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Transvaginal cervical length surveillance frequency and the management of spontaneous preterm delivery in twin gestations

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Preceptorship Location and Description:

Methodist Women's Hospital Perinatal Center

A full-service consultation, testing and treatment center for high-risk pregnancies staffed by Maternal-Fetal Medicine specialists.

Abstract

Strategies to prevent preterm birth in multifetal gestation remain a high-priority in the United States. In women with a history of spontaneous preterm birth (sPTB) and singleton gestation, transvaginal cervical length (TVCL) surveillance and subsequent treatment is associated with a reduction in spontaneous preterm birth, however, there is limited data on the role of TVCL surveillance in twin gestation. The goal of this study is to determine if an association exists between TVCL and spontaneous preterm birth in twin gestations. Additionally, our research will assess whether TVCL surveillance impacts the timing of antenatal corticosteroids (ACS), magnesium sulfate administration, and maternal and neonatal outcomes in multiple gestations. We performed a retrospective cohort study of women with twin gestations born at Methodist Women's Hospital between January 1st, 2013 and April 30th, 2016. Patients having six or more TVCL measurements during their twin gestation were compared to those with less than six TVCL measurements. Women without TVCL measurement, monochorionic-monoamniotic twins, or monochorionic-diamniotic twins with twin-twin transfusion syndrome were excluded from statistical analysis. We hypothesized that women who experience spontaneous preterm birth will demonstrate shorter TVCL measurements throughout their surveillance. We also hypothesized that those with more frequent TVCL surveillance would result in optimized timing of ACS within seven days of delivery, increased exposure to magnesium sulfate in those born before 32 0/7 weeks and improved neonatal and maternal outcomes. Our study found no association between TVCL frequency and spontaneous preterm birth, exposure to magnesium sulfate for neuroprotection, or maternal or neonatal outcomes. Twins whom delivered at <34 0/7 weeks were more likely to receive first course ACS (55% vs 31%, p=0.03) within 7 days of delivery in the <6 TVCL measurement surveillance group. It was concluded that TVCL surveillance is not beneficial more frequently than every 28 days and timing of ACS and magnesium sulfate administration for neuroprotection should not be based on TVCL measurements.

Introduction

Prematurity is the leading cause of death in children under the age of five.[1-3] While more than 60% of preterm birth occurs in Africa and South Asia; preterm birth remains a global problem.[1] While preterm birth rates remain highest for low-income countries (11.8% of live births), high-income countries maintain a relatively high rate (9.3% of live births).[1] The United States accounts for 42% of the estimated 1.2 million preterm births occurring in high-income countries.[1] The rate of preterm birth continues to increase in the United States, and remains an economic burden and public health concern.[3]

While preterm birth may be indicated for maternal or fetal medical indications, the majority of preterm births are spontaneous.[4] Spontaneous preterm birth includes all birth following preterm labor, preterm premature rupture of membranes, or cervical insufficiency.[4] An intermixing of genetic, epigenetic, and environmental risk factors drives spontaneous preterm birth, and an identified cause remains unknown in more than 50% of cases.[1] Behavioral risk factors for premature birth include low maternal pre-pregnancy weight, smoking, substance abuse, prior cervical surgery and short-interval pregnancy.[4] Women with a prior preterm birth have a 1.5 fold increased risk of premature birth in a subsequent pregnancy.[4] Vaginal bleeding, urinary or genital tract infections, and periodontal disease during pregnancy are also believed to increase risk; however, one of the strongest clinical risk factors for preterm birth is multifetal gestation.[4]

Women with multiple gestations are six times more likely to give birth <37 0/7 weeks and thirteen times more likely to give birth before 32 0/7 weeks than women with singleton gestations.[5] The mean gestational age for a twin to be born is preterm at 35.3 weeks.[2] The twin birth rate in the United States rose 76% from 1980 to 2009, leading to a 40% increase in the proportion of preterm births due to twin gestations.[6] In addition, there is disproportionate morbidity and mortality associated with multiple gestations.[6] Twins have a 4-fold higher mortality risk, with 50% of deaths occurring from the complications of prematurity. [6] Thus, the prevention and management of premature birth in multifetal gestation remains a high-priority when developing strategies to reduce morbidity and mortality related to preterm birth within the United States.

Screening for preterm birth risk has traditionally included transvaginal cervical length (TVCL) surveillance. It is well-established that a shorter midtrimester TVCL increases the risk of premature birth in both singleton and multiple gestations.[7,8] The Preterm Prediction Study (1996) found that a midtrimester TVCL less than or equal to 25mm was associated with a six fold increase in premature birth in singleton gestations and an eight fold increase in twin gestations.[7] Cervical length surveillance has become an integral part of obstetric practice in the prevention of preterm birth and those identified by TVCL at risk for preterm birth in singleton gestation may benefit from an intervention such as cerclage or progesterone therapy.[4]

In many institutions, TVCL surveillance has expanded to include twin gestations; however, there is no evidence to suggest cervical length surveillance and subsequent interventions (cerclage or progesterone treatment) decrease neonatal morbidity or mortality in twins.[2] Secondary to this lack of evidence, The American College of Obstetricians and Gynecologists (ACOG) does not recommend the use of TVCL surveillance in asymptomatic women with multifetal gestations.[2] Even with this recommendation, TVCL surveillance in multiple gestations remains widely used in clinical practice with the goal of identifying women who may benefit from closer monitoring and optimizing administration of antenatal corticosteroids (ACS).

The optimal frequency of cervical length surveillance in twin gestations remains unknown. Recent meta-analyses suggest that a transvaginal ultrasound during the second trimester is a powerful predictor of preterm birth in multiple gestation.[9,10] Given that the timing of cervical shortening may occur anytime during the second trimester, serial monitoring of cervical length into early in the third trimester to improve detection rates and determine pattern of change or rate of cervical shortening has been suggested.[11,12] In two studies, Melamed et al. found that the relative degree of shortening over time improved the prediction of preterm birth at <32 weeks in singleton and multiple gestations compared with a single measurement and classified four patterns of cervical lengths over time each with an independent risk for preterm birth.[11,12] Notably, the optimal frequency of cervical length surveillance and how to best use the information obtained requires further research.

Currently, there is no evidence for an effective intervention to prolong gestation in multiple gestation pregnancies with a short cervix.[2] If gestation cannot be prolonged, the information may be used to help clinicians and families best prepare for a premature birth. This surveillance also may allow for appropriately timed administration of antenatal corticosteroids 1-7 days before birth in twin pregnancies, which has been found to have a significant reduction in neonatal mortality, short-term respiratory morbidity, and severe neurological injury similar in magnitude to that observed in singletons.[13,14] Studies have demonstrated that twin newborns delivering >7 days after their ACS treatment experienced significantly more respiratory disorders and were hospitalized longer than infants receiving steroids <7 days before birth if born at <34 weeks.[15] Thus, the timing of ACS relative to delivery in twin gestations remains a critical intervention to maximize neonatal outcomes.

Previous literature remains conflicted on the use of cervical length measurements for the appropriate timing of ACS administration in twins. Several studies have found cervical length ≤2 cm and cervical change to be strong predictors of optimally timed ACS.[16, 17] Marcellin et al. reported that routine monthly cervical length monitoring compared to targeted use in women with suspected preterm labor does not affect the rate of ACS administration <34 weeks.[18] Further, their findings suggested that in those born >34 weeks more individuals in the routine surveillance group received steroids, suggesting routine surveillance may lead to a greater amount of unnecessary ACS administration.[18] Cervical length surveillance also has been suggested to help time administration of magnesium sulfate for neuroprotection when delivery is anticipated before 32 weeks gestation in twins.[4] The effectiveness of this has yet to be studied. Further research is needed to determine the role and frequency of cervical length surveillance in the timing of ACS and magnesium sulfate.

