Published in final edited form as:

J Urol. 2014 May ; 191(5): 1381–1388. doi:10.1016/j.juro.2013.11.054.

Practice patterns and resource utilization for infants with bladder exstrophy: a national perspective

Anthony J. Schaeffer¹, Emilie K. Johnson^{1,2}, Tanya Logvinenko³, Dionne A. Graham³, Joseph G. Borer¹, and Caleb P. Nelson¹

¹Department of Urology Boston Children's Hospital, Boston, MA

²Harvard-wide Pediatric Health Services Research Fellowship Boston Children's Hospital, Boston, MA

³Department of Clinical Research Center Boston Children's Hospital, Boston, MA

Abstract

Purpose—Substantial variability exists in bladder exstrophy (BE) care, and little is known about costs associated with BE. We aim to define the care patterns and first-year cost for BE patients at select free-standing children's hospitals in the United States.

Materials and Methods—The Pediatric Health Information System (PHIS) database was used to identify BE patients born between 1/99 and 12/10 whose primary closure occurred in the first 120 days of life (DOL). Demographic, surgical, postoperative, and cost data for all encounters were assessed. A multivariable linear regression was used to examine the association between patient, surgeon, and hospital characteristics and costs.

Results—Of the 381 patients who underwent primary closure within the first 120 DOL, 279 (73%) had this done within 3 DOL. 119 (31%) patients received pelvic osteotomies, including 51/279 (18%) of those closed within DOL 3, 38/67 (56%) of those closed between DOL 4–30 and 30/35 (86%) of those closed between DOL 31–120 ($p=0.0017$). The median inflation-adjusted first-year cost (US\$) per patient was \$66,577 [IQR: 45,335–102,398]. The presence of non-renal comorbidity and primary closure after 30 DOL were associated with 24% and 53% increased first-year costs, respectively. Increasing post-closure length of stay (LOS) was associated with increased costs.

Conclusions—At select freestanding U.S. children's hospitals, the majority of bladder closures occur within the first 3 DOL. Most, but not all, patients closed after the neonatal period underwent osteotomy. The presence of non-renal comorbidity and increasing postoperative LOS were associated with increased costs.

Corresponding Author: Anthony J. Schaeffer, MD, 300 Longwood Avenue, HU-390, Boston, MA 02115, PHONE: (617) 919-3261, FAX: (617) 730-0474, anthony.schaeffer@childrens.harvard.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

Resource Utilization; Cost; Bladder Exstrophy; National Trends

INTRODUCTION

Much of our knowledge regarding bladder exstrophy (BE) operative technique, postoperative care, and outcomes comes from single institution case series^{1–4}. Two national cross-sectional studies using the Nationwide Inpatient Sample (NIS) have shown that most BE patients are closed in the first year of life, many are transferred from another healthcare facility, and only 30% receive pelvic osteotomies^{5, 6}. However, the NIS neither allows individual patients to be followed across multiple encounters nor captures ambulatory surgery and emergency department (ED) visits, information which would help to better elucidate the care patterns for this complex disease.

There is an acknowledged need to control the cost of medical care in the United States (US). Given the chronic nature of and intensive sub-specialty treatment required for BE, understanding the cost of exstrophy care is important. One NIS study showed a median charge of the initial BE repair (in year 2000 \$USD) of approximately \$48,000⁶. Another report using the Pediatric Health Information System (PHIS) found that the median adjusted charge at one exstrophy center (\$53,291) was lower compared to median charges at other PHIS hospitals (\$93,127)¹. However, these reports only studied the initial hospitalization and thus provide an incomplete picture of the cost of BE care after the initial hospitalization.

The PHIS database provides a more comprehensive picture of BE care because it captures data on inpatient, ambulatory surgery, and emergency department (ED) encounters, cost data, and follows individual patients longitudinally through time. Using the PHIS database, the aims of this study are: 1) to describe the patient, provider, and hospital characteristics of the initial BE closure and follow-up care within the first year of life, 2) to describe the medical expenditures associated with BE care in the first year of life, and 3) to analyze patient, provider, and hospital level factors associated with cost of care.

MATERIALS AND METHODS**Study Design, Setting and Data Source**

Using the PHIS database, we conducted a retrospective cohort study of infants with BE born between 1/1999–12/2010. This database contains inpatient, ED, ambulatory surgery and observation data from 43 not-for-profit, tertiary care pediatric hospitals in the US affiliated with the Child Health Corporation of America (CHCA) (Overland Park, KS). This study was approved by our hospital's institutional review board.

