Complications of Delivery Among Mothers With Spina Bifida

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OBJECTIVE To determine rates and types of peripartum morbidity among delivering women with spina bifida (SB) compared to those without SB. The rates of pregnancy and delivery among women with SB have been significantly increasing. Current knowledge of peripartum outcomes for these women is limited.

METHODS Using 2004-2013 National Inpatient Sample data, we identified all hospitalizations for delivery, distinguishing between women with and without SB. Using a code-based algorithm, we determined whether a complication occurred during the hospitalization. We then fit a series of multivariable logistic models to examine for associations between a complication occurrence during vaginal or cesarean delivery and a woman's SB status.

RESULTS We identified 38,319,814 weighted admissions for delivery, 9516 of which were made by women with SB. Women with SB had a significantly higher rate of cesarean delivery than women without this diagnosis (53% vs 32%, $P < .001$). The 46.7% of women with SB who delivered vaginally did not have significantly increased odds of a complication associated with their delivery compared to women without SB [odds ratio 1.15, 95% confidence interval 0.99-1.34, $P = .066$]. However, women with SB who underwent a cesarean delivery did have higher odds of morbidity compared to those without (odds ratio 1.49, 95% confidence interval 1.25-1.78, $P < .001$). Common complications included preterm delivery, urinary tract infection, hematologic event, and blood transfusion.

CONCLUSION Compared to women without SB, those with SB deliver more frequently by cesarean section and have higher odds of morbidity associated with cesarean delivery, but not vaginal delivery. UROLOGY 123: 280–286, 2019. © 2018 Elsevier Inc.

Over the last several decades, refinements in medical and surgical management have greatly reduced childhood mortality from spina bifida (SB), allowing most to survive well into adulthood.[1] Consequently, adult patients with SB, and the providers who care for them, now face entirely new health challenges related to their disability that remain poorly understood. There is perhaps no single area more under investigated for this population than the reproductive health of women with SB.

Despite the fact that the number of women with SB giving birth has increased by 56% over the last 10 years,[2] there are a paucity of studies on peripartum outcomes. Reports are limited to a few small case series, the largest of which describes 69 deliveries in 38 women with SB. These studies suggest a higher rate of complications associated with delivery as would be expected owing to their atypical skeletal anatomy, medial comorbidities, and prior surgical procedures (eg, urinary tract reconstruction, placement of cerebrospinal fluid shunt). However, without larger scale studies, the risk of various complications remains unknown, hampering preconception counseling and delivery planning.

In this context, we conducted an observational study using national discharge data. During hospitalizations for delivery, we determined the modes of delivery as well as rates and types of peripartum morbidity among women with SB compared to those without this diagnosis. Findings from this study will allow urologists and other health care providers who care for women with SB to

Financial Disclosure: *The authors declare that they have no relevant financial interests.*
Source of Funding: *This research was supported by a T-32 grant from the National Institutes of Health's National Institute of Diabetes and Digestive and Kidney Diseases (grant number 5T32DK007782-17).*

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Submitted: January 22, 2018, accepted (with revisions): April 20, 2018

https://doi.org/10.1016/j.urology.2018.04.045
0090-4295

facilitate informed discussions about their potential risks of delivery.

MATERIALS AND METHODS

Data Source and Study Population

For our study, we used data from the National Inpatient Sample (NIS). Developed by the Healthcare Cost and Utilization Project, the NIS is an all-payer database that captures a 20% sample of admissions from participating hospitals. Weighted estimates from the NIS are considered generalizable to all discharges in the United States.[3] Using appropriate *International Classification of Diseases, Ninth Revision* (ICD-9), *Clinical Modification* diagnosis codes and Clinical Classification Software groups (Supplementary Table 1), we identified all women admitted to an acute care hospital following an obstetric delivery between 2004 and 2013. Through a previously described algorithm,[2] we distinguished between admissions for women with and without SB. Women with SB were further categorized by severity of SB (SB occulta, SB without hydrocephalus, and SB with hydrocephalus). We then used Clinical Classification Software groups (Supplementary Table 1) to determine whether these women underwent vaginal or cesarean delivery.