If TVCL is associated with improved timing of ACS administration, it is important to determine if TVCL surveillance and its subsequent clinical decision pathway are cost effective in the reduction of neonatal morbidity associated with respiratory distress syndrome. In singleton gestations, universal TVCL screening has been shown to be cost effective to identify those at risk for preterm delivery. In an analysis by Werner et al., for every 100,000 women with low-risk singleton gestations screened $12,119,947 could be saved, 423.9 quality adjusted life years could be gained, and 22 cases of neonatal death due to prematurity could be prevented.[19] These results are largely due to the use of progesterone to prevent premature birth when a short cervix is identified. In twin gestations, no effective strategy has been proven to prevent preterm birth, thus it is important to determine if the potential benefit of improved neonatal respiratory and neurological morbidity gained from appropriately timed antenatal corticosteroids and magnesium sulfate administration outweighs the cost associated with a TVCL screening strategy in twins. The financial costs must be considered for TVCL surveillance as part of the armamentarium of care when outcome data concerning morbidity and mortality are still being evaluated to determine best future practices concerning cervical length measurements in twin gestations.

Preterm birth remains a leading cause of morbidity and mortality in the United States despite significant effort and research into its prevention. There are currently no interventions with significant evidence to prolong gestation in multiples, and TVCL surveillance is not recommended by the American College of Obstetrics and Gynecologists. Yet, TVCL is often used in multifetal gestations with varying frequency to help clinicians predict preterm birth and time interventions such as antenatal corticosteroid administration. The literature is inconclusive on whether TVCL improves this timing, and no literature exists on the economic impact of universal TVCL screening in twins. This study aims to add to the limited literature and help guide clinicians on best practice for their patients, including considerations of the financial impact of TVCL surveillance. The purpose of this study is to (1) determine if there is an association between the frequency of cervical length surveillance and spontaneous preterm birth in twins; (2) determine if an association exists between the frequency of cervical length surveillance and the timing of ACS administration; (3) determine if an association exists between the frequency of cervical length surveillance and the timing of magnesium sulfate for neuroprotection; (4) determine if an association exists between the frequency of cervical length surveillance and composite maternal and neonatal morbidity; and (5) determine the economic impact of implementing standard TVCL surveillance in twin gestations.

Problem Statement

Shortened cervical length measurements on TVCL has been associated with spontaneous preterm birth, yet there is limited data regarding the frequency of this surveillance in twin births and whether this surveillance affects interventions such as timing of antenatal corticosteroid administration within seven days of delivery.

Research Question 1:

Does an association exist between TVCL surveillance frequency and the rate of spontaneous preterm birth among twin gestations?

Hypothesis 1:

1. Women who receive six or more cervical lengths measurements are less likely to experience spontaneous preterm birth compared to women who receive less than 6 cervical lengths measurements among twin gestations.

Research Question 2:

Does an association exist between TVCL surveillance frequency and the timing of antenatal corticosteroid administration among twin gestations delivering at ≤34 0/7 weeks?

Hypothesis 2:

1. Women who receive ≥6 TVCL measurements are more likely to receive any (first course or rescue) antenatal corticosteroid administration within seven days of delivery among twin gestations delivering at ≤34 0/7 weeks compared to women who receive <6 TVCL measurements.

Research Question 3:

Does an association exist between TVCL surveillance frequency and exposure to magnesium sulfate for neuroprotection in twins born ≤32 0/7 weeks?

Hypothesis 3:

1. Women who receive ≥6 TVCL measurements are more likely to be exposed to magnesium sulfate for neuroprotection if born at ≤32 0/7 weeks compared to women who receive <6 TVCL measurements.

Research Question 4:

Does an association exist between TVCL surveillance frequency and composite maternal and neonatal morbidity among twin gestations?

Hypothesis 4:

1. Women who received ≥6 TVCL measurements are more likely to be associated with lower composite maternal (e.g. peripartum venous thromboembolism, pelvic abscess, sepsis, wound disruption, intensive care unit admission, blood transfusion, and readmission) and neonatal (e.g. umbilical artery pH <7.1, five minute APGAR <5, diagnosis of respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy, periventricular leukomalacia, intraventricular hemorrhage grade 3 or 4, necrotizing enterocolitis, proven sepsis, stillbirth or death before discharge) morbidity among twin gestations compared to women who receive <6 TVCL measurements.

Research Question 5:

What is the economic impact of incorporating a universal TVCL surveillance strategy in twins and considering neonatal morbidity and mortality outcomes?

Hypothesis 5:

1. Implementing a universal TVCL surveillance strategy will be cost effective at reducing neonatal morbidity and mortality compared to no TVCL surveillance

Research Design and Methods

A retrospective cohort study was chosen to include all twin pregnancies delivered at Methodist Women's Hospital in Omaha, Nebraska between January 1st, 2013 and April 30th, 2016 using a pre-existing de-identified database, which was approved by the Methodist Women's Hospital Research Ethics Board and waived by UNMC Ethics Board. Cases for the database were identified using ICD 9 discharged codes V27.2 (Outcome of delivery, twins, both live born) and V27.3 (Outcome of delivery, twins, one live born and one stillborn). Maternal and neonatal outcomes were individually extracted from medical records. A single research team member was responsible for performing all data abstraction and entry of identified cases to avoid interpersonal variation in data collection methods. A random sample of five patients every one hundred was chosen and reviewed for accuracy to ensure data quality. For this study, all twins within the database were screened for analysis. Women without TVCL measurement, monochorionic-monoamniotic twins, and monochorionic-diamniotic twins with a history of twin-twin transfusion syndrome were excluded. Those with ≥6 TVCL measurements were compared with those with <6 TVCL measurements.

Gestational age was determined by earliest ultrasound examination. All ultrasound reports throughout gestation were reviewed for TVCL measurements. The gestational age at TVCL measurement and TVCL measurement in millimeters was recorded.

All sonographic examinations were performed by experienced sonographers and interpreted by a maternal-fetal medicine physician using a transvaginal approach. The measurement of TVCL was done using a set protocol as described by Iams et al.[20] A transvaginal probe was placed into the anterior fornix of the vagina while the women's bladder was empty. The appropriate sagittal view was identified, visualizing the full length of the endocervical canal from the internal to the external cervical os while exerting as little pressure as possible on the cervix. Three measurements were taken and the shortest measurement was recorded. The presence of cervical funneling, either spontaneously or in response to fundal pressure, was also documented.

In order to evaluate charges associated with surveillance, the following information was obtained from the database for each patient: the number of TVCLs performed, inpatient hospital days for cervical shortening, outpatient administration of ACS following the diagnosis of cervical shortening, the cervical length at which these decisions occurred, and whether or not delivery occurred within seven days of ACS administration. Charges were obtained from Methodist Hospital System financial records. The total charge for each patient was calculated using the total number of TVCL performed, administration of outpatient ACS, and inpatient admission for ACS. The added charge of implementing a standardized TVCL surveillance protocol into Methodist Health system was determined.

Chorionicity was confirmed by placental pathology following delivery. Baseline maternal characteristics collected included: age, parity, race, insurance status at delivery, height and weight at diagnosis of pregnancy, mode of conception, smoking status, chronic conditions, and history of preterm birth, diabetes, or hypertensive disorders in pregnancy. The use of antenatal corticosteroids and magnesium sulfate for neuroprotection during pregnancy was abstracted from medical records. The gestational age at which these were completed was recorded. Additional maternal outcomes included hospital days greater than five, number of days of bed rest, use of tocolytics, development of gestational hypertension, preeclampsia, gestational diabetes, preterm premature rupture of the membranes, indication for delivery, mode of delivery, and postpartum hemorrhage. A set maternal morbidity composite was recorded to include any of the following:

peripartum venous thromboembolism, pelvic abscess, sepsis, wound disruption, ICU admission, blood transfusion, and readmission. Additional neonatal outcomes included were gestational age at delivery, birthweight Twin A, birthweight Twin B, weight discordance, and admission and length of stay (days) in the neonatal intensive care unit. A predefined neonatal composite of adverse outcomes included: umbilical artery pH <7.1, five minute APGAR <5, diagnosis of respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy, periventricular leukomalacia, intraventricular hemorrhage grade 3 or 4, necrotizing enterocolitis, proven sepsis, stillbirth or death before discharge.

