The Effect of Level of Care on Gastroschisis Outcomes

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Objective To examine the relationship between level of care in neonatal intensive care units (NICUs) and outcomes for newborns with gastroschisis.

Study design A retrospective cohort study was conducted at 130 California Perinatal Quality Care Collaborative NICUs from 2008 to 2014. All gastroschisis births were examined according to American Academy of Pediatrics NICU level of care at the birth hospital. Multivariate analyses examined odds of mortality, duration of mechanical ventilation, and duration of stay.

Results For 1588 newborns with gastroschisis, the adjusted odds of death were higher for those born into a center with a level IIA/B NICU (OR, 6.66; $P = .004$), a level IIIA NICU (OR, 5.95; $P = .008$), or a level IIIB NICU (OR, 5.85; $P = .002$), when compared with level IIIC centers. The odds of having more days on ventilation were significantly higher for births at IIA/B and IIIB centers (OR, 2.05 [$P < .001$] and OR, 1.91 [$P < .001$], respectively). The odds of having longer duration of stay were significantly higher at IIA/B and IIIB centers (OR, 1.71 [$P < .004$]; OR, 1.77 [$P < .001$]).

Conclusions NICU level of care was associated with significant disparities in odds of mortality for newborns with gastroschisis. *(J Pediatr 2017;190:79-84).*

Since the 1970s, there has been a transition toward deregionalized neonatal intensive care.[1-3] This may be attributed in part to an expansion of the neonatology workforce, economic forces, and the dissemination of medical technology. Pediatric surgery has largely resisted this trend. In general, there is an established relationship between case-specific surgical experience and outcome that has been previously demonstrated in many adult studies.[4-8] However, the case-specific surgical volume-to-outcome relationship is less well-established for pediatric neonatal surgical anomalies. The optimal level of neonatal intensive care unit (NICU) care for surgical congenital anomalies remains a matter of debate.

A recent study demonstrated that infants with gastroschisis treated at centers with high repair volume have lower mortality and shorter duration of stay.[9] An important factor in this study was the transfer status of the study subjects, suggesting that initial perinatal management was critical in achieving optimum outcomes.[10] In 2007, Phibbs et al examined very low birth weight (VLBW) infants born in California, finding that hospital VLBW volume and hospital level of care impact survival.[11] A 2015 study found a similar relationship for infants with necrotizing enterocolitis.[12]

Given the importance of initial supportive management, we hypothesized that factors including and other than surgical case volume impact gastroschisis outcomes. In this study, we examined infants born with gastroschisis in California NICUs between 2008 and 2014, and determined the variability of outcomes according to level of care, NICU volume, VLBW volume, and gastroschisis-specific case volumes.

Materials and Methods

We performed a retrospective cohort study using data collected by the California Perinatal Quality Care Collaborative (CPQCC) from 2008 to 2014. The CPQCC collects clinical data in a prospective fashion for infants born at 136 member hospitals, using standard definitions developed by the Vermont Oxford Network.[13] This study was conducted under institutional review board approval from the Stanford University Panel on Human Subjects Research. More than 90% of all California NICUs submit detailed clinical data to the CPQCC,[14] enabling high-integrity data capture for infants that meet eligibility criteria. Data are collected on infants that have any of the following: (1) surgery requiring anesthesia, (2) mechanical ventilation >4 hours, (3) death, (4) acute transfer, and (5) <1500 g or <32 weeks of gestational age, as well as other criteria.[15] Based on these criteria, we would expect the all infants with gastroschisis admitted to the NICU to be included. Our study cohort included all infants with gastroschisis admitted into a CPQCC-enrolled facility or a colocated

CPQCC	California Perinatal Quality Care Collaborative
NICU	Neonatal intensive care unit
VLBW	Very low birth weight

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facility (born into a separate hospital with an onsite satellite NICU) during the study period. We used the CPQCC birth defect codes for gastroschisis to locate all study infants.

The dataset was indexed for each infant's first admission, but also transposed to include information on all subsequent transfers and hospital admissions. Infant mortality was determined as death at any hospital during the initial hospital course. Total days on ventilation was calculated by adding ventilation days across all hospitals visited during the hospital course if the initial hospitalization included >1 hospital. Total duration of stay was computed by adding each successive duration of stay if a subject was transferred to multiple hospitals. Because continuous outcome variables were non-normally distributed and right skewed, and for easier interpretation of results, they were transformed into binary variables based on their respective sample medians.

