increases compared with combinations inclusive of comorbidities with less robust effect such as advancing maternal age or tobacco use.

To our knowledge, this is the first population-based study utilizing data from live birth records to examine the influence of multiple maternal medical conditions on rates of primary cesarean delivery. The primary cesarean rates in patients with single medical conditions in our study cohort were similar to rates demonstrated in the published literature demonstrating similarity in the numbers of our study.^{10–15} This suggests that the rates we observed in women with more than one medical condition are also likely

Table 2 Rate and RR of primary cesarean delivery with maternal medical conditions

Exposure	Primary cesarean section	RR	Adjusted RR
NMC	106,121 (15.2)	Referent	Referent
C	1,740 (25.4)	1.35 (1.30–1.41)	1.28 (1.23–1.34)
G	8,484 (28.2)	1.56 (1.53–1.59)	1.34 (1.31–1.36)
P	837 (30.4)	1.61 (1.52–1.70)	1.53 (1.45–1.62)
D	24,275 (28.2)	1.51 (1.50–1.54)	1.61 (1.59–1.63)
A	23,882 (22.3)	1.22 (1.21–1.24)	1.59 (1.57–1.60)
T	23,737 (14.9)	0.76 (0.75–0.77)	0.79 (0.78–0.81)
O	45,696 (22.9)	1.38 (1.36–1.39)	1.45 (1.43–1.46)
GP	199 (47.8)	2.67 (2.41–2.95)	2.44 (2.22–2.68)
CP	84 (40.0)	2.14 (1.81–2.52)	1.99 (1.70–2.34)
AP	154 (27.8)	1.53 (1.34–1.75)	2.04 (1.79–2.32)
AG	1,464 (33.14)	1.93 (1.85–2.01)	2.22 (2.14–2.31)
AC	597 (29.3)	1.62 (1.52–1.73)	2.03 (1.91–2.17)
TG	1,330 (26.14)	1.43 (1.37–1.50)	1.32 (1.26–1.38)
TC	368 (23.4)	1.22 (1.12–1.33)	1.37 (1.26–1.49)
OG	12,996 (48.6)	3.01 (2.97–3.05)	2.73 (2.70–2.77)
OC	3,019 (31.6)	1.91 (1.86–1.98)	2.01 (1.95–2.06)
OP	805 (35.5)	2.14 (2.03–2.27)	2.30 (2.18–2.43)
CD	154 (27.5)	1.48 (1.30–1.70)	1.51 (1.33–1.73)
GD	621 (32.9)	1.78 (1.67–1.89)	1.63 (1.53–1.74)
OD	5,144 (27.9)	1.51 (1.47–1.54)	1.58 (1.55–1.62)
AD	1,705 (23.0)	1.23 (1.19–1.29)	1.54 (1.48–1.61)
TD	918 (18.2)	0.98 (0.93–1.04)	1.06 (1.00–1.13)
TPG	28 (37.3)	2.06 (1.53–2.76)	1.96 (1.48–2.59)
TPC	27 (39.7)	2.09 (1.56–2.80)	2.51 (1.93–3.24)
ATC	114 (28.8)	1.55 (1.33–1.82)	2.49 (2.17–2.85)
ATG	139 (27.04)	1.56 (1.36–1.81)	2.20 (1.94–2.50)
ATP	28 (27.72)	1.51 (1.10–2.07)	2.54 (1.92–3.36)
OPG	237 (46.0)	2.87 (2.61–3.15)	2.89 (2.65–3.15)
OPC	294 (41.4)	2.52 (2.31–2.75)	2.65 (2.45–2.88)
ATOG	164 (32.8)	2.14 (1.89–2.43)	2.11 (1.87–2.40)
ATOC	160 (36.6)	2.31 (2.04–2.61)	2.28 (2.02–2.59)
OPAG	71 (36.8)	2.42 (2.01–2.91)	2.43 (2.02–2.93)
OPAC	167 (40.5)	2.60 (2.31–2.91)	2.56 (2.27–2.89)

Abbreviations: A, advanced maternal age; C, chronic hypertension; D, gestational diabetes; G, gestational hypertension; NMC, no medical condition; O, obesity; P, pregestational diabetes; RR, relative risk; T, tobacco use.

