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Risk of Obstetric Anal Sphincter Injuries after Labor Induction †

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Abstract: Background: Obstetric Anal Sphincter Injuries (OASI) are associated with significant morbidity. Data regarding induction of labor (IOL) and risk of OASI is conflicting. The objective of this study is to evaluate if IOL increases the odds of OASI when compared to spontaneous labor. Methods: This is a retrospective case–control study in women with term, singleton pregnancies, who had a vaginal delivery at a single, academic center in an urban setting from October 2015 to December 2021. Individuals with the primary outcome, OASI, were identified and matched with controls (no OASI) by delivery date. Results: 303 OASI individuals were identified and matched with 1106 controls. Women with OASI were more likely to be White or Asian, have commercial insurance, and have a previous cesarean delivery (CD). IOL increased the likelihood of OASI by 49% compared to spontaneous labor (OR 1.49, 95% CI [1.138, 1.949]). IOL was no longer significant when adjusting for confounding variables and known risk factors. Conclusion: IOL was not associated with OASI when accounting for known antepartum and intrapartum risk factors. Further investigation of modifiable and non-modifiable risks during labor is imperative to decrease the risk of OASI and associated pelvic floor disorders.

Keywords: obstetric anal sphincter injury; obstetric laceration; postpartum; induction of labor; maternal morbidity

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1. Introduction

The incidence of severe perineal lacerations involving obstetric anal sphincter injuries (OASI) have been reported to be up to 3.3% for third-degree lacerations and 1.1% for fourth-degree lacerations, with the highest incidence present in nulliparous women (5.8%) [1–3]. OASI are associated with significant maternal morbidity in the postpartum period, and oftentimes have long-term sequelae. Immediate complications observed in the postpartum period involve increased perineal pain, infection, and wound dehiscence, while longer-term effects include sexual dysfunction and pelvic floor disorders such as urinary incontinence, pelvic organ prolapse, and defecatory dysfunction [3,4].

Identification of modifiable and non-modifiable risk factors is imperative in reducing the risk of OASI. Risk factors identified in the existing literature include higher neonatal birth weight, midline episiotomy (incidence of 7–21.4%), and prolonged second stage of labor [5–8]. Operative deliveries are a well-established risk factor for OASI, with forceps-assisted vaginal delivery having the highest risk for OASI when compared to vacuum-assisted vaginal delivery (13–83% vs. 22–45%) [4]. Using a shared decision model,

obstetricians and pregnant individuals must balance the risk of OASI during a vaginal delivery with that of a cesarean delivery when considering these interventions.

In an effort to decrease maternal and neonatal complications, labor inductions at term have become increasingly more common involving over 25% of all pregnancies [9]. Induction of labor (IOL) involves stimulating uterine contractions with the goal of achieving a vaginal delivery prior to the onset of spontaneous labor. The decision to undergo an IOL is complex and multifactorial, ranging from maternal and fetal obstetrical conditions, gestational age, as well as psychosocial indications in certain circumstances [10]. The IOL process may include membrane stripping, amniotomy, use of prostaglandin analogs, and/or oxytocin infusion. Risks of an IOL should be considered; these might include common side effects such as uterine tachysystole, non-reassuring fetal heart tracing, and less common complications such as placenta abruption or uterine rupture [10]. The benefits of IOL include expediting vaginal delivery to prevent maternal and fetal complications that could carry significant morbidity and mortality risks. The recent literature has highlighted the safety of IOL without evidence of significant adverse perinatal outcomes in comparison to expectant management [11].

A recent systematic review of seven studies evaluating induction of labor at term found a decreased risk of severe perineal lacerations in those undergoing labor inductions at 39 weeks compared to spontaneous labor [12,13]. However, another systematic review, including IOL at 37 weeks gestation, did not find IOL decreased the risk of OASI [14]. Notably, the studies included in these reviews underrepresent racial and ethnic minorities. Given conflicting data around IOL and OASI and the lack of racial/ethnic representation in previous studies, we sought to evaluate whether IOL increased the risk of OASI when compared to spontaneous labor, in a diverse, urban population.

