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Methicillin-Resistant *Staphylococcus aureus* Colonization in the Neonatal Intensive Care Unit Increases Total Hospital Costs

Eric D. Schultz, DO, MPH¹, David T. Tanaka, MD¹, Ronald N. Goldberg, MD¹, Daniel K. Benjamin Jr., MD, MPH, PhD^{1,2}, and P. Brian Smith, MD, MHS^{1,2}

¹Department of Pediatrics, Duke University Medical Center, Durham, NC

²Duke Clinical Research Institute, Duke University, Durham, NC

Abstract

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections are increasing in neonatal intensive care units. We determined the economic impact of isolating and cohorting MRSA colonized neonates on total hospital cost at a 49 bed, level III-IV Neonatal Intensive Care Unit.

Keywords

MRSA; newborn; length of stay

INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections have increased in neonatal intensive care units (NICUs).^{1,2} Effective strategies to control outbreaks of MRSA in the NICU have included cohorting both patients and healthcare workers, implementing active surveillance of the NICU population, reinforcing proper hand hygiene, and contact isolation.¹⁻³

Previous investigators have described the economic impact of MRSA blood stream infections, screening programs and contact isolation in adult medicine;⁴⁻⁶ however, the impact of MRSA colonization on total hospital cost in the NICU is unknown. We compared MRSA colonized and non-colonized MRSA neonates to determine differences in length of stay, total hospital cost, and the number of new patient admissions prevented by isolation of MRSA colonized neonates.

METHODS

Patients

We identified all neonates admitted to the Duke University Medical Center NICU from June 2004 to December 2006. The NICU has a total of 49 beds and had an average daily census of 47 patients during the study period.

Weekly MRSA surveillance consisting of nasopharyngeal swab PCR or nasopharyngeal culture (prior to May 2006) was performed on all NICU patients during the study period.

Corresponding author P. Brian Smith Duke Clinical Research Institute PO Box 17969 Durham, NC 27715 Ph: 919-668-8951 Fax: 919-668-7058 brian.smith@duke.edu.

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Patients identified with MRSA were placed on contact isolation and cohorted both by location and healthcare providers.

We excluded neonates who died during their hospitalization. Deaths in the non-colonized MRSA neonates occurred much earlier than deaths in the MRSA colonized neonates because MRSA colonized patients had to survive long enough to become colonized and subsequently identified with MRSA.

Definitions

The Hospital Budgets and Analysis Office provided hospital cost data. We defined length of stay as the total number of NICU days at Duke University Medical Center. The total MRSA associated days was defined as the difference between the mean length of stay for MRSA colonized neonates minus the mean length of stay for non-colonized MRSA neonates multiplied by the total number of MRSA colonized cases. The total MRSA associated cost was the total MRSA associated days multiplied by the mean total hospital cost per day of all neonates, including MRSA colonized and non-colonized MRSA neonates. The total number of new NICU admissions that were prevented due to bed occupancy by MRSA colonized patients was equal to the total MRSA associated days divided by the mean length of stay for non-colonized MRSA patients.

Statistical Analysis

The primary outcome variable was total MRSA associated cost. Chi-square and t-tests were used where appropriate. We used multivariate logistic regression with forward and backward stepwise selection of variables to examine the effect of colonization status, gestational age (GA), admission status (inborn or outborn), discharge disposition (transfer to another medical center or discharged home), gender, and ethnicity on length of stay. A P value <0.05 was considered significant. JMP 7.0 (SAS Institute, Cary, NC) was used for statistical analysis. This study was approved by the Duke Institutional Review Board.

RESULTS

Study Population

We identified 59 MRSA colonized and 1701 non-colonized MRSA neonates (Table 1). The mean GA of the MRSA colonized group (29 weeks) was significantly lower than the non-colonized MRSA group (34 weeks, $P < 0.001$). MRSA colonized neonates were more likely to be inborn compared to the non-colonized MRSA group ($P = 0.03$). Gender and race were not significantly different between the groups.

Disposition and Length of Stay

In the multivariable analysis, MRSA status, GA, and discharge disposition were the only significant predictors of length of stay. In the MRSA colonized group, 32% were transferred to a different facility versus 68% in the non-colonized MRSA group ($P < 0.001$). Length of stay for the MRSA colonized patients was significantly longer across all gestational ages compared with non-colonized MRSA patients: 1) <28 weeks gestation at birth 118 ± 9.0 days (mean \pm SEM) versus 68 ± 3.5 days ($P < 0.001$), 2) 28-31 weeks gestation at birth 48 ± 7.1 days versus 25 ± 1.7 days ($P < 0.001$), and 3) <31 weeks gestation at birth 33 ± 8.1 days versus 8 ± 0.4 days ($P < 0.001$).