Outcomes

We measured 2 binary outcomes: (1) the occurrence of an immediate peripartum complication around a vaginal delivery and (2) the occurrence of an immediate peripartum complication around a cesarean delivery. We defined the peripartum period as the time between admission and discharge. Based on author consensus, complications were abstracted using definitions from the Centers for Disease Control and Prevention,[4] the American Congress of Obstetricians and Gynecologists,[5] and the American College of Surgeons.[6] We also identified complications specific to the patients with SB, including malfunction or replacement of a ventriculoperitoneal shunt and common complications of abdominal surgery after bladder augmentation such as cystotomy and enterotomy (Supplementary Table 2).

Statistical Analysis

For our initial analytical step, we tested for differences between women with and without SB, who were admitted for delivery. We made comparisons over a variety of sociodemographic characteristics including age on admission, primary payer, and urban-rural residence, level of comorbidity (assessed by the Elixhauser methodology),[7] and specific comorbidities (Supplementary Table 3). Next, we compared crude rates of peripartum complication between women with and without SB stratified by type of delivery. Additionally, we performed temporal trends analysis to determine if the utilization of cesarean delivery changed over this time period.

We fit 2 multivariable logistic regression models to determine if a woman's SB status and severity were independently associated with the occurrence of a peripartum complication among women who underwent a vaginal delivery, as well as among women who underwent a cesarean delivery. We adjusted for the patient factors described above.

We performed all analyses using SAS version 9.4 (Cary, NC). All of our tests were 2 sided with the probability of type I error set at 0.05. Our institutional review board deemed our study to be exempt from its oversight.

RESULTS

We identified 38,310,298 hospitalizations for delivery among women without SB and 9516 among women with SB (33.7% SB occulta, 47.5% SB without hydrocephalus, and 18.8% SB with hydrocephalus). Among women without SB, 67.7% underwent a vaginal delivery, and 32.3% underwent a cesarean delivery. Among women with SB, 46.7% underwent a vaginal delivery, and 53.3% underwent a cesarean delivery ($P < 0.001$ for the difference in distribution between these groups of women). The frequency of cesarean delivery increased with increasing severity of SB (42.6% of all deliveries for women with SB occulta, 56.1% for SB without hydrocephalus, and 65.2% for SB with hydrocephalus). The percentage of women with SB who delivered by cesarean section over the last 10 years has not significantly changed ($P = .47$ for trend, Supplementary Fig. 1). Women with SB were younger and were more likely to be have private insurance or Medicare, live outside of a city, and deliver at an urban teaching hospital (Table 1). Women with SB also had higher levels of comorbid illness.

When comparing overall frequencies of specific immediate peripartum outcomes, women with SB were more likely to have several adverse fetal and maternal outcomes compared to women without SB (Table 2). They were more likely to have preterm delivery defined as delivery before 37 weeks gestation (11.3% vs 7.3%, $P < .001$). Women with SB had a nearly 6-fold increased incidence of urinary tract infections (4.6% vs 0.8%, $P < .001$). In addition, they were more likely to suffer a hematologic event (4.0% vs 2.0%, $P < .001$) and they were also more likely to undergo blood transfusion (2.3% vs 1.0%, $P < .001$). Women with SB were also significantly more likely to have neurologic, pulmonary, renal, and cardiac complications, although the frequencies were very low.

The frequency of immediate peripartum adverse outcomes differed by delivery type. For vaginal delivery, women with SB were more likely to have a renal complication or urinary tract infection than women without SB (Table 3). Although they were more likely to sustain trauma to the perineum or vulva (56.3% vs 52.5%, $P = .021$), they were less likely to require forceps- or vacuum-assisted delivery (0.6% vs 1.5%, $P = .039$). They were more likely to have a hematologic complication (2.3% vs 1.2%, $P = .002$), but were no more likely to require a blood transfusion (0.6% vs 0.5%, $P = .65$). The remainder of their outcomes were similar to women without SB.