2. Materials and Methods

2.1. Study Population and Data Collection

This is a retrospective case–control study from a single academic center at an urban tertiary care setting. Institutional Review Board (IRB) approval was obtained from the George Washington University Committee on Human Research (IRB Reference NCR203181, 27 May 2021). The study included women who had a vaginal delivery of a singleton term pregnancy (37 to 42 weeks) from October 2015 to December 2021 in the George Washington University Hospital. This time frame was selected given hospital-wide changes in the electronic medical record prior to the selected date. Exclusion criteria included breech presentation and maternal age less than 18 years old. An initial power analysis was conducted to detect a significant difference with a power of 80% and alpha 0.05 by matching cases and controls 1:2. The initial calculation demonstrated a needed sample size of n = 935 (controls = 623, cases = 312). This was originally calculated with the plan to match controls by the delivery immediately before and after each case of OASI. However, after obtaining the initial list of deliveries, the delivery time was not available and, thus, matching of subjects and controls was completed by delivery date, yielding an approximate 1:4 ratio. An additional sample estimate was not performed with this change. A finalized list of subjects and controls was created from which detailed data was collected retrospectively from the electronic medical record.

Data were collected retrospectively to obtain sociodemographic, antepartum, intrapartum, and postpartum information. The two cohorts, IOL and spontaneous labor, were created based on reason for admission. The spontaneous labor group included individuals that presented in labor, defined as contractions and cervical change without intervention. Those individuals that required labor augmentation (for example, oxytocin or artificial rupture of membranes) during their labor course remained in their original group. For both cohorts, details regarding labor induction or augmentation were collected; this included the use of balloons for mechanical cervical dilation such as indwelling bladder catheters or double-balloon uterine catheters, prostaglandins, oxytocin, and artificial rupture of membranes. Detailed labor information was collected, including use of epidural anesthesia,

operative delivery, and episiotomy. Delivery outcomes included vaginal laceration type, neonatal weight, hypertensive disorders, estimated blood loss, and hospital length of stay. The second stage of labor (i.e., length of second stage) and outpatient postpartum data for all subjects were excluded from the analysis given significant missing data in the electronic medical records.

2.2. Data Analysis and Statistical Methods

The primary outcome was a comparison of OASI frequency between pregnant individuals who presented in spontaneous labor compared to those with an IOL. Additional risk factors with bivariable association with OASI were considered in order to build a more comprehensive model. These factors were identified a priori due to the reported association with OASI: maternal age, race/ethnicity, BMI, delivery history, OASI history, gestational age, analgesia, type of delivery, episiotomy, labor augmentation, and pre-eclampsia.

Independent *t*-tests were used to assess for bivariable association between OASI and potential risk factors. Chi-square and Fisher Exact tests were used to compare categorical variables. Then, for potential risk factors that demonstrated statistically significant bivariable association with OASI at the 5% alpha level, a simple logistic analysis was conducted to calculate the ORs and corresponding 95% CIs.

In consideration for the multivariable regression model, known risk factors for OASI were identified from the literature, as listed above. Multicollinearity among the predictors demonstrating statistical significance from the bivariate analysis were evaluated with OASI using the variance inflation factor (VIP). Potential risk factors with high correction as indicated by a VIP score of greater than 5 were excluded from the model. A p value of <0.05 was considered statistically significant. For the multivariable logistic regression, adjusted ORs and corresponding 95% CIs were reported. For any given predictor in the model, odds ratios greater than 1, adjusting for the other risk factors, indicated higher odds of OASI. Additionally, if the corresponding 95% CI excluded the null OR of 1, this concluded statistically significant association with the outcome of OASI, while accounting for the other predictors in the model. All data analysis was performed using R Statistical Software Version 4.2.0 (R Core Team 2022 by the R Foundation for Statistical Computing, Vienna, Austria) [15]. STROBE guidelines were followed for reporting (https://www.strobe-statement.org).