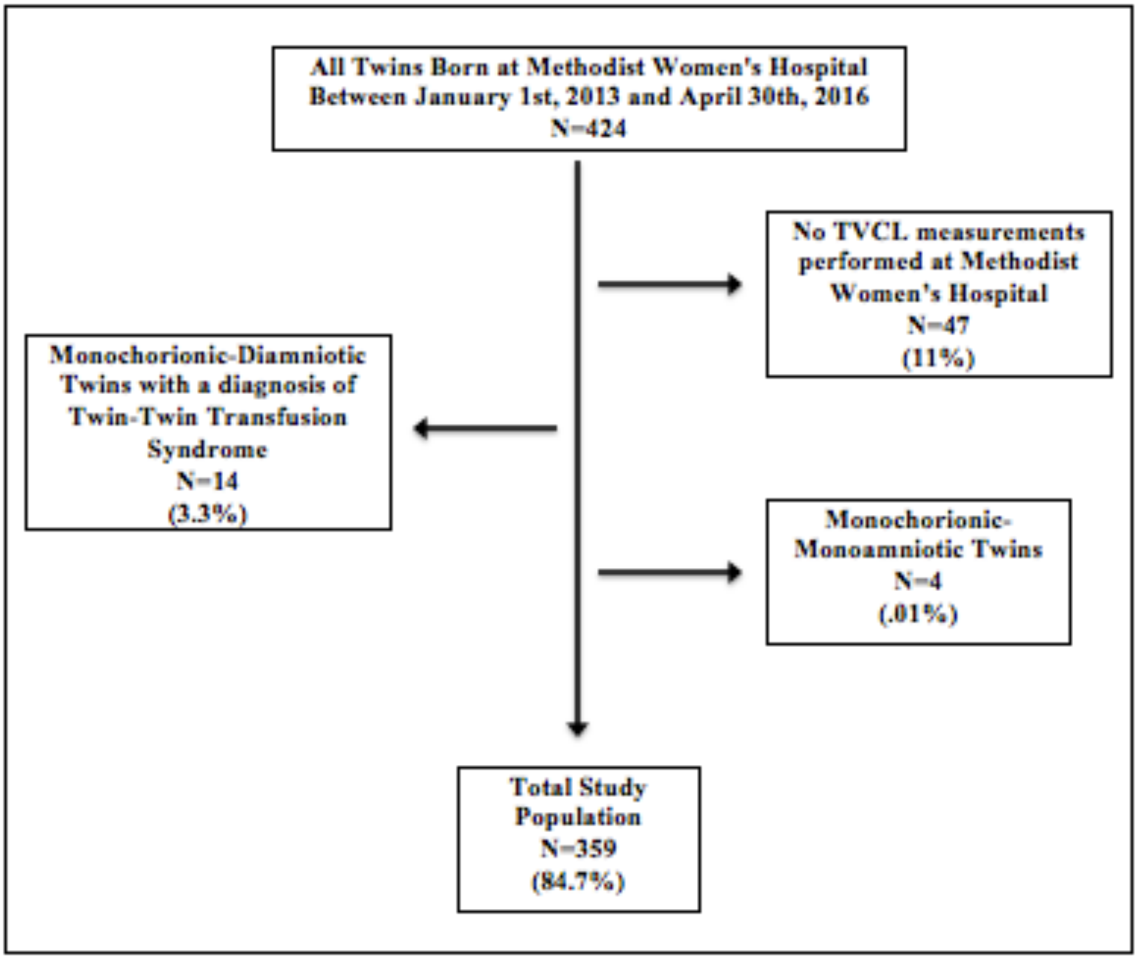
Statistical analysis was performed using Statistical Package for the Social Science Version 24 (SPSS) by IBM Analytics. Continuous variables were compared using a Student's T test. Categorical variables were explored using Chi-squared tests or Fisher's exact tests where appropriate based on cell size. The threshold for significance for all tests will be set at $P < 0.05$. A power analysis using Gpower computer program indicated that a total sample size of 128 would be needed to detect medium effects (d=.5) with 80% power using a t test between means with an alpha at .05.

Results

Characteristics of the Study Population

A total of 424 women with twin pregnancies were identified during the study period, of whom 359 (84.7%) were eligible for the study. 47 (11%) had no TVCL performed at Methodist Women's Hospital Perinatal Center, 4 (1%) were monochorionic monoamniotic twin pregnancies, and 14 (3.3%) were monochromic diamniotic twin pregnancies diagnosed with twin-twin transfusion syndrome (**Figure 1**).

Figure 1. Study Population Selection



The characteristics of these excluded groups did not differ from our included population. Demographic characteristics of our population are included in **Table 1**.

Women in the ≥6 TVCL measurement group received TVCL screening significantly more frequently (8.5 ± 2.9 times during pregnancy vs. 3.8 ± 1.1 times during pregnancy, p=<0.001). The mean gestational age at delivery did not differ between the two groups (34.9 ± 3.6 weeks, ≥6 vs 35.3 ± 2.4 weeks; p=0.36). Those that received ≥6 TVCL measurements were more likely to have a monochorionic-diamniotic pregnancy (19.2% vs 10.9%, p=0.03), had a greater likelihood of cerclage placement (8.9% vs 1.3%, p=0.002), and were more likely to be exposed to tocolytics (35.5% vs 17.3%, p=<0.001). Additionally, while those in the ≥6 TVCL measurement group had statistically significantly lower BMI (26.5 ± 6.4 vs 28.0 ± 6.6, p=0.03) this is unlikely clinically significant.

Table 1. Maternal Population Demographics

Maternal Characteristics			
	<6 TVCL Measurements n= 156	**≥6 TVCL Measurements** n= 203	**p value**
Gestational age at delivery, weeks ± SD	34.9 ± 3.6	35.3 ± 2.4	0.36
Age (years ± SD)	31.3 ± 4.8	31.5 ± 4.8	0.7
Caucasian (%)	146 (93.6%)	192 (94.6%)	0.69
Medicaid, n (%)	10 (6.4%)	15 (7.4%)	0.72
Nulliparity, n (%)	57 (36.5%)	69 (34%)	0.62
BMI, kg/m^2 ± SD	28.0 ± 6.6	26.5 ± 6.4	**0.03**
Conception via reproductive technology, n (%)	79 (50.6%)	82 (40.4%)	0.06
Monochorionic-Diamniotic, n (%)	17 (10.9%)	39 (19.2%)	**0.03**
Chronic hypertension, n (%)	15 (9.6%)	11 (5.4%)	0.13
Diabetes (any), n (%)	18 (11.5%)	27 (13.3%)	0.62
Tobacco Use, n (%)	8 (5.1%)	9 (4.4%)	0.76
History of Cervical Surgery, n (%)	4 (2.6%)	6 (3.0%)	0.82
History of Preterm Birth, n (%)	6 (3.8%)	12 (5.9%)	0.37
Average Number of TVCL during Pregnancy, mean ± SD (min, max)	3.8 ± 1.1 (1,5)	8.5 ± 2.9 (6, 22)	**<.001**
Cerclage, n (%)	2 (1.3%)	18 (8.9%)	**0.002**
Preterm Labor Symptoms, n (%)	57 (36.5%)	94 (46.3%)	0.08
Polyhydramnios, n (%)	37 (23.7%)	62 (30.5%)	0.15
Exposure to Tocolytics, n (%)	27 (17.3%)	72 (35.5%)	**<.001**
Cesarean Delivery, n (%)	102 (65.4%)	137 (67.5%)	0.68

Spontaneous Preterm Birth Rates

Previous work from our cohort presented at the 38th Annual Pregnancy meeting in Dallas, Texas on February 2nd, 2018, demonstrated significantly shorter TVCL after 23 weeks gestation in those women who ultimately experienced spontaneous preterm birth at < 32 0/7 weeks, 32 0/7 to 33 6/7 weeks, and at 34 0/7 to 36 6/7 weeks (**Figure A1**). However, higher TVCL frequency did not improve the rate of spontaneous preterm birth. As shown in **Table B1**, no association existed between the frequency of TVCL surveillance and the rate of spontaneous preterm birth at <32 0/7 weeks, <34 0/7 weeks, and <37 0/7weeks.