With respect to cesarean delivery, women with SB were more likely to suffer from an intraoperative injury. Hematologic complications were more frequent among SB women (5.5% vs 3.7%, $P < .001$) as were blood transfusions (3.7% vs 1.9%, $P < .001$). Women with SB were more likely to sustain neurologic, pulmonary, shunt-related, and infectious complications, but the frequency of renal complications among them did not differ from that of women without SB (Table 3).

After adjusting for measured patient and hospital factors, for vaginal delivery, a woman's risk of an immediate peripartum complication was not associated with her SB status [odds ratio (OR), 1.15; 95% confidence interval (CI), 0.99-1.34; $P = .066$] (Fig. 1). However, for cesarean delivery, a woman's odds of suffering an immediate peripartum complication were nearly 50% higher if she had SB (OR, 1.49; 95% CI, 1.25-1.78; $P < .001$). When evaluating the odds of complication by SB severity, the increased odds of complication during cesarean delivery was driven by the largest group of women, SB women without hydrocephalus (OR, 1.71; 95% CI, 1.35-2.16; $P = .016$) (Supplementary Fig. 2).

Table 1. Personal and hospital characteristics of women hospitalized for a delivery

Characteristic	No Spina Bifida	Spina Bifida	*P* Value
	Sociodemographic Factors		
Age			.0043
<18	2,042,638 (5.3)	440 (4.6)	
18-22	7,371,181 (19.2)	2021 (21.2)	
22-26	7,140,991 (18.6)	1891 (19.9)	
26-30	8,877,900 (23.2)	2280 (24.0)	
30-34	7,268,459 (19.0)	1737 (18.3)	
>34	5,609,129 (14.6)	1147 (12.1)	
Primary payer			<.001
Self-pay	1,128,307 (2.9)	138 (1.4)	
Private	19,561,812 (51.1)	5038 (52.9)	
Medicare	232,260 (0.6)	373 (3.9)	
Medicaid	16,291,052 (42.5)	3635 (38.2)	
No charge/Other	1,096,866 (2.9)	334 (3.5)	
Residence			<.001
Central/Fringe (1 million or greater)	21,894,088 (57.1)	4971 (52.2)	
50,000-999,999	10,786,337 (28.2)	2914 (30.6)	
10,000-49,999	3,515,184 (9.2)	1043 (11.0)	
<10,000	2,114,689 (5.5)	589 (6.2)	
Hospital location and teaching status			<.001
Rural	4,291,728 (11.2)	1014 (10.7)	
Urban nonteaching	16,257,311 (42.4)	3460 (36.4)	
Urban teaching	17,761,258 (46.4)	5043 (53.0)	
	Patient factors		
Previous cesarean section	6,043,535 (15.8)	1732 (18.2)	.0035
Mean number of elixhauser Conditions	0.34	0.67	<.001
Comorbid Conditions directly Related to SB			
Chronic renal failure	12,112 (0.0)	19 (0.2)	<.001
Chronic lung disease	1,277,928 (3.3)	1039 (10.9)	<.001
	Type of delivery		
Vaginal delivery	25,945,792 (67.7)	4445 (46.7)	<.001
SB occulta	n/a	1842 (19.3)	
SB no hydrocephalus	n/a	1982 (20.8)	
SB with hydrocephalus	n/a	622 (6.5)	
Caesarean delivery	12,364,506 (32.3)	5071 (53.3)	<.001
SB Occulta	n/a	1368 (14.4)	
SB no hydrocephalus	n/a	2536 (26.7)	
SB with hydrocephalus	n/a	1166 (12.2)	