Notes: Rates of primary cesarean delivery are displayed for single and multiple coexisting maternal medical conditions, displayed as number (%). RR, displayed as RR (95% confidence interval). Adjusted RRs were adjusted for maternal race, parity, and marital status.

representative to rates that would be observed in other populations across the United States.

While we identified a higher rate of primary cesarean delivery in patients with higher number of medical conditions compared with the rate of primary cesarean delivery in the general population,^{1,4} it is important to emphasize that none of the rates of primary cesarean delivery observed in this study cohort exceeded a rate of 50% or greater. Therefore,

despite the presence of many medical comorbidities, women with these conditions were more likely to achieve vaginal delivery than cesarean. This is important with regard to patient counseling as it does not preclude a patient from attempting a trial of labor. Additionally, our data include women who may have undergone planned primary cesarean without an initial trial of labor. If all women with medical conditions who were candidates for vaginal birth had first

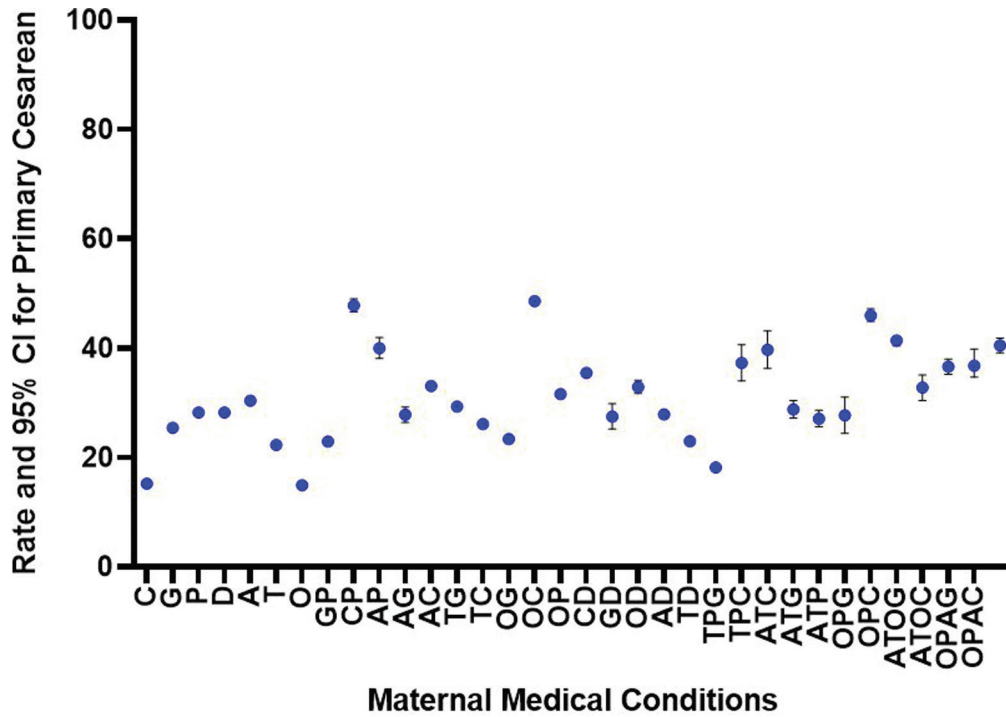


Fig. 1 Rates of primary cesarean delivery in pregnancies with single and multiple maternal medical conditions. A, advanced maternal age; C, chronic hypertension; CI, confidence interval; D, gestational diabetes; G, gestational hypertension; O, obesity; P, pregestational diabetes; T, tobacco use.