Timing of Antenatal Corticosteroids

Women with higher TVCL surveillance frequency whom delivered at >37 0/7 weeks were more likely to be exposed to antenatal corticosteroids during pregnancy (11/56 (19.6%)) than women with less TVCL surveillance frequency whom delivered at >37 0/7 weeks (3/56 (5.4%), p value=0.02) (**Table B2**). There is no significant difference in ACS exposure between groups among those who delivered at <37 0/7 weeks, <34 0/7 weeks, or <32 0/7 weeks. Of twins whom delivered at <34 0/7 weeks, the mean days between first course ACS exposure (21.78 ± 16.3 vs 9.62 ± 11.6, p=0.03) or any ACS exposure (14.97 ± 14.97 vs 7.61 ± 9.41, p=0.01) and delivery was significantly higher in the >6 TVCL measurement surveillance group. Twins whom delivered at <34 0/7 weeks were more likely to receive first course ACS (55% vs 31%, p=0.03) or any ACS exposure (47.5% vs. 23.8%, p=0.02) within 7 days of delivery in the <6 TVCL measurement surveillance group. ACS were given more frequently for an indication of cervical length less than 25 mm in the >6 TVCL measurement frequency group than the <6 TVCL measurement frequency group. Other ACS indications included preterm labor, PPROM, IUGR, and preeclampsia.

Magnesium Sulfate Exposure for Neuroprotection

There is no evidence to suggest that the frequency of TVCL surveillance is associated with exposure to magnesium sulfate in twins born at <32 0/7 weeks. In our study population of those born at <32 0/7 weeks, exposure to magnesium sulfate for neuroprotection trended higher but not statistically significant in the ≥6 TVCL (68% vs 54%, p=0.34)(**Table B3**).

Composite Maternal and Neonatal Morbidity

Maternal morbidity and neonatal morbidity were analyzed using composites. Composite maternal morbidity included peripartum venothromboembolism, pelvic abscess, sepsis, wound disruption, ICU admissions, blood transfusion, and readmission to the hospital. Among TVCL frequency groups there is no evidence to suggest a difference in composite maternal morbidity (7.7% vs 7.4%, p=0.91) (**Table 5**). Composite neonatal morbidity included umbilical artery pH <7.1, five minute APGAR <5, diagnosis of respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy, periventricular leukomalacia, intraventricular hemorrhage grade 3 or 4, necrotizing enterocolitis, proven sepsis, and stillbirth or death before discharge in either twin. Among TVCL frequency groups there is no evidence to suggest a difference in composite neonatal morbidity (24.4% vs 24.6%, p=0.95) (**Table B4.**).

TVCL Screening for Reassurance

The negative predictive value of TVCL screening was also determined in our study population. **Table 2** displays the negative predictive value of spontaneous delivery following a negative TVCL screening at varying gestational ages. A negative TVCL screen was defined as a TVCL measurement >25 mm. Regardless of gestational age at screening, no women experienced a spontaneous delivery within 7 days following a negative screening. The negative predictive value decreased with increasing gestational age and increasing time following a negative screen.

Table 2. TVCL Screening, Negative Predictive Value

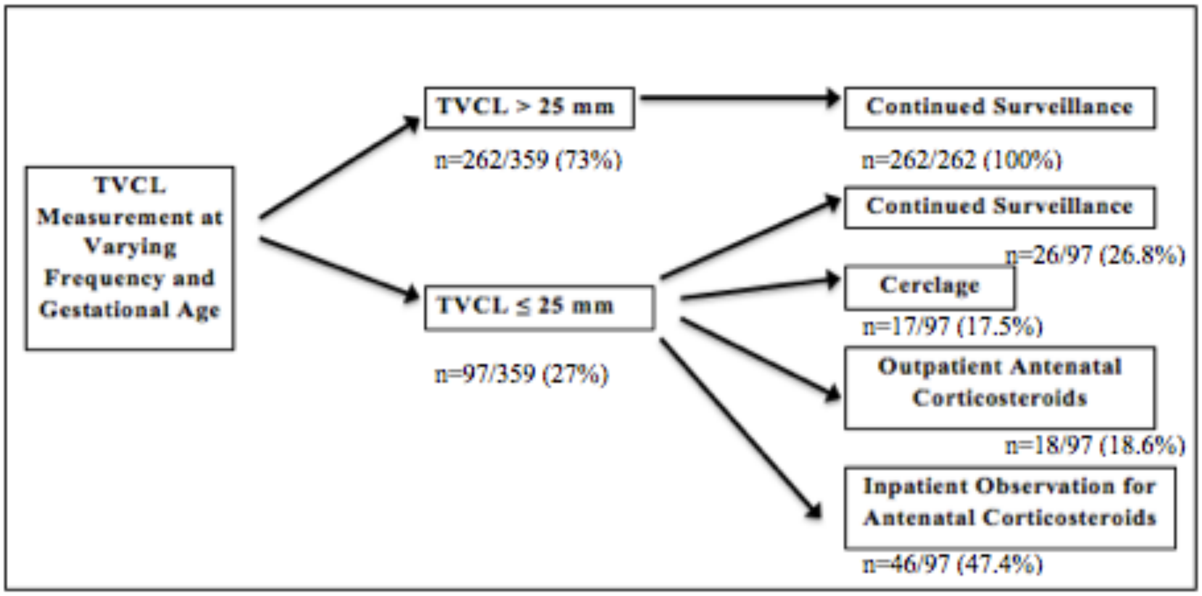
Negative Predictive Value (NPV) of TVCL Screening		n=379			
		NPV of Spontaneous Delivery within x days of >25 mm TVCL Screening			
Gestational Age of TVCL Screening	**n >25 mm TVCL in GA period**	***7 days***	***14 days***	***21 days***	***28 days***
24 weeks 0/7 - 25 weeks 6/7	236	1	0.992	0.979	0.979
26 weeks 0/7 - 27 weeks 6/7	224	1	1	0.996	0.978
28 weeks 0/7 - 29 weeks 6/7	156	1	0.994	0.987	0.981
30 weeks 0/7 - 31 weeks 6/7	67	1	0.97	0.925	0.866
32 weeks 0/7 - 33 weeks 6/7	14	1	0.929	0.714	0.643

The Cost of TVCL Screening

While a negative TVCL measurement provides reassurance against sPTB up to 28 days after screening, more frequent TVCL surveillance did not improve the timing of ACS or magnesium sulfate administration in our study population making it unlikely to be cost effective in the reduction of neonatal morbidity and mortality. Thus, a cost-effective analysis was not performed. In its place, we decided to investigate the total charges associated with TVCL surveillance and its potential economic impact on the organization and its patients.

In order to investigate the total charges associated with TVCL screening, it was first necessary to understand the various clinical decision pathways our perinatalogists take when a woman screens positive for a short cervix, as defined by a TVCL measurement <25 mm in agreement with previous studies (**Figure 2**). In our study population 27.0% of women with twin gestations experienced a short cervix during pregnancy (**Table C1**). The pathway of intervention appears to be based on TVCL length, gestational age, and accompanying symptoms of preterm labor.

Figure 2: Management Tree for TVCL Measurements in Pregnancy



Following the finding of a short cervix, 47% (n=46/97) of women were admitted to the antepartum unit for ACS administration and observation with an average TVCL measurement of 12.65 ± 5.72 mm and at an average gestational age of 27.19 ± 2.33 weeks. Nearly half of these women (n=22/46, 47.8%) were symptomatic on admission. Of those admitted, 42 (91.3%) received a course of ACS at some point in the admission, but only 6 (13%)were within the recommended 1 to 7 days of delivery. Delivery occurred an average of 42.47 ± 26.93 days after ACS completion. Although every patient was admitted under 72-hour observation, 26 (56.5%) transferred to a full admission. On average, a patient admission lasted 6.67 ± 6.53 days compared to the expected 48-72 hours. Four women were readmitted later in pregnancy under the same indication. Spontaneous preterm birth at <34 0/7 weeks was experienced by 47.8%, with 8 (36.4%) of these deliveries occurring during an admission for a short cervix.