Table 2. Frequency of fetal and maternal diagnoses and morbidity overall

Variable	No Spina Bifida	Spina Bifida	*P* Value
	Fetal outcomes		
Preterm delivery (<37 wk gestation)	2,787,426 (7.3)	1080 (11.3)	<.001
Maternal antenatal diagnosis			
Fetopelvic disproportion/obstruction	1,861,285 (4.9)	502 (5.3)	.38
	Maternal outcomes		
Outcomes likely related to a SB condition			
Neurologic event	86,371 (0.2)	57 (0.6)	<.001
Pulmonary event	60,576 (0.2)	89 (0.9)	<.001
Renal event	25,743 (0.1)	21 (0.2)	.014
VP shunt malfunction/replacement	1116 (0.0)	*	<.001
Urinary tract infection	291,566 (0.8)	439 (4.6)	<.001
Other outcomes			
Anesthesia-related complication	143,721 (0.4)	44 (0.5)	.53
Blood transfusion	368,359 (1.0)	217 (2.3)	<.001
Cardiac event	88,798 (0.2)	62 (0.6)	<.001
Hematologic event	763,717 (2.0)	383 (4.0)	<.001
DVT	15,889 (0.0)	*	.17
Delivery-related infections	163,148 (0.4)	48 (0.5)	.61
Hemorrhage	1,090,237 (2.8)	310 (3.3)	.28

* Incidence too low to report.

Table 3. Frequency of fetal and maternal morbidity associated associated with vaginal and cesarean deliveries

Variable	No Spina Bifida	Spina Bifida	*P* Value
	Vaginal Delivery Outcomes		
Fetal outcomes			
Fetal distress	1,640,011 (6.3)	324 (7.3)	.22
Umbilical cord complication	6,382,296 (24.6)	1130 (25.4)	.56
	Maternal outcomes		
Outcomes likely related to a SB condition			
Neurologic event	42,264 (0.2)	14 (0.3)	.24
Pulmonary event	18,327 (0.1)	*	.70
Renal event	9649 (0.0)	*	.0033
Urinary tract infection	178,646 (0.7)	157 (3.5)	<.001
VP shunt malfunction/replacement	*	*	n/a
Other outcomes			
Anesthesia-related complication	73,856 (0.3)	14 (0.3)	.91
Forceps or vacuum delivery	378,255 (1.5)	29 (0.6)	.039
OB-related trauma to perineum or vulva	13,623,040 (52.5)	2502 (56.3)	.021
Blood transfusion	136,951 (0.5)	28 (0.6)	.65
Cardiac event	13,928 (0.1)	*	n/a
Hematologic event	310,269 (1.2)	103 (2.3)	.002
DVT	7911 (0.0)	*	.16
Delivery-related infection	49,202 (0.2)	*	.91
Hemorrhage	821,234 (3.2)	179 (4.0)	.13
	Cesarean delivery outcomes		
Outcomes likely related to a SB condition			
Gastrointestinal tract injury	13,806 (0.1)	23 (0.5)	<.001
Urinary tract injury	33,879 (0.3)	71 (1.4)	<.001
VP Shunt malfunction/replacement	460 (0.0)	*	<.001
Hysterectomy	28,052 (0.2)	14 (0.3)	.76
Neurologic event	44,107 (0.4)	43 (0.8)	.0072
Pulmonary event	42,249 (0.3)	84 (1.7)	<.001
Renal event	18,473 (0.1)	*	.65
Urinary tract infection	112,920 (0.9)	283 (5.6)	<.001
Other outcomes			
Anesthesia-related complication	69,865 (0.6)	30 (0.6)	.88
Blood transfusion	231,408 (1.9)	189 (3.7)	<.001
Cardiac event	74,870 (0.6)	62 (1.2)	.009
Hematologic event	453,448 (3.7)	280 (5.5)	<.001
DVT	7978 (0.1)	*	.67
Delivery-related infection	113,946 (0.9)	39 (0.8)	.59
Hemorrhage	269,003 (2.2)	130 (2.6)	.40
Wound complication	*	*	n/a

* Incidence too low to report.