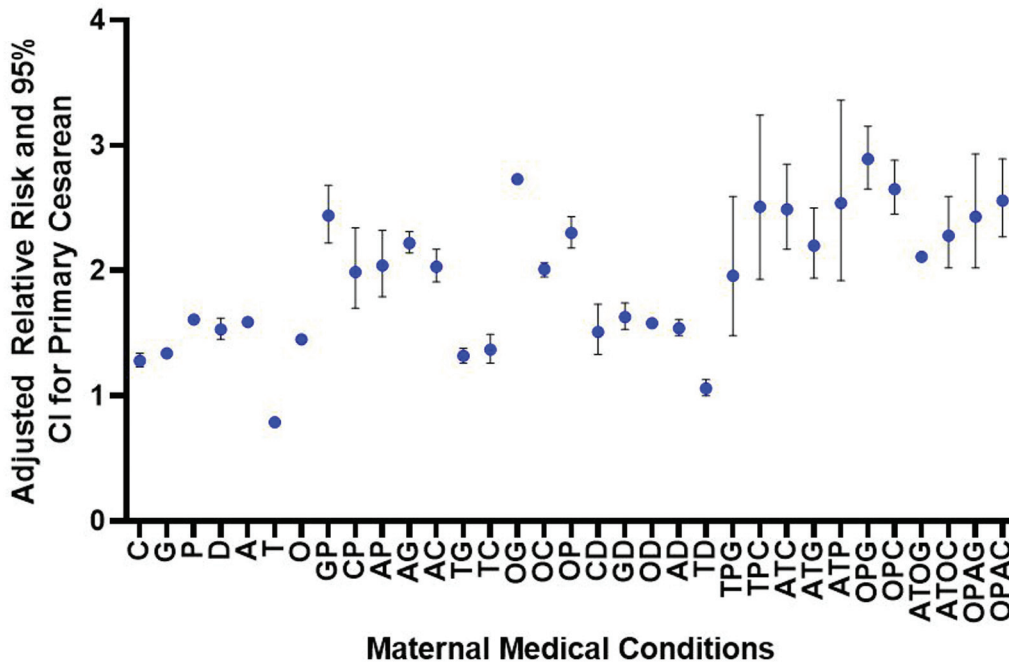


Fig. 2 Adjusted relative risk of primary cesarean in pregnancies with single and multiple maternal medical conditions. Adjusted relative risks compared with women with no medical condition and adjusted for maternal race, parity, and marital status. A, advanced maternal age; C, chronic hypertension; D, gestational diabetes; G, gestational hypertension; O, obesity; P, pregestational diabetes; T, tobacco use.

undergone a trial of labor, it is possible the rate of primary cesarean may have been lower than that which we observed. Therefore, even for patients with multiple medical comorbidities, we assert that primary cesarean delivery should be reserved for the usual obstetric indications.¹⁶

Our study has many strengths, including is large sample size and data that originate from a recent cohort which increased our ability to detect small effect sizes that can have impact on large populations of patients. In addition, a strength of this study is that it is novel, calculating more

individualized patient-specific risks using more granular data on specific combinations of medical conditions rather than just estimating based on individual risk factors alone. Limitations of this study are primarily related to the data source, vital statistics live birth records, which are not intended for research purposes. While demographic factors such as maternal race and age are thought to be accurate in birth records, other variables are known to be underreported, specifically maternal comorbid conditions such as hypertension and diabetes. This however is not felt to diminish the validity of our data as underreported maternal medical conditions would therefore be categorized with the null group. It is actually possible that with more accurate reporting, the rates and relative risks may be slightly larger.¹⁷ In addition, our study only includes a population of births from the state of Ohio and may not be directly reflective of populations elsewhere in the United States. It is of importance to note however that there are statewide efforts to constantly improve data accuracy specifically in the state of Ohio through workshops and training summits.¹⁸ An additional limitation to our study was lack of reliable data that would indicate whether trial of labor occurred prior to primary cesarean.^{19,20}

Future studies including other maternal medical conditions known to be associated with increased rates of cesarean delivery could contribute further to the existing literature on this topic. It would also be of benefit to perform future analyses using data that include whether a trial of labor occurred prior to the primary cesarean section. In addition, it may be beneficial to replicate this analysis utilizing a nationwide live birth database to assess generalizability to patients from other regions of the country.

Conclusion

Overall, we identified a higher rate of primary cesarean delivery in patients as the number of maternal medical conditions increased compared with our referent group.^{1,4} As the rates for primary cesarean delivery never exceeded 50%, despite the presence of medical comorbidities, women with these conditions were more likely to achieve vaginal delivery than cesarean. Based on these findings, we recommend that women with multiple medical comorbidities be offered a trial of labor. We believe that the results from this study afford us strong data to utilize while counseling our patients about risk of primary cesarean delivery and can permit more detailed and specific information to be discussed with our patients regarding their pregnancies.

Note

This study was presented as a poster presentation at the Society of Maternal-Fetal Medicine 40th Annual Pregnancy Meeting, between February 3 and 8, 2020, in Grapevine, TX.

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None.

Conflict of Interest

None declared.

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