Women who received outpatient ACS for the discovery of a short cervix appeared to have a longer cervix (16.21 ± 3.88 mm) and were less likely to be symptomatic (0%), but tended to be of similar gestational age (27.88 ± 2.48 weeks) compared to those who were admitted. No women in the outpatient ACS group received steroids within the recommend 1-7 days of delivery, although 50% (n=9/18) experienced sPTB at <34 0/7 weeks.

A cerclage appeared to be the intervention of choice among women with a short cervix identified in the second trimester. This group had an average gestational age of 21.48 ± 2.0 weeks at the time of positive screening. Additionally, TVCL measurement appeared to be shorter (10.98 ± 8.0 mm) compared to either the admitted or outpatient ACS groups. Spontaneous preterm birth at <34 0/7 weeks was experienced in 23.5% (n=4/17) women with cerclage.

A final clinical decision pathway included no immediate intervention at the time of identifying a short cervix. These positive screens appeared to occur at slightly later gestational ages (29.29 ± 1.86 weeks) and have considerably longer TVCL measurements (20.97 ± 2.96 mm). Only 7.7% (n=2/26) of women receiving no intervention for a short cervix had a sPTB at <34 0/7 weeks.

Our study population of 379 patients had a total of 2,311 TVCL performed during a 40-month time period. Hospital charges were obtained from financial charge sheets and medication charges were obtained through outpatient pharmacy services. The total charge associated with TVCL measurements during this time period was estimated at $1,585,346, an average of $418,297 per 100 patients (**Table C2**). Observation admission charges were estimated at $19,743, or $5,209 per 100 patients. The charges for transfers to full admissions and a corresponding discharge summary estimated $21,892, or $5,776 per 100 patients. These hospital charges may be considered basic minimum charges of a stay as other interventions that may have occurred during hospitalization were not included. Total charges for outpatient ACS amounted to an estimated $8,064, or $2,127 per 100 patients. This includes medication and injection for a full course of ACS (two doses 24 hours apart). The estimated charge for a cerclage suture placement and subsequent removal under anesthesia, required by one-third of our patients, was $8,948, or $2,361 per 100 patients. Overall, the current TVCL surveillance in the twin population approximates $433,770 per 100 patients.

Discussion/Recommendations

In our comparison of TVCL surveillance frequencies, we found that: 1) increased TVCL surveillance frequency did not improve sPTB rates at < 32 0/7 weeks, <34 0/7 weeks, or <37 0/7 weeks, 2) women who received ≥6 cervical lengths were significantly less likely to receive any (first course or rescue) antenatal corticosteroid administration within seven days if delivery occurred at ≤34 0/7 weeks; 3) no association of TVCL surveillance frequency with magnesium sulfate exposure or composite neonatal or maternal morbidity, 4) the negative predictive value of a TVCL screen over 2.5cm is >98% up to 28 days between 24 0/7 weeks and 29 6/7 weeks gestation; and 5) TVCL surveillance is unlikely cost effective in the management of sPTB in twin gestations with total charges amounting to $433,770 per 100 patients with twin gestation at our institution.

Our findings support previous studies conclusions that TVCL is a strong predictor of sPTB in women with twin gestations. While we found that women ≥6 TVCL (approximately every 2-weeks in the second trimester) compared to women who had <6 TVCL (approximately every 4-weeks in the second trimester) during their twin pregnancy did not improve neonatal and maternal outcomes in our study population; thus, there was no advantage to performing more frequent surveillance. Furthermore, the negative predictive value of a TVCL >2.5cm was similar at 28 days compared to 14 days. While this may prove reassuring to providers and patients, it remains unclear whether the cost of this surveillance is warranted given it did not improve timing of any intervention that may improve perinatal outcomes. Future research to compare every four-week TVCL measurements during pregnancy to no TVCL measurements during pregnancy may further elucidate the optimal frequency of surveillance, if any exists.

Previous studies on the use of TVCL measurements for the appropriate timing of ACS administration in twins have been conflicting. Several studies have found cervical length ≤2 cm and cervical change to be strong predictors of optimally timed ACS.[19, 20] Other studies have reported routine monthly cervical length monitoring, compared to targeted use in women with suspected preterm labor, did not affect the rate of ACS administration in those delivering at <34 weeks. [16] In fact, in those born >34 weeks, more patients in the routine surveillance group received steroids, suggesting high frequency surveillance leads to a greater amount of unnecessary ACS administration. [16] Optimizing timing of ACS remains important minimizing morbidities associated with prematurity, thus it is crucial to determine methods, if any, clinicians can use to identify patients who will benefit from ACS.

In a retrospective comparison between a practice with standardized TVCL and fetal fibronectin surveillance and one without this routine surveillance, Lifshitz et al. found improved optimal ACS exposure in the standardized surveillance cohort.[21] In contrast, our findings suggest that women receiving more frequent TVCL measurements were significantly less likely to appropriately receive first course or any ACS (first course or rescue) within the recommended 1 to 7-day window. In fact, the mean days between ACS course completion and delivery was twice that in the ≥ 6 TVCL surveillance group compared to the <6 TVCL surveillance group and led to a greater amount of unnecessary ACS administration in those born at >34 0/7 weeks.

Individuals in either frequency group who screened positive for a short cervix were found to receive frequent and often unnecessary intervention in our study population. In addition to the cost of ACS, these patients were frequently admitted to the hospital without delivery. The negative financial and emotional impact of prolonged hospitalization is not to be underestimated. At the discovery of a short cervix, patients are counseled that they will be admitted for a short observation to receive an ACS course; however, our findings suggest that patients often end up hospitalized considerably longer than 72 hours as providers discover alternative indications that would likely have gone unnoticed in an outpatient setting.

Prolonged hospitalization has financial impact beyond that of medically-related charges including the indirect financial impact through the loss of a woman’s contribution to the workforce or by pulling other family members out of work to help care her and her additional children. While difficult to quantify, it is worth noting that the estimated cost of an obstetric intervention such as bedrest that includes lost wages and productivity costs approximately $250 to billions of dollars per year.[22]

It is also important to consider that the ≥6 TVCL measurement group had a significantly higher number of cerclage placements during the study period, despite the lack of evidence for their efficacy in multiple gestations. The more screening measurements taken, the higher likelihood a positive screen occurs prompting an unnecessary intervention. While providers and patients may be tempted to do something for a positive screen, rather than solely observing, this adds medical cost with no evidence-based benefit. A routine TVCL measurement may spiral into an invasive surgical intervention merely to give a patient the sense that their physician has “done something” to help.

Our study was the first to assess the effectiveness of TVCL surveillance in twins with regard to timing of magnesium sulfate for neuroprotection when delivery is anticipated <32 0/7 weeks. We found that more frequent surveillance did not improve the rate of appropriately timed administration of magnesium sulfate, thus a shortened TVCL should not be a contributing factor in the decision to administer magnesium sulfate in patients at risk of delivery at <32 weeks.

One factor for TVCL surveillance in twin gestations despite the recommendations of ACOG is patient/provider reassurance of negative screening. The negative predictive value of TVCL measurements in multiple gestations was found to be >98% up to 28 days following a negative screen in those between 24 0/7 weeks and 29 6/7 weeks gestation. This information allows for further discussion into the frequency at which TVCL should be performed in twin gestations. If a patient has a negative screen at <29 6/7 weeks there is no clinical indication to re-screen during the next 28 days as her chance of sPTB is very low. If TVCL screening is to be performed during twin pregnancy, this provides further evidence for every 4-week TVCL screening compared to every 2-week TVCL screening in the second trimester. This level of reassurance may be especially beneficial for women living at great distance from a NICU able to care for a preterm infant, as is common in our Nebraskan patient population. Further research is necessary to determine if TVCL screening in the rural population has an impact on the location of delivery and availability of resources to care for a preterm infant.