COMMENT

This is the first large-scale study describing obstetrical outcomes among mothers with spina bifida, which allows for a broader understanding than the current small case series. We demonstrated that despite the fact that most women live outside a city, most delivered at an urban teaching hospital. This indicates that many women with SB must travel for their care. There was a significantly higher incidence of cesarean delivery among women with SB compared to the general population, with utilization increasing with increasing severity of SB. The utilization of cesarean delivery has been stable over time. Immediate peripartum complications occur with significantly greater frequency in this population than among women without SB after cesarean section, but not vaginal delivery. These findings serve to inform SB providers when counseling women who are of child-bearing age.

Certain trends have been reported in prior case series which are consistent with our findings. Specifically, the higher incidence of preterm delivery has been noted, although at higher rates than seen in this study.[8,9] This could be caused, in part, by the inability to sense contractions in patients with higher level lesions or by the increased incidence of urinary tract infection among women with SB during pregnancy, which is associated with preterm labor.[8] Their increased risk of urinary tract infections is a well-documented phenomenon that may be explained by these patients' underlying predisposition as well as changes during pregnancy causing increased urinary stasis and difficulties with urinary catheterizations.[9-12] The reported rates of renal complication such as acute renal injury vary widely and likely relates to baseline renal function prior to surgery.[11-15] The significantly higher odds of neurologic and pulmonary complications that we

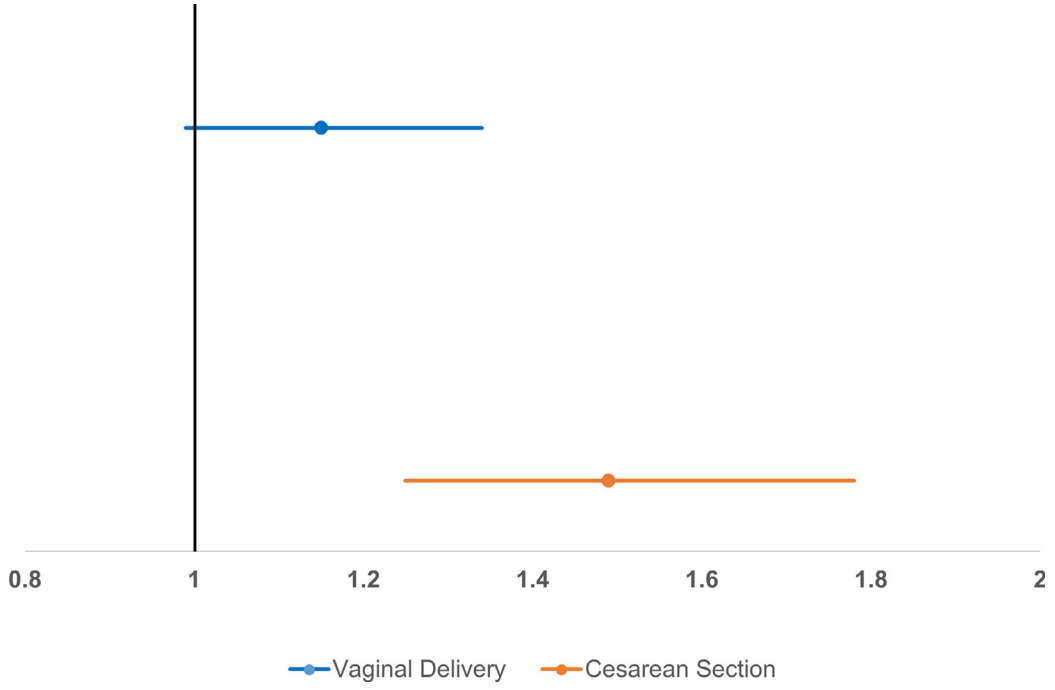

Figure 1. Odds of complication of deliver for women with spina bifida compared to women without spina bifida. (Color version available online.)

observed are consistent with other reports of an increased incidence of seizure episodes, shunt malfunctions, respiratory compromise, and pneumonia after delivery.[16]