3. Results

A total of 9573 women with term deliveries from October 2015 to December 2021 were identified. There were 303 women with OASI matched with 1106 controls based on delivery date (Table 1). Most women in the study had commercial insurance, identified as White or Black race, and had a mean BMI of 28.4 kg/m^2. In this cohort, 1072 women (76.1%) had a vaginal laceration of any type. Out of these women, 769 (54%) had a first- or second-degree laceration, and 303 (21.5%) had an OASI. Of the OASI group, 287 (20.4%) had third-degree OASI, and 16 (1.1%) had fourth degree laceration.

Individuals with OASI were more likely to be non-Hispanic White or Asian and have commercial insurance (Table 1). Women with OASI were less likely to have a previous vaginal delivery (9.2% vs. 54.2%, $p < 0.001$), but more likely to have a previous cesarean delivery (CD) (13.9% vs. 9.0%, $p = 0.014$) (Table 2). They were less likely to have an unspecified thyroid disease or gestational hypertension. There were no differences in the frequency of prior OASI between women with or without OASI in this study or other medical and surgical history.

Intrapartum factors associated with OASI were higher gestational age of 40 to 42 weeks (58.1 vs. 41.6%, $p < 0.001$), epidural anesthesia (76.9% vs. 60%, $p < 0.001$), operative delivery (32% vs. 3.5%, $p < 0.001$), episiotomy (4% vs. 1.4%, $p = 0.005$), and higher birth weight ($p < 0.001$). In addition, those with OASI had higher mean estimated blood loss (EBL) (563 mL vs. 318 mL, $p < 0.001$), and were more likely to have a prolonged hospital stay, including a hospital stay greater than 2 days postpartum (12.9% vs. 4.8%, $p < 0.001$; Table 2).

Table 1. Demographics of women with and without Obstetric Anal Sphincter Injuries.

	OASI (N = 303)	No OASI (N = 1106)	*p*-Value
Age	32.5 (±4.63)	31.7 (±5.54)	0.007
Race/Ethnicity			<0.001
White	169 (55.8%)	456 (41.2%)	
Black or African American	54 (17.8%)	425 (38.4%)	
Asian	26 (8.6%)	44 (4.0%)	
Hispanic/Latina	8 (2.6%)	46 (4.2%)	
Other/Unknown	46 (15.2%)	135 (12.2%)	
Insurance type			<0.001
Commercial	251 (82.8%)	689 (62.3%)	
Government/Medicaid	50 (16.5%)	409 (37.0%)	
Self-pay/Other/Unknown	2 (0.7%)	8 (0.8%)	
Body mass index (kg/m^2)	28.4 (±5.16)	29.0 (±6.22)	0.068
Medical and Surgical History			
Thyroid disease	34 (11.2%)	59 (5.3%)	<0.001
Cesarean delivery	39 (12.9%)	95 (8.6%)	0.024
Operative hysteroscopy	3 (1.0%)	1 (0.1%)	0.033
Obstetric Histories			
History of vaginal delivery	28 (9.2%)	599 (54.2%)	<0.001
History of operative delivery	3 (1.0%)	35 (3.2%)	0.038
History of cesarean delivery	42 (13.9%)	100 (9.0%)	0.014
History of 3rd degree laceration	7 (2.3%)	15 (1.4%)	0.292
Gestational diabetes	20 (66%)	57 (5.2%)	0.326

Data reported as mean (±SD) or number (%); *p*-values < 0.05 represent significance.

Table 2. Labor factors with and without Obstetric Anal Sphincter Injuries.