For the level of care, which is self-reported by NICUs on an annual basis, investigators used designations corresponding with the period-appropriate 2004 American Academy of Pediatrics (AAP) policy statement, and not corresponding to the more recent 2012 policy that applied for only a fraction of the study time.[16,17] We merged this database with the CPQCC to assign an AAP level of care for each subject's birth hospital. Those born at a level I center (n = 38), or at a center without a reported level of care designation (n = 50), were removed from our analysis. For birth hospital NICU volume and VLBW volume, we computed total number of admissions and total VLBW admissions for the pertinent year, respectively. For gastroschisis birth volume and repair volumes, we determined yearly totals for each patient's birth hospital.

We calculated the number of NICUs by level of care for each year during the study period, as well as the total number of infants with gastroschisis treated at each level. We associated each infant with the AAP level of care at the hospital of birth. To examine other potential volume measurements affecting outcomes for these infants, we associated each infant with their birth hospital's total annual NICU volume of CPQCC-eligible infants, VLBW volume, gastroschisis birth volume, and gastroschisis repair volume. Because our list of volume predictors had widely different magnitudes, varying degrees of linear vs nonlinear outcome relationships, and non-normal distributions, we made each predictor a categorical variable according to their infant sample quartiles.

We compared infant and maternal characteristics across NICU levels of care using the χ^2 test for categorical variables and the Wilcoxon rank-sum test for continuous variables with non-normal distributions. IQRs were calculated for numeric variables. We performed univariate and multivariate logistic regression using NICU level of care as the independent variable, modeled for mortality, total days on ventilation, and total duration of stay. Analyses for days on ventilation and duration of stay were performed after removal of the infants who died to minimize the effect of mortality on these variables. Covariates for risk adjustment included sex, gestational age, mode of delivery, birth weight, Apgar scores at 1 and 5 minutes, neonatal respiratory distress, maternal race, prenatal care, and the presence of maternal or obstetric perinatal complications. We adjusted for a congenital anomaly score to account for additional birth defects. All statistical analyses were performed using SAS, version 9.3 (SAS Institute, Cary, North Carolina).

Results

The total number of NICUs increased from 122 in 2008 to 129 in 2014 (**Figure**; available at www.jpeds.com). During the study period there were 1588 infants with gastroschisis born in California, 38 were born into centers with a level I NICU (2.4%), 206 (13.0%) born into level IIA or IIB, 132 (10.2%) born into to level IIIA, 608 (38.3%) born into to level IIIB, and 524 (33.0%) born into level IIIC centers. Fifty (3.1%) had no reported levels of care, and were not analyzed. Infant characteristics were similar across groups (**Table I**) and very few had maternal or obstetric complications.

Median maternal age was 21 years (IQR, 19-24). Infants born at level IIIC centers more often had white mothers and less often had Hispanic mothers ($P < .001$). Mothers at level IIIB and IIIC centers more often had maternal or obstetric complications ($P < .001$). Infants born at level IIA/B or IIIA centers had a shorter initial duration of stay and were more often transferred to a higher level of care within 48 hours ($P < .001$). Overall in-hospital mortality was 2.5%, and ranged from 1.0% for infants born at level IIIC centers to 3.7% for infants born at level IIIA centers. Median days on ventilation was 5 (IQR, 2-10), but was higher for infants born at level IIA/B and IIIB centers at 9 and 6 days, respectively ($P < .001$). Median total duration of stay was 36 days (IQR, 27-60), but was higher for births at level IIA/B and IIIB centers at 43 and 38.5 days, respectively ($P < .001$; **Table II**).

The adjusted odds of death were higher for infants born into level IIA/B (OR, 6.66; 95% CI, 1.81-24.5; $P = .004$), those born into level IIIA (OR, 5.95; 95% CI, 1.58-22.3; $P = .008$), and those born into level IIIB centers (OR, 5.85; 95% CI, 1.95-17.6; $P = .002$), when compared with level IIIC centers. The odds of having ≥5 days on ventilation were significantly higher for births at level IIA/B and IIIB centers, respectively (OR, 2.05 [95% CI, 1.41-2.98, $P < .001$]; OR 1.91 [95% CI, 1.47-2.48, $P < .001$], respectively). The odds of having a duration of stay of >36 days were significantly higher for births at level IIA/B and IIIB centers (OR, 1.71 [[95% CI, 1.18-2.47; $P = .004$]; OR, 1.77 [95% CI, 1.37-2.28; $P < .001$], respectively; **Table III**).

Univariate and multivariate analyses showed that NICU volume and VLBW volume had similar effects on trends in mortality, duration of mechanical ventilation, and duration of stay, but these relationships were less statistically profound. Notably, infants had significantly increased mortality after birth at hospitals with lower gastroschisis repair volumes, but these volumes were less strongly associated with time on ventilation and duration of stay (**Table IV**).

Discussion

In this study, we examined outcomes for infants born with gastroschisis, categorized by a series of hospital characteristics. The