Selection of Participants

We identified all patients with a primary diagnosis of BE (defined by presence of ICD-9 code 753.5). Data were collected longitudinally over the first 12 months of life for each patient. Patients who had also had an ICD-9 procedure code for a colostomy (461, 461.0,

461.1, and/or 461.3) during the first year of life were excluded as they likely represented infants with cloacal exstrophy. Only patients who underwent BE closure within the first 120 days of life (DOL) at a PHIS institution were included in order to capture first-year costs associated with BE closure during early infancy.

Data Collection and Processing

Demographic variables included gender, race, insurance status, prematurity (birth at <37 weeks gestation and/or presence of ICD-9 code 765.0 or 765.1), age at first admission to a PHIS hospital, and age at primary closure. Comorbidities were classified according to the complex chronic condition (CCC) flags⁷. A non-renal comorbidity was assessed separately from renal CCCs given the high likelihood that a diagnosis of BE alone could generate a CCC flag for a renal condition.

BE closures were defined by ICD-9 code 57.86 with the primary closure assumed at the first appearance of this code in the first 120 DOL. Other synchronous (same day as BE closure) or asynchronous procedures of interest were epispadias/hypospadias repair (ICD-9 58.45), hernia repair (ICD-9 53.0, 53.00–53.05 [unilateral]; or 53.1, 53.10–53.17 [bilateral]), pelvic osteotomy (ICD-9 77.1, 77.10, 77.19, 77.2, 77.20, 77.29, 77.3, 77.30 or 77.39), cystoscopy (ICD-9 57.32) and vesicocutaneous fistula repair (ICD-9 57.84). Revisions or additional instances of the same procedure were defined as subsequent appearances of an identical ICD-9 code.

Perioperative data included surgeon specialty, patient age at closure (categorized as 3 days, 4 – 30 days, 31 – 120 days), and type(s) of synchronous procedures performed. Postoperative data included asynchronous and revision procedures, postoperative length of stay (LOS), and use of intensive care unit (ICU) services postoperatively.

Facility characteristics included US Census Region and volume of closures in a hospital. Hospitals were split into quartiles according to their mean annual case volume of BE closure (number of BE repairs divided by number of years in the PHIS database), with the highest quartile hospitals performing at least 1.7 primary BE closures/year (maximum: 3.0/year).

Total charges for each patient were inflation-adjusted to 2011 US\$ using the Bureau of Labor Statistics Consumer Price Index Tables for Hospital and Related services⁸. Charges were then converted to costs (i.e. monetary estimate of services rendered) for each patient using the cost/charge ratios provided by PHIS. When not provided by PHIS, cost/charge ratios were based on the average yearly state Medicaid ratios for a given study year and hospital location⁹. For reference, the mean cost/charge ratio provided by PHIS for our patient population was 0.45, meaning that the cost values described in our study are approximately 45% of the charges reported in previous studies of resource utilization in BE patients.

Outcome Measures

Our primary outcome was inflation-adjusted total cost in the first year of life for each patient.

Statistical Analysis

Descriptive statistics were used to characterize the cohort. The associations between resource utilization (as defined by per patient first-year cost) and the potentially relevant patient- and facility factors detailed above were evaluated via linear regression using generalized estimating equations (including a random effect for hospital to account for patient clustering by site). Total cost was log-transformed prior to analysis to ensure normality of residual distribution. Variables that had significant univariate associations and/or clinical relevance were included in the final multivariate model: prematurity, non-renal comorbidity, age at primary closure, surgeon type, average number of primary closures per year (by quartile), presence of osteotomy at primary closure, post-closure ICU admission, and post-closure LOS (by quintiles). To address missing data, 5 sets of multiple imputations were performed with different starting points. Both the complete case data and one multiple imputation are shown, with the complete case data used to describe effect estimates that were significant in both complete case and multiple imputation analysis. Diagnostic checks and sensitivity to outliers of the fitted model were performed.

Data processing and statistical analysis was conducted using SAS v9.3 (Copyright (c) 2002–2010 by SAS Institute Inc., Cary, NC, USA) and statistical software R¹⁰. A p-value of <0.05 was considered to be statistically significant.

RESULTS

Between 1/1999–12/2010, 381 patients with bladder exstrophy were closed within the first 120 DOL at 43 PHIS hospitals. Of these patients, 59% were male, 67% were white, and less than half of patients had private insurance (Table 1).

Characteristics of Primary Bladder Closure

73% of closures were performed within 3 DOL, 37% of which were done at the 7 highest volume hospitals (Figure 1). Closures were performed by a urologist in 71% and a general surgeon in 7% of cases (Table 1).