	OASI (N = 303)	No OASI (N = 1106)	*p*-Value
Gestational age at admission			<0.001
37 to 39 weeks	127 (41.9%)	646 (58.4%)	
40 to 42 weeks	176 (58.1%)	460 (41.6%)	
Labor augmentation (medical)	198 (65.3%)	592 (53.5%)	<0.001
Antepartum gestational HTN [1]	5 (1.7%)	45 (4.1%)	0.044
Intrapartum preeclampsia	20 (6.6%)	42 (3.8%)	0.035
Epidural analgesia	233 (76.9%)	664 (60.0%)	<0.001
Suspected malpresentation	17 (5.6%)	23 (2.1%)	0.006
Operative delivery	97 (32.0%)	39 (3.5%)	<0.001
Episiotomy	12 (4.0%)	16 (1.4%)	0.005
Neonatal birth weight (grams)	3530 (±481)	3370 (±431)	<0.001
Estimated blood loss (mL)	563 (±388)	318 (±257)	<0.001
Hospital length of stay (days)	3.14 (±1.14)	2.63 (±0.922)	<0.001

Data reported as mean (±SD) or number (%); *p*-values < 0.05 represent significance; [1] HTN, hypertension.

For the primary outcome, we found an increased odds of OASI with IOL versus spontaneous labor (p = 0.004; Table 3). IOL increased the likelihood of OASI by 49% compared to spontaneous labor (OR 1.49, 95% CI [1.138, 1.949]). This association was no longer significant on multivariable analysis when adjusting for known risk factors for OASI, including, race, gestational age, neonatal weight, episiotomy, operative delivery, analgesia use, labor augmentation, pre-eclampsia, history of vaginal delivery, history of CD, and history of third-degree laceration (aOR 1.35, 95% CI [0.910, 1.999]; Table 4). The factors most strongly associated with OASI were Black race, which decreased the odds, and operative delivery, which increased the odds of OASI (Figure 1).

Table 3. Reason for delivery admission with and without Obstetric Anal Sphincter Injuries.

Reason for Admission	OASI (N = 303)	No OASI (N = 1106)	*p*-Value
Spontaneous labor	194 (19.5%)	803 (80.5%)	0.004
Induction of labor	109 (26.5%)	303 (73.5%)	

Data reported as number (%); *p*-values < 0.05 represent significance.

Table 4. Multivariable logistic regression for Obstetric Anal Sphincter Injuries.

	Unadjusted Model		Adjusted Model	
	OR	95% CI	OR	95% CI
Labor Induction	1.489	(1.138, 1.949)	1.349	(0.910, 1.999)
Age	1.031	(1.006, 1.056)	1.019	(0.983, 1.056)
Race [a]				
Asian	1.594	(0.952, 2.671)	1.812	(0.989, 3.318)
Black or African American	0.343	(0.246, 0.479)	**0.594**	**(0.376, 0.937)**
Latina/Hispanic	0.469	(0.217,1.015)	0.72	(0.297, 1.746)
Body Mass Index	0.982	(0.960, 1.004)	1.004	(0.977, 1.032)
Prior Operative Delivery	0.306	(0.094, 1.001)	0.65	(0.164, 2.577)
Prior Vaginal Delivery	0.086	(0.057, 0.129)	**0.109**	**(0.068, 0.174)**
History of 3rd degree lacerations	1.72	(0.695, 4.257)	5.522	(1.786, 17.076)
Gestational Age, 37–39 weeks [a]	0.514	(0.397, 0.665)	0.861	(0.619, 1.199)
Neonatal birth weight	1.001	(1.0005, 1.0011)	**1.001**	**(1.0006, 1.0013)**
Analgesia Prior to Delivery	2.304	(1.705, 3.114)	1.272	(0.867, 1.866)
Operative Delivery	12.883	(8.632, 19.227)	**7.685**	**(4.913, 12.021)**
Episiotomy	2.809	(1.314, 6.004)	1.132	(0.453, 2.831)
Prior C-section	1.508	(1.025, 2.218)	0.834	(0.522, 1.332)
Labor Augmentation (Medical)	1.637	(1.257, 2.133)	1.03	(0.695, 1.526)
Pre-eclampsia	1.79	(1.035, 3.098)	1.363	(0.703, 2.642)

For the race variable—White race is the reference group; bolded values indicate statistical significance. In order to reach statistical significance, the 95% confidence interval cannot cross 1; [a] gestational age was dichotomized to 37–39 and 40–42-week intervals; the 40–42 interval was the reference group.