With a lack of benefit in women who screen positive for a short cervix, the cost associated with TVCL surveillance should be considered. The ≥6 TVCL surveillance group underwent an average of 8.5 ± 2.9 TVCL at a charge of $686 per TVCL measurement, leading to an estimated charge of $5,861 ± $2019 per twin pregnancy. The <6 TVCL surveillance group received an average of 3.8 ± 1.1 TVCL measurements during pregnancy, an estimated charge of $2,607 ± $755 per twin pregnancy. As there is no added benefit to every two-week TVCL surveillance compared to every four-week surveillance, this modification to surveillance would result in a 55.5% decrease in cost. Future study to compare every four-week TVCL measurements during pregnancy to no TVCL measurements during pregnancy may further address this question. If it is determined that every four-week TVCL measurements during pregnancy provides no added benefit the potential cost savings and avoidance of unnecessary hospitalizations approximates $433,770 per 100 patients with twin gestation.

We recognize limitations in our study. TVCL measurement frequency is at the discretion of the individual provider. While ≥6 and <6 TVCL measurement frequencies corresponded to approximately every two-week and every four-week surveillance in the second trimester, respectively, these measurements may not have always been at evenly spaced intervals. Providers often increased the frequency of surveillance at the discovery of a short cervix. Our study was hindered by our access to financial data. We were unable to analyze the full estimated cost of a prolonged hospitalization due to non-transparency in billing costs and limited authorized access to financial information on patients.

Strengths of our study should also be noted. All TVCL measurements and interventions studied were provided at a single institution. Additionally, our study added to the limited literature TVCL surveillance and associated timing of antenatal corticosteroids. We anticipate our study will serve to spark discussion among perinatalogists, obstetricians, and the public health community about best practice for twin gestations with the goal of maximizing perinatal outcomes and minimizing unnecessary intervention and added cost.

Conclusion

TVCL surveillance in multiple gestations remains widely used in clinical practice with the goal of identifying women who may benefit from closer monitoring and optimizing administration of antenatal corticosteroids (ACS); however, our study calls these goals into question. Higher frequency TVCL surveillance did not improve the optimization of ACS, magnesium sulfate administration, or composite neonatal or maternal morbidity. We recommend the clinical decision to administer an ACS course not be based on a TVCL measurement <25 mm. Until an effective intervention for the prevention of sPTB in multiple gestations is determined, TVCL surveillance does not appear to improve perinatal outcomes related to prematurity in multiple gestations. A TVCL screen measuring >25 mm, however, did provide a high level of reassurance against sPTB within 28 days. Cost considerations of universal TVCL surveillance to provide this reassurance must be balanced against the limits of public health resources and may be a key cost saving measure for hospitals performing the surveillance. Further research is needed to identify select groups of patients, such as those from rural areas that may benefit from the strong negative predictive value of a negative screen discovered in this study.

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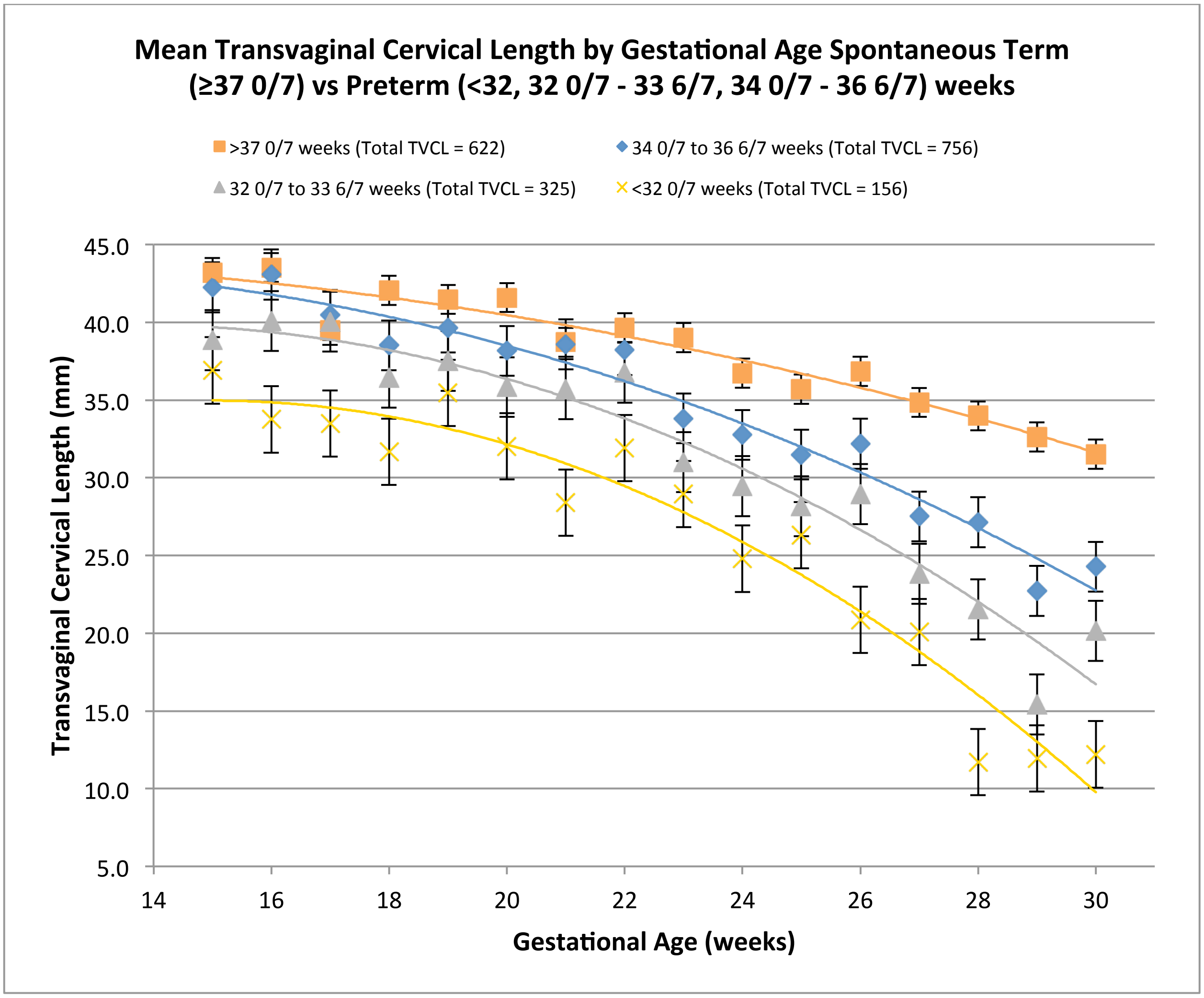
Appendix A

Figure A1. Mean Transvaginal Cervical by Gestational Age



Appendix B

Table B1. Spontaneous Preterm Birth Rates

Spontaneous Preterm Birth Rates			
	<6 TCVL Measurements n= 156	**≥6 TVCL Measurements n= 203**	**p value**
Spontaneous Preterm Birth at <37 weeks 0 days, n (%)	49 (31.4%)	77 (37.9%)	0.20
Spontaneous Preterm Birth at <34 weeks 0 days, n (%)	21 (13.5%)	32 (15.8%)	0.54
Spontaneous Preterm Birth at <32 weeks 0 days, n (%)	13 (8.3%)	14 (6.9%)	0.61