Cost Data

There was no difference in mean total hospital cost per day between MRSA colonized and non-colonized MRSA patients ($P = 0.60$). The mean total hospital cost per day for all patients was

between \$2,148 and \$5,066, depending on the GA (Table 2). The total number of excess hospital days associated with MRSA was 2,081 (Table 2). The total excess cost associated with MRSA colonized neonates was \$6,901,180.

Although we excluded infants that died from the primary analysis, when the analysis was repeated including the neonates in both cohort that died (MRSA colonized 5/59 versus non-colonized MRSA 83/1701), the total excess cost associated with MRSA was \$1,500,000 more than our original estimate, \$8,400,000. This cost differential was attributable to prolonged lengths of stay of the MRSA colonized patients who died compared to the relatively short courses of the non-colonized MRSA neonates that died.

Preventing New NICU Admissions

MRSA colonization increased the total length of stay of these 59 neonates by a total of 2,081 days. Based on the average length of stay of non-colonized MRSA patients (19 days), 110 additional NICU admissions were prevented.

DISCUSSION

As MRSA becomes more prevalent, the cost of isolating MRSA colonized neonates will increase. This cost is reflected in the effect MRSA colonization has on length of stay, total hospital cost, and the number of new admissions to the NICU.

Because the Duke NICU is a major referral hospital in a state with consistently high bed occupancy rates, it becomes imperative to transfer patients back to their local hospitals as soon as they have sufficiently recovered in order to have high acuity bed spaces available for the sickest, most premature neonates. The transfer of MRSA colonized neonates has proven to be difficult as local medical centers do not have the nursing staff, protected bedspace, and resources for parental and nursing re-education of proper contact isolation to accommodate patients that need long-term monitoring in isolation. This results in an inability to move patients from level III NICUs. It was this prolongation of hospital stay that accounted for the majority of excess costs noted for the MRSA colonized cohort.

During this study period, we estimated that an additional 110 admissions were prevented by our policy of isolating MRSA positive neonates. This number is likely underestimated. Cohorting odd numbers of neonates actually increased the number of unoccupied beds, further decreasing the unit's ability to admit more critically ill neonates. In addition, this analysis ignores the difficulty in staffing the cohorted MRSA positive neonates resulting in less efficient staffing ratios and decreased numbers of nurses available to care for new admissions.

In view of the negative consequences associated with the prolonged length of stay of the MRSA positive patient in the level III NICU, as well as the associated loss in revenue from the prevention of new admissions, there is substantial need to increase the ability of the level II NICUs to accommodate MRSA colonized patients. An increase in the number of MRSA colonized patients transferred to level II NICUs could be facilitated by careful logistical planning of bed utilization, re-education of healthcare workers concerning contact isolation and proper hand hygiene, and increasing numbers of nursing staff. Further planning and cost analysis is needed to increase the efficiency of the transfer of the MRSA colonized patient.

Acknowledgments

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Table 1

Demographics of all neonates admitted to the Duke NICU from July 2004 to December 2006.

	MRSA (+) (%)	MRSA (-) (%)	p value
N	59	1701	
Gestational Age			
< 28 Weeks	26 (44)	226 (13)	<0.001
28-31 Weeks	19 (32)	249 (15)	<0.001
> 31 Weeks	14 (24)	1226 (72)	<0.001
Sex			
Male	38 (64)	951 (56)	0.23
Birth Location			
Inborn	50 (85)	1219 (72)	0.03
Race			
Caucasian	27 (46)	693 (41)	0.35*
African American	26 (44)	720 (42)	
Hispanic	3 (5)	219 (13)	
Other	3 (5)	69 (4)	

* comparing all races.

Table 2

The total MRSA associated cost for the excess length of stay of the MRSA positive neonates.

	Total MRSA Associated Days	Mean Total Cost Per Day*	Total MRSA Associated Cost
< 28 Weeks	1300	\$3,246	\$4,219,800
28-31 Weeks	437	\$2,148	\$938,676
> 31 Weeks	344	\$5,066	\$1,742,704
Total	2081		\$6,901,180

* includes both MRSA colonized and non-colonized MRSA neonates