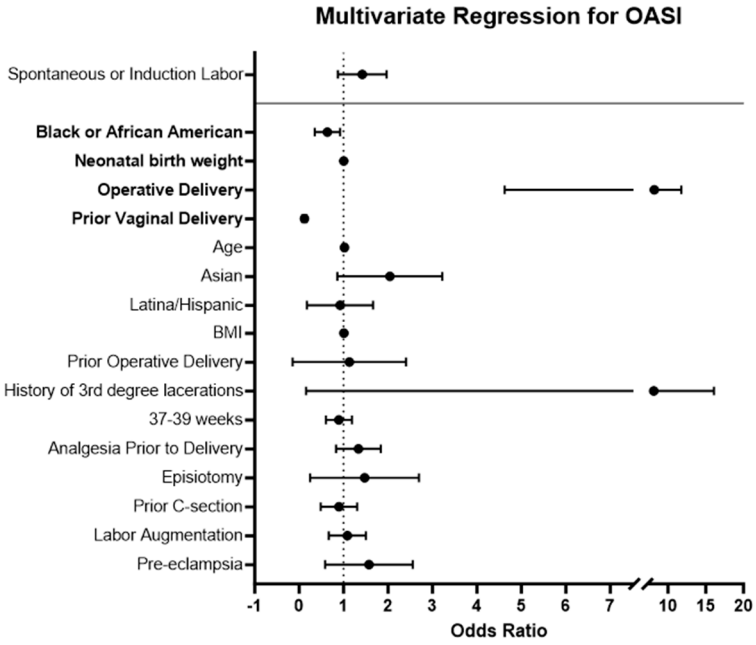

Figure 1. Multivariate regression for OASI. Forest plot demonstrating odds ratio (OR) and 95% confidence intervals for variables included in the multivariate regression. Bolded variables demonstrate a significant association with OASI. Black or African American race and prior vaginal delivery demonstrate decreased odds of OASI. Increased neonatal birth weight and operative delivery demonstrate increased odds of OASI.

4. Discussion

In this retrospective case–control study, we sought to evaluate if IOL was associated with OASI in a diverse group of pregnant individuals with term pregnancies given the increasing prevalence of IOL over the last decade. We found IOL was not associated with an increased odds of OASI compared to spontaneous labor when controlling for risk factors including operative delivery, higher neonatal birth weight, parity, race/ethnicity, and a prior history of OASI. This finding contributes to the literature that supports IOL, even elective at term, does not increase the risk of OASI.

There is limited data in the literature evaluating the association between labor induction and OASI as a primary outcome. In a retrospective cohort study abstract of over 5 million term pregnant individuals, authors found that IOL was associated with a significant decrease in second, third, and fourth degree perineal lacerations [12]. In a large, randomized control trial study, the ARRIVE trial, the risk of OASI as a secondary outcome was not found to be increased in nulliparous women undergoing elective labor induction [11]. Finally, Grobman et al., in a meta-analysis of six cohort studies, assessed IOL and OASIS as a secondary outcome, finding that severe perineal lacerations were similar between those who underwent expectant management versus induction of labor at 39 weeks [16]. Notably, in that meta-analysis, the rates of CD were lower in the IOL group. In contrast to prior studies, our study evaluated the risk of OASI in IOL as a primary outcome, and included an older and more racially/ethnically diverse population. We found there was no association between IOL and OASI once we adjusted for known risk factors. This is consistent with the prior literature, and reassuring for pregnant individuals, given the increase in elective IOL. These findings can be used to support informed decision-making in the office allowing providers to discuss labor induction as a safe option without added concerns regarding perineal lacerations.