There are limitations of our study that merit discussion. First, we must acknowledge the risk of selection bias. In our observational study, women with SB who undergo vaginal delivery may differ in unobserved ways from those who had cesarean deliveries, such as differences in level of lesion. The difference in disability based on level of lesion may moderate a woman's odds of complication. The reliability of using ICD9 codes to determine the severity of SB is unclear and providers less familiar with the nuances of SB may have entered these codes. The higher rates of cesarean delivery and complications with delivery among women with SB occulta was unexpected given patients with this diagnosis are usually asymptomatic. These patients may represent a particular subset of women with SB occulta who are particularly symptomatic, or alternatively some of these women may have a neural tube defect but were assigned an incorrect ICD-9 code. Additionally, we are unable to distinguish between planned versus labored cesarean deliveries. The NIS database does not allow us to follow patients before and after discharge, so complications that occurred during pregnancy and in the later postpartum period are unknown. We also cannot determine which patients have previously undergone other surgeries such as bladder reconstruction. Finally, the outcomes of the neonates are unknown, which is an important part of prenatal counseling. This is an area that needs further study.

Despite these limitations, our study has several important clinical implications. It is currently recommended that women with SB undergo vaginal delivery unless there are obstetrical contraindications, or the patient has undergone a reconstructive urethral continence surgery.[11,12,15] The findings of this study support this recommendation with a cesarean section done for obstetrical or urological reasons only. However, our findings do not imply that a cesarean delivery should not be performed when indicated as this will be the safest type of delivery for some women. Other studies have reported similar rates of cesarean delivery, most commonly for previous cesarean delivery, pelvic contraction, breech presentation, premature delivery, and preeclampsia.[8] Greenwell et al reported on 28 deliveries among women who underwent lower urinary tract reconstruction for various congenital anomalies including SB. They found that 43% of deliveries were planned cesarean deliveries and 23% were emergent, most commonly for premature labor and preeclampsia.[14] There is general consensus that a urologist should be present or immediately available for a women with SB who requires a cesarean delivery if she has undergone bladder reconstruction or has other urinary tract anomalies to help decrease the risk of intraoperative injury.[11,12]

Our role in discussing reproductive function with these women cannot be limited to the perinatal period. It is concerning that 26% of the deliveries in this study occurred by age 22 for women with SB as 59%-76% of pregnancies in women this age are unintended.[17] While this rate is no different than for women without SB, providers may not be talking about sex with their adolescent and young adult SB patients; indeed, as few as 5% of

young women with SB have talked to a physician about this topic.[18,19] This is especially worrisome as many women with physical disabilities assume sexual education they get in school does not apply to them, yet most adolescent and young adult women with physical disabilities are just as sexually active as their able-bodies counterparts.[20,21] These women deserve to understand their sexual and reproductive health and have access to family planning options and gynecologic care. As lifelong genitourinary providers who are especially invested in these patients, urologists are best positioned to initiate discussions about sexual and reproductive health with these women and indeed have taken responsibility for starting these conversations.[22-24] With intentional collaboration with obstetricians and primary care providers, we can help these women make informed decisions. Additionally, these women should be screened for safety in their relationships as women with physical disabilities are 4 times more likely to be victims of sexual abuse and are more likely to experience intimate partner violence than able-bodied women.[25,26]

For women who are pregnant or considering pregnancy, they should be informed while vaginal delivery is safe and possible for women without contraindications, most women with SB undergo cesarean section. The overall risk of complications during delivery is similar to women without SB, but slightly higher during a cesarean section than for women without this diagnosis. With the increased risk of preterm delivery, they should be informed of signs and symptoms that could indicate contractions in women with abnormal abdominal sensation. Due to the high prevalence of urinary tract infections, they should be closely monitored by their urologists and obstetricians to help prevent the infections and ensure the enlarging uterus does not inhibit adequate bladder drainage. There may be a need for prophylactic antibiotics to prevent urinary tract infections and alternative catheterization schedules or approaches during pregnancy.[8,12,16] Patients should be informed of their increased likelihood of hematologic events and possible need for a blood transfusion. Finally, patients should work with their SB-specific subspecialists to optimize their medical status before and during pregnancy. Active collaboration between specialists and obstetricians will help to manage and possibly prevent complications associated with delivery.