Pelvic osteotomies were performed in 31% (119/381) of all closures. Specifically, 18% (51/279) of those closed within 3 DOL underwent osteotomy, compared to 57% (38/67) of those closed between 4–30 DOL, and 86% (30/35) of those closed between 31–120 DOL ($p=0.0017$). 56% (127/226) of males had an epispadias repair on the day of their primary BE repair, suggesting that these patients underwent a so-called “complete primary repair”¹¹.

Postoperative Care

11% of patients were admitted postoperatively to the ICU (Table 1). The median postoperative LOS following primary closure was 20 days [IQR: 9–26]. By age at closure, the LOS was 21 days [12,26] for those closed within 3 DOL, 22 days [12,37] for those closed between 4–30 DOL, and 21 days [8,29] for those closed between 31–120 DOL ($p=0.25$). Within the first year of life, 44% of patients had at least 1 additional operation and 30% required at least 1 ED visit (Table 2).

It is possible that a longer post-closure LOS could decrease readmissions following discharge. However, by using an ER encounter subsequent to a patient's discharge as a proxy for readmissions, there was no difference in the median post-closure LOS between those patients who were (23 days [IQR: 15–33]) and were not (20 [10–27]) seen in the ER ($p=0.16$).

Economic Burden of Exstrophy Care in First Year of Life

Median first-year cost per patient closed at a PHIS hospital was \$66,577 [IQR: 45,335–102,398], mostly incurred during the first three months (Figure 2). Prematurity, presence of a non-renal comorbidity, and age at primary closure were associated with higher costs on univariate analysis, as were a lower average annual case volume and a longer postoperative LOS (see supplemental Table 1 at *JU* to [insert link here](#)). After adjustment for prematurity, operative surgeon, average annual case volume, presence of osteotomy at primary closure, and post-closure ICU admission, the multivariate model suggested that the presence of a non-renal comorbidity and closure after 30 DOL were associated with 24% and 56% increased costs, respectively, in the first year of life. LOS was also found to be a significant predictor of first-year costs. Compared to those staying 18–23 days after primary closure, 48% and 24% cost reductions were seen in those staying <11 and 11–17 days after surgery, and 20% and 104% cost increases were seen in those staying 24–31 and >32 days after surgery (Table 3). When multiple imputations were done to address missing data, the magnitudes, directions and statistical significance of the model covariates did not change with the exception of the effect of the closure after 30 DOL that was no longer significant.

DISCUSSION

The traditional age for bladder closure in an otherwise medically stable child with BE has been in the first three DOL¹², which may obviate the need for osteotomy and decrease family burden in caring for the exstrophic bladder. A majority of patients in this cohort was closed within 3 DOL; however, a significant minority was not. Reasons for delayed closure include a small bladder plate, prematurity, or social reasons¹³. Some have recently advocated for delayed repair at several months of age to facilitate family bonding, simplify the procedure technically, allow the surgeons to perform the technically challenging procedure electively and with adequate rest, and to reduce anesthetic risks¹⁴. Given this potential paradigm shift, the use of adjunctive procedures such as pelvic osteotomy and the overall cost of care will need to be closely examined.

The benefits of pelvic osteotomy in BE care, particularly for closures beyond 30 DOL, have been well described¹⁵. In our study, only 56% and 86% of those closed between 4–30 and 31–120 DOL, respectively, underwent osteotomies. These findings are similar to a 2005 study using the NIS, in which only 31% of patients had pelvic osteotomy performed⁵. Since osteotomy, where indicated, may reduce postoperative complications and improve outcomes¹⁶, and especially in light of the current trend towards delayed elective repair¹⁴, this represents a potential area for quality improvement.

Complex diseases such as BE require a multi-specialty approach and extensive care coordination. Thus, it is not surprising that at least 60% of patients were transferred to the

hospital where the closure was performed (data not shown), which for nearly 40% of the patients was a hospital in the highest quartile for annual volume. However, the wide range in surgical volume at PHIS hospitals demonstrates that not all cases are sent to high-volume centers: compared to the 7 hospitals with the most (1.7) closures per year, 30 hospitals performed 1 or fewer cases per year. Although the univariate analysis showed a clear inverse relationship between case volume and first-year cost, as reported previously⁵, this association was not significant after controlling for other potential confounders in the multivariate model. Thus other hospital and patient level factors, such as the presence of a non-renal comorbidity and the postoperative LOS, play at least as important a role in determining costs in this selection of hospitals as does annual case volume. Another critical distinction is that the highest volume hospitals in the previously cited study performed at least 5 closures per year⁵. In comparison, the highest volume PHIS institutions performed on average 1.7 and no more than 3 closures per year and would have been classified as low volume hospitals in the aforementioned study. While this may be a reflection of the perceived decrease in exstrophy volumes during this study period, the volumes reached at 'high-volume' exstrophy centers represented in this sample may not have reached the threshold at which the presumed benefits of high volume become manifest (increased efficiencies, team cohesion, familiarity with variability in clinical course, etc). More studies will be needed to follow trends in annual case volume and to test the traditionally-held belief that higher volume exstrophy 'centers-of-excellence' contain costs and improve patient outcomes.

Our adjusted analysis included several patient- and provider-specific variables that could be important additional drivers of cost. Specifically, non-renal comorbidities were associated a 24% increase in first-year cost. These comorbidities may serve as markers of patients with increased complexity and care needs whose medical costs are higher regardless of when and where their bladder closure occurs. Another significant driver of costs is postoperative LOS. Not surprisingly, our data indicate that the shorter the postoperative LOS the lower the first-year costs. Thus, decreasing the postoperative LOS is another potentially modifiable factor that could contain exstrophy costs in the first year of life, but it is important that this be approached cautiously so as not to sacrifice the potential for a successful primary closure or compromise long-term outcomes.

This study should be viewed in light of its limitations. The PHIS database does not include all BE centers, and thus does not provide a complete national picture of exstrophy care patterns. Nevertheless, several well-known BE centers with high clinical volume are included in the database, and the wide range of institutions allows us to study the variation in BE care across the US. Administrative databases such as PHIS rely on billing codes to classify patient diagnoses and procedures, with potential for missing data, clerical error, and misclassification. Although individual patients can be followed longitudinally within a PHIS hospital, any care received by these patients at non-PHIS hospitals is not captured; similarly, patients who present to a different PHIS hospital might be double-counted as two individuals. We were also unable to examine trends related to the ongoing controversy of staged vs. single-stage BE repair, as the ICD-9 procedure codes used in PHIS are not granular enough to reliably distinguish between these management strategies. Finally, the costs described in this analysis are estimated based on hospital charges. The estimates do not

include professional physician billing costs, and do not represent the costs to the health care system from the societal perspective (such as parental time lost from work).

CONCLUSION

At select freestanding U.S. children's hospitals, the majority of bladder closures occur within the first 3 DOL. Most, but not all, patients closed after the neonatal period undergo osteotomy. Patient level factors associated with increased costs include the presence of a non-renal comorbidity and longer post-closure LOS.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Sources of funding:

Dr. Nelson is supported by K23-DK088943 from NIDDK

Dr. Johnson is supported by AHRQ/ARRA Recovery Act 2009 T32 HS19485 National Research Service Award (NRSA) in Expanding Training in Comparative Effectiveness for Child Health Researchers.

Abbreviations

BE	Bladder Exstrophy
PHIS	Pediatric Health Information System
NIS	Nationwide Inpatient Sample
CPRE	Complete Primary Repair of Exstrophy
US	United States
DOL	Day of Life
LOS	Length of Stay
ICU	Intensive Care Unit

REFERENCES

1. Shnorhavorian M, Grady RW, Andersen A, et al. Long-term followup of complete primary repair of exstrophy: the Seattle experience. *J Urol.* 2008; 180:1615. [PubMed: 18710721]
2. Gargollo PC, Borer JG, Diamond DA, et al. Prospective followup in patients after complete primary repair of bladder exstrophy. *J Urol.* 2008; 180:1665. [PubMed: 18715576]
3. Baird AD, Nelson CP, Gearhart JP. Modern staged repair of bladder exstrophy: a contemporary series. *J Pediatr Urol.* 2007; 3:311. [PubMed: 18947762]
4. Hafez AT, El-Sherbiny MT, Shorrab AA, et al. Complete primary repair of bladder exstrophy in children presenting late and those with failed initial closure: single center experience. *J Urol.* 2005; 174:1549. [PubMed: 16148650]
5. Nelson CP, Dunn RL, Wei JT, et al. Surgical repair of bladder exstrophy in the modern era: contemporary practice patterns and the role of hospital case volume. *J Urol.* 2005; 174:1099. [PubMed: 16094068]

6. Nelson CP, Bloom DA, Dunn RL, et al. Bladder exstrophy in the newborn: a snapshot of contemporary practice patterns. *Urology*. 2005; 66:411. [PubMed: 16040099]
7. Feudtner C, Christakis DA, Connell FA. Pediatric deaths attributable to complex chronic conditions: a population-based study of Washington State, 1980–1997. *Pediatrics*. 2000; 106:205. [PubMed: 10888693]
8. [Retrieved on October 1, 2012] <http://www.bls.gov/cpi/>
9. [Retrieved on October 1, 2012] <http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/IPPS-Regulations-and-Notices.html>
10. The R Core Team: R. A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2012.
11. Grady RW, Mitchell ME. Complete primary repair of exstrophy. *J Urol*. 1999; 162:1415. [PubMed: 10492227]
12. Gearhart, JP.; Jeffs, RD. The bladder exstrophy-epispadias complex and bladder anomalies. In: Walsh, PC.; Retik, AB.; Vaughan, ED., Jr, et al., editors. *Campbell's Urology*. 7th ed.. Vol. 2. Philadelphia: WB Saunders; 1998. p. 1939-1990.
13. Baradaran N, Stec AA, Schaeffer AJ, et al. Delayed primary closure of bladder exstrophy: immediate postoperative management leading to successful outcomes. *Urology*. 2012; 79:415. [PubMed: 22188756]
14. Canning, DA. Bladder Exstrophy: Is Newborn Closure an Emergency?. Presented at the Society of Pediatric Urology; Atlanta, GA. 2012 Apr.
15. Vining NC, Song KM, Grady RW. Classic bladder exstrophy: orthopaedic surgical considerations. *J Am Acad Orthop Surg*. 2011; 19:518. [PubMed: 21885697]
16. Schaeffer AJ, Stec AA, Purves JT, et al. Complete primary repair of bladder exstrophy: a single institution referral experience. *J Urol*. 2011; 186:1041. [PubMed: 21784464]

Figure 1.
Number of primary bladder exstrophy closures per year in PHIS database by hospital

Figure 2.
Quarterly distribution of total patient cost in the first year of life Each dot represents an individual patient
 *indicates truncated data

Table 1

Characteristics of infants and their primary bladder closures (n=381)

Characteristic:	N (%)
Postnatal age at presentation (DOL)	
0	245 (64.3)
1	94 (24.7)
2–3	13 (3.4)
4–30	17 (4.5)
31–120	12 (3.1)
Gestational age at presentation	
Term (≥ 37 weeks)	168 (44.1)
Premature(<37 weeks)	38 (10.0)
Unknown	175 (45.9)
Gender	
Male	226 (59.3)
Female	154 (40.4)
Unknown	1 (0.26)
Non-renal comorbidity	
Cardiovascular	96 (25.2)
Gastrointestinal	39 (10.2)
Respiratory	12 (3.2)
Hematologic/Immunologic	2 (0.5)
Malignancy	29 (7.6)
Metabolic	4 (1.1)
Neuromuscular	29 (7.6)
Other Congenital or Genetic	27 (7.1)
Race/Ethnicity	
White	256 (67.2)
Black	26 (6.8)
Hispanic	20 (5.3)
Other ^I	58 (15.2)
Missing	21 (5.5)
Insurance status – primary payer	
Private	169 (44.4)
Public	145 (38.1)
Other	59 (15.5)
None/no bill	6 (1.6)
Unknown	2 (0.52)
Hospital region	

Characteristic:	N (%)
West	79 (20.7)
Midwest	120 (31.5)
Northeast	53 (13.9)
South	129 (33.9)
Age category at primary closure (DOL)	
3	279 (73.2)
4–30	67 (17.6)
31–120	35 (9.2)
Operative surgeon	
Urologist	271 (71.1)
Pediatric Surgeon	25 (6.6)
Orthopedic Surgeon	3 (0.79)
Unknown	85 (22.3)
Hospital volume (average # primary closures/year)	
Highest quartile (>1.71)	170 (45.6)
Third quartile (50 th – 75 th %: 0.72–1.71)	109 (29.2)
Second quartile (25 th – 50 th %: 0.34–0.71)	63 (16.9)
Lowest quartile (< 0.33)	31 (8.3)
Additional procedures performed at time of primary closure	
Epispadias ²	127 (56.2)
Hernia Repair ³	51 (13.4)
Osteotomy	119 (31.2)
Postoperative intensive care unit admission	42 (11)

¹ Includes Asian, American Indian, Mixed and Other

² 127 out of 226 males

³ Of these, 45 (88%) were bilateral

Table 2

Procedural and hospital visit burden in the first year of life

	Number (%) or Median [IQR]
Additional procedures required:	
0	214 (56.2)
1	112 (29.4)
2	39 (10.2)
3+	16 (4.2)
Additional procedures performed:	
Repeat exstrophy closure	22 (5.8)
Repeat epispadias or hypospadias Repair	19 (5.0)
Asynchronous hernia repair	74 (19.4)
Cystoscopy	87 (22.8)
Repair of vesicocutaneous fistulae	1 (0.26)
ED visits required:	
0