In our multivariable regression analysis, we found factors associated with OASI were increasing neonatal birth weight, nulliparity, and operative delivery, which had the strongest association. Our findings were similar to prior studies where nulliparity, increasing neonatal birth weight, and operative vaginal delivery have been established as an independent risk factor for severe perineal lacerations [17–21]. In our study population, there were 136 operative vaginal deliveries accounting for 9.7% of all deliveries. Operative deliveries, forceps and vacuum deliveries accounted for 32% of all OASI (22.8% vs. 9.2% respectively). Our study demonstrated a clinically significant increase in the odds of OASI with operative delivery with OR 7.685 (95% CI 4.913, 12.02). Both forceps-assisted and vacuum-assisted deliveries have been associated with increased risk of OASI, including an incidence of 8–23% and 6–24% [7]. Given that not all operative deliveries within the study period were included, it was unable to determine the true incidence of OASI in operative delivery within this population. Notably, in the multivariate regression, episiotomy was not associated with increased odds of OASI. This finding is difficult to generalize, given that episiotomy prevalence was low in this population at 2% of all deliveries. In addition, there was insufficient documentation regarding type of episiotomy, midline versus lateral, performed at the time of delivery.

Our data also demonstrated that OASI was less likely in Black women compared to White women, as seen in prior studies [22]. In a study evaluating racial and ethnic differences in perineal lacerations in a diverse urban population at first vaginal delivery, Asian and White women had an increased severity in laceration compared to Black and Latina women [23]. However, we need to critically examine how we interpret this finding. Evaluating labor and delivery outcomes, including OASI, by racial or ethnic group warrants consideration of differences in direct patient care as opposed to genetic differences. The literature has demonstrated that racial/ethnic minoritized women experience unique barriers and inequalities within the healthcare system, contributing to poorer outcomes. For example, one study demonstrated that non-Hispanic Black women were at higher risk for late preterm inductions, potentially due to hospital and physician policies surrounding selection for IOL [24]. While studies cite race/ethnicity as risk factors, it is important

to note that structural racism, not race, is correlated with negative health outcomes in a variety of surgical and non-surgical specialties [25]. Standardization of care is one proposed methodology to reduce disparities in healthcare, as demonstrated through a standardized labor induction protocol to reduce cesarean delivery rates at one institution [26]. Our study demonstrates that disparities may exist within our institution surrounding mode of delivery. Future studies are needed to better understand how race and ethnicity drive the risk of OASI.

There are limitations in this study, mainly given its retrospective nature. Given this study was conducted in a single center, limitations of generalizability exist in centers with different patient populations. The Latina/Hispanic population is underrepresented in this study, accounting for only 3.8% of the population in comparison to 18.5% in the United States in 2020 [27]. Second, the data for the second stage of labor was not included and, thus, could not be assessed as a risk factor for OASI. Similarly, the outpatient postpartum data were not included due to changes in outpatient EMR during the study timeframe. We also matched individuals with OASI to those without, thus decreasing the numbers of controls in this study.

The strengths of this study were its robust cohort of individuals over a six-year time period, which included a diverse patient population from an urban academic medical center, increasing the generalizability of our study data. Data were collected directly from the electronic medical records by research team personnel, rather than from a database, minimizing misclassification errors and allowing for the collection of detailed demographic and delivery information. The individuals admitted in spontaneous labor remained in their originally assigned group regardless of labor augmentation. We were able to collect more granular data that can be difficult to achieve with large, claims-based database studies due to inconsistent coding. We matched pregnant individuals by date of delivery to minimize variability in care that can occur based on the delivering provider or team. For this reason, the total percentage of OASI in this population is not reflective of OASI incidence. Incidence of OASI for the selected period was 3.1% similar to national data of 4.4% [2,3].

5. Conclusions

In summary, our study did not demonstrate an association between IOL and OASI once controlling for established risk factors. Labor inductions are an important obstetric intervention that allows reducing maternal and fetal risks. Understanding potential implications of IOL is important to ensure completion of a comprehensive informed consent process. With regards to OASI concerns, this study supports the clinical safety of labor inductions. Future directions include further investigation of modifiable and non-modifiable risks during labor to decrease the risk of OASI and the associated pelvic floor disorders.

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Informed Consent Statement: Informed consent was not applicable.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

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