CONCLUSION

While delivery among women with SB is generally safe, these women do have a slightly increased risk of peripartum complications, particularly after cesarean section. These are likely related to their underlying comorbidities. A team approach including urologists, obstetricians, and other appropriate subspecialists will be needed to help women with SB make informed decisions and to optimize their obstetrical outcomes.

Acknowledgments. The authors would like to thank Lindsey Admon, M.D., M.S. (National Clinician Scholars Program, University of Michigan Institute for Healthcare Policy and Innovation and the US Department of Veteran Affairs, Ann Arbor) for her contribution to designing this research study and editing the manuscript.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.urology.2018.04.045.

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EDITORIAL COMMENT

The authors present a thought-provoking analysis of a large database (National Inpatient Sample) regarding delivery and peripartum complications among women with spina bifida (SB) vs those without SB. Women in this sample with SB had a significantly higher rate of cesarean delivery. Specifically the frequency of cesarean delivery increased with the presence of SB and increasing severity of SB (no SB < SB occulta < SB without hydrocephalus < SB with hydrocephalus). It is puzzling that those with a potentially benign diagnosis such as SB occulta had such an increased frequency of cesarean delivery. Women with SB who had a cesarean delivery did have higher odds of morbidity (ie, preterm delivery, urinary tract infection, hematologic event, and blood transfusion) compared to those without SB who had the procedure.

The results highlight important implications for women of childbearing age with SB of whom there has been a paucity of information. Clearly, the results provide healthcare providers who care for women with SB with much needed evidence to facilitate informed dialogue about potential risks at delivery.

As the authors appropriately acknowledge, the data is exclusively drawn from hospital discharge encounters. The reliability of using ICD-9 codes to determine the type and severity of SB is unclear and relying on providers who may not be familiar with the nuances of SB classification may be significantly problematic. However, this type of analysis is useful in identifying overall trends and information about rare events in an SB population. The lack of SB specific details necessary for teasing out clinical differences provides fodder for future studies that can follow. These findings present an opportunity for more meticulous SB-related research, as well as a basis for future guidelines regarding care for this population living with such a complex condition.

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https://doi.org/10.1016/j.urology.2018.04.047
UROLOGY 123: 286, 2019.

AUTHOR REPLY

We appreciate the comments of the reviewer. As pointed out in the editorial and discussed in our paper, the lack of research on pregnancy and delivery among women with spina bifida impedes preconception counseling and birth planning for these women. This study provides foundational knowledge to have informed conversations with women with spina bifida interested in pregnancy.

The benefit of performing a population-based study with a large database such as the National Inpatient Sample is that it allows for a better understanding of rare events in small populations such as, delivery among women with spina bifida. However, it does come with limitations. In this study, we described overall trends among all women with spina bifida and also distinguished between those women with spina bifida with and without hydrocephalus and with spina bifida occulta. While we are unable to verify the appropriateness of these subcategories, the findings of increased likelihood of a cesarean delivery and increased odds of complication during delivery with increasing severity of spina bifida seems appropriate. As commented on in the editorial, nearly 43% of women with spina bifida occulta underwent a cesarean delivery compared to 32% of women without spina bifida. This could be due to symptomatic disease in this cohort causing problems such as leg weakness or changes in sensation that could make labor more difficult and obstetricians more cautious. Alternatively, given that obstetricians may not be familiar with distinguishing between types of spina bifida, some of these women may actually have open spina bifida but were assigned the incorrect ICD-9 code.

Nonetheless, this study provides a needed starting point for informing both doctors and women with spina bifida about delivery. Further research including multi-institutional reviews and interviews with women who have been pregnant are necessary for a more comprehensive understanding of pregnancy and delivery in women with spina bifida.

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https://doi.org/10.1016/j.urology.2018.04.048
UROLOGY 123: 286, 2019.