Table B2. Antenatal Corticosteroid Exposures between TVCL measurement groups

Antenatal Corticosteroid (ACS) Exposure			
	<6 TVCL Measurements n= 156	**≥6 TVCL Measurements n= 203**	**p value**
Overall ACS Exposure, n (%)	48 (30.8%)	81 (39.9%)	0.07
Delivery >37 0/7 weeks, n (%)	3/56 (5.4%)	11/56 (19.6%)	**0.02**
Delivery <32 0/7 weeks, n (%)	22/24 (91.7%)	18/19 (94.7%)	0.59
Delivery <34 0/7 weeks, n (%)	34/38 (89.5%)	36/42 (85.7%)	0.74
Delivery <37 0/7 weeks, n (%)	45/100 (45%)	70/147 (47.6%)	0.69
First Course ACS to delivery if <34 0/7 weeks, mean days ± SD	9.62 ± 11.6	21.78 ± 16.3	**0.03**
Any ACS (1st course or rescue) to delivery if <34 0/7 weeks, mean days ± SD	7.61 ± 9.14	14.97 ± 14.97	**0.01**
Any ACS (1st course or rescue) >7 days of delivery if <34 0/7 weeks	15/38 (39.5%)	20/42 (47.6%)	0.46
Any ACS (1st course or rescue) ≤7 days of delivery if <34 0/7 weeks	21/38 (55.3%)	13/42 (31%)	**0.03**
First ACS course ≤7 days of delivery if < 34 0/7 weeks	19/38 (47.5%)	10/42 (23.8%)	**0.02**
Rescue ACS course ≤7 days of delivery if < 34 0/7 weeks	2/38 (5.3%)	6/42 (14.3%)	0.27
RDS in either twin with sPTB <34 0/7 weeks, n (%)	6/21 (28.6%)	4/32 (12.5%)	0.17
Steroids Given due to TVCL <25 mm	6/38 (15.8%)	23/42 (54.8%)	**<.001**

Table B3. Magnesium Sulfate Exposure for Neonatal Neuroprotection

Magnesium Sulfate (MgSO4) Exposure for Neuroprotection			
	<6 TVCL Measurements	**≥6 TVCL Measurements**	**p value**
	n=156	n=203	
MgSO4 Given if delivery at <32 weeks 0/7 days	13/24 (54.2%)	13/19 (68.4%)	0.34

Table B4. Composite Maternal and Neonatal Morbidity

Composite Morbidity			
	<6 TVCL Measurements n=156	**≥6 TVCL Measurements** n=203	**p value**
Composite Maternal Morbidity[1]	12 (7.7%)	15 (7.4%)	0.91
Composite Neonatal Morbidity[2]	38 (24.4%)	50 (24.6%)	0.95

[1] Peripartum VTE, Pelvic Abscess, Sepsis, Wound Disruption, ICU Admit, Blood Transfusion, Re-admission, n (%)

[2] UA pH < 7.1, 5 min. APGAR < 5, RDS, BPD, Retinopathy, PVL, IVH 3 or 4, NEC, Proven Sepsis, Stillbirth or Death Before Discharge, n (%)

Appendix C

Table C1. Positive TVCL Screening Interventions

Intervention for a Positive Screen (TVCL < 25 mm)	
Number of TVCL <25 mm, n (%)	97/359 (27.0%)
Number of Women Admitted for Positive Screen, n (%)	46/97 (47.4%)
CL at admission, mm ± SD (min, max)	12.65 ± 5.72 (0, 23)
GA at occurrence of admisison, weeks ± SD (min, max)	27.19 ± 2.33 (23.57, 31.43)
Received ACS during hospitalization, n (%)	42 (91.3%)
Inpatient Steriods Given within 7 days of delivery, n (%)	6 (13.0%)
Mean days between ACS and Delivery, days ± SD (min, max)	42.47 ± 26.93 (1.0, 91.0)
Average days of Admission, days ± SD (min, max)	6.67 ± 6.53 (1, 28)
Transfer to Full Admission, n (%)	26/46 (56.5%)
Symptomatic on Admission, n (%)	22 (47.8%)
Readmission for Short Cervix, n (%)	4 (8.7%)
sPTB at <34 weeks 0 days, n (%)	22 (47.8%)
sPTB at <34 weeks 0 days with delivery during admission, n (%)	8/22 (36.3%)
sPTB at <34 weeks 0 days with symptoms on admit, n (%)	10/22 (45.5%)
Number of Women Receiving Outpatient ACS for Positive Screen, n (%)	18/97 (18.6%)
GA at steriod completion, weeks ± SD (min, max)	27.88 ± 2.48 (24, 31.14)
CL at decision for steriods, mm ± SD (min, max)	16.21 ± 3.88 (7.7, 20.7)
Symptomatic at presentation, n (%)	0 (0%)
Outpatient Steriods Given within 7 days of delivery, n (%)	0 (0%)
Mean days between ACS and Delivery, days ± SD (min, max)	41.39 ± 25.13 (11.0, 91.0)
sPTB at <34 weeks 0 days	9 (50%)
Number of Women Receiving Cerclage for Positive Screen, n (%)	17/97 (17.5%)
GA at cerclage, weeks ± SD (min, max)	21.48 ± 2.0 (17.43, 24.14)
CL at cerclage, mm ± SD (min, max)	10.98 ± 8.0 (0, 28.5)
sPTB at <34 weeks 0 days, n (%)	4 (23.5%)
No Intervention with Positive Screen, n (%)	26/97 (26.8%)
GA at shortest TVCL, weeks ± SD (min, max)	29.29 ± 1.86 (25.71, 32.86)
Average shortest TVCL, mm ± SD (min, max)	20.97 ± 2.96 (14.10, 25.0)
sPTB at <34 weeks 0 days	2 (7.7%)

Table C2. Cost of TVCL Screening and Interventions

Cost of Intervention	
Hospital Admission	
High Risk Hospital Observation	$429
Hospital Discharge Management >30 minutes	$290
Transfer to Full Hospital Admission	$552
Outpatient ACS	
Medication Cost	$40
Staff Injection Fee	$184
Cerclage	
Cerclage Suture Placement	$407
Removal of Cerclage Suture Under Anesthesia	$358
TVCL Screening	
Facility TVCL Screening Cost	$404
Professional Fee	$282

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I would like to thank Methodist Women's Hospital perinatalogists, sonographers, nurses, and office staff for the kindness they showed me during my time at the clinic. Thank you to Dr. Smith and Dr. Moore for your time and effort on my committee. Thank you to Dr. Goedert for serving as my committee chair given your busy schedule. Your encouraging words throughout the process meant the world. Finally, thank you Dr. Dahlke for taking me in as a student researcher and developing my skills to become a strong future physician and public health practitioner.

Service Learning/Capstone Experience Reflection

Describe the experience with the placement site.
-What did you learn about the organization?
-What was different than what you expected when you started the project?

My experience at my placement site was incredibly positive. I developed strong relationships with not only my preceptor, but also the other perinatalogists in the office. These relationships will last into my future career as an obstetrician gynecologist and public health professional providing me mentorship and community. In addition to providing feedback and suggestions for my project, these individuals were kind enough to be my sounding board as I debated residency programs and went on interviews. The staff were always available to help me trouble shoot when I ran into computer access issues or needed to figure out who I needed to contact in various Methodist financial departments. I have the utmost respect for all physicians, sonographers, and staff at this office.

I was able to consistently observe the coordination it takes to provide the highest quality of care for patients with complicated pregnancies. Receptionists, nurses, sonographers, geneticists, and a team of physicians all play essential roles in patient care and patient education. I was able to gain valuable knowledge and skills through each of these different professions. As a future physician I will make sure to recognize and respect each and every one of my staff members that help me care for patients. The people who work behind the scenes often go unnoticed, particularly when it comes to research. Physicians would not be able to produce the research that they do without their staff. It takes significant time and effort to gain funding, write an IRB, gather data, perform an analysis, and write/publish a professional paper. The work behind research cannot be underestimated, but I also think something I learned throughout this process is that quality research is possible. The process intimidated me, but Methodist staff really taught me it was possible even without all the tools and resources some academic intuitions have.

As I had already been researching for Methodist at the start of my project there were not many things that were different than I expected. I did expect the financial information I was seeking to be more attainable than it was. It took many phone calls with many different individuals to gain access to prices on specific ICD codes and without a code I was not able to gain any information. I was surprised by physicians' lack of knowledge of the charges for the interventions and medications they prescribe their patients. I was not aware of the disconnect between the perinatal office and the Methodist staff that do the billing prior to the start of my capstone.

Describe how SL/CE activities were performed: what, where, when, with whom, how long, etc.
-What resources, relationships, and skills permitted these activities to occur?

All of my activities revolved around my creation of a database for the Methodist perinatal system and research activities based on this database. I created a database of all twins born at Methodist Women's Hospital from January 1st, 2013 to April 30th, 2016. This database contains an immense amount of variables for current and future research projects. My capstone project was only a small part of the variables that I added. As a part of my service learning hours, I added several variables based on requests from the perinatalogists for future research projects. All of my data collection was performed in rotating offices at the perinatology office based on whichever physician was off that day. I performed all data collection alone; however, I would often discuss the proper way to define the variables with physicians and staff in the office when I ran into difficulty.

Data analysis as well as the production of abstracts, manuscripts, and my capstone paper was performed between Methodist and my home laptop (via a deidentified version). I would often sit in my preceptor's office during his clinic hours and between patients we would discuss the variables we wanted to analyze and the best way to perform the analysis. While he was off seeing patients, I would perform this analysis and report to him when he returned. There was also a significant amount of back and forth emails of drafted versions of the abstracts we submitted to the annual pregnancy meeting as well as the poster creation for this meeting.

Additionally as a part of my service learning hours, I had the honor of submitting and being accepted to present a poster at the annual pregnancy meeting in Dallas, Texas. This meeting occurred from January 29th- February 3rd, 2018. This was an incredible learning experience for me as I was able to listen to oral presentations of the latest breaking research in my future field. Dr. Dahlke was kind enough to introduce me to key individuals in the field and help me network for my future career. This was my first poster presentation and it was an excellent experience to be able to go through the process from start to finish. I learned how rewarding and sometimes challenging it is to describe your research to other professionals. I had a significant number of people come ask me questions, even several European physicians. It was very valuable to experience the various ways one can share research with the community in order to change practice patterns.

As I was nearing the end of my time at Methodist, I spent time cleaning up the database in order to pass it on to the next person that will continue to expand this database and the research. I also helped Methodist reach out into the medical and public health schools at UNMC to find potential candidates to "replace me" as a research assistant. I held casual meetings with several students to discuss my research and explain the roles, responsibilities, and benefits of working with the perinatal center. It was fun to be able to share my research with my peers and encourage those in the earlier stages of school to get involved in research.

I am very thankful for the resources and people that allowed this project to be possible. The Methodist perinatal office really opened up its arms to me and created opportunities for me to access any resources I needed for this research. The most valuable resource to this project was my preceptor and the other perinatalogists in the office. They truly had an open door policy with me. I was able to stroll into their office at any time and they were more than willing to discuss research strategy or to teach me various statistical skills. By allowing me to be apart of their conversations, I gained an enormous amount of medical knowledge that will benefit me as I enter my residency in obstetrics and gynecology. I truly feel leaps and bounds above my peers. The perinatalogists consistently provided me with research to read up on relating to my topic or relating to an interesting patient we had been discussing.

The skills I needed for my capstone project included skills in defining variables, proper and efficient data collection, and statistical analysis. These are all skills I gained during my public health curriculum and it was rewarding to be able to put that knowledge to use. While learning in a class setting is beneficial, I truly believe that you will never fully acquire a skill into you apply it to a project such as this one. I am very grateful to this requirement to graduate with my masters.

Describe the product(s) (training manual, presentation, brochure, policy statement, database, etc.) that were outcomes of the Service Learning component.

-If a presentation was developed, for whom was the presentation developed?

-If a database was developed, what was the sustainability plan to continue tracking the data?

The outcome of my service learning component was a database on all twins (N=424) born between January 1st, 2013 and April 30th, 2016 at Methodist Women's Hospital as well as the presentation of one abstract at the annual pregnancy meeting in Dallas, TX and the submission of two additional abstracts to the ACOG annual meeting in Austin, TX to be presented at the end of April following the conclusion of my capstone.

A poster presentation was developed for the 38th Annual Pregnancy meeting. I was able to share my research project with many professionals in the field of perinatology. The two posters to be presented at the National ACOG meeting will be shared with members of the entire obstetrics and gynecology community.

There is a sustainability plan for the database. I have several medical students in the class below me that plan to continue to add to the database and hopefully get it up to the current time. I am planning to meet with these individuals in April/May after they have been added to IRB to teach them my method of gathering data and where to locate all the variables within the Methodist electronic medical record. I will also make sure the database is easy to read and be used by the perinatalogists in the office so they may continue research projects I began for them.

Related to your Service Learning activities, what do you think were your greatest contributions/accomplishments? What strengths did you bring into the project?

I think my greatest contribution to the organization was the database itself. They had previously had an individual who was gathering data on twins on simple paper forms. I started where this individual left off, however I created an electronic and more readily useable version of the data going forward. This database is now available for any Methodist perinatalogist to use at their convenience and desire. I also think that I added to the organization by presenting research at a national conference. Research output is a measure of the strength of an institution and I was able to add to Methodist's strength in this area but representing the organization on a national level.

I believe the greatest strengths I brought to the project were my motivation and work ethic. I was able to be a driving force for research within the clinic. The physicians previously had the desire to produce research, but did not have the time with their busy clinic schedules. I was able to provide my time and skills to make their research desires become a reality. Gathering data was a time intensive process and took significant motivation to accomplish, as it is often hard to picture the end product. I am proud of the time I put in and the outcome of the project.

What were the greatest challenges of your Service Learning/Capstone Experience?
-How did you address and overcome those challenges?

The greatest challenge of my project was gathering financial information on various interventions. In order to gather the financial information I had to reach individuals outside of the Methodist clinic, but still within the Methodist system. Without specific ICD-10 codes I was not able to gain charge amounts for interventions. The individuals in the billing office were slightly weary of why I needed the numbers, and I would need to know the exact information I needed prior to communicating with them. There were also various ways of billing for the hospitalizations I was trying to record and it became difficult to estimate the exact charges for each hospitalization. In order to overcome this challenge, I ended up modifying the charge numbers I gathered. I used only the charge numbers for hospital observation admissions, transfers to full admissions, and discharge paperwork. The charges for interventions during hospitalization were challenging and too variable to make accurate estimates. With the help of my committee chair, I was able to use an outside source to gain information about the cost of antenatal corticosteroids and the cost of their administration.

Another challenge I faced during the project was balancing time between medical school and my master's project. It was harder than anticipated to balance spending time on my project while I was traveling on medical residency interviews throughout October-January. To overcome this challenge, I would set out specific days and times when I knew I could be at the Methodist office or go to a coffee shop to truly focus on the project. I had to use my time management skills as well as be within constant communication with my preceptor. It was also challenging to be out of the country on rotation for the months of February and March. Working on a project remotely was not without challenges. I am grateful to my committee for being understanding during this difficult time as I complete my project.

How have your views of public health practice been impacted by your SL/CE?

Prior to the start of this project I was intimated by performing public health research and did not fully understand how it worked. My view of this has drastically changed. Research is innovative and stimulating. While difficult and often not glamorous, it is definitely achievable with the right resources. The end product makes the process worth it. It was extremely fun when my group reached the point of data analysis, as I was able to see that my research had the potential to positively change practice patterns within my institution and on a larger scale. I believe my views of public health practice have changed from this process because I have a greater respect and appreciation of each and every step of the process. The amount of work that goes into taking an idea and making it a reality in the public health realm cannot be underestimated.

How did your public health education prepare you to address any ethical or other issues you encountered during your SL/CE?

While no ethical issues arose during my project, my public health education helped me to prevent potential ethical issues. The main potential issue was the keeping patient information confidential and in the proper locations to ensure its safety. I knew what information I was and was not allowed to access and who I was able to share it with. I learned how to properly deidentify data so that I would be able to work on my project remotely. Additionally, my public health education helped me to do quality statistical analysis to help ensure the integrity of the information I distributed to the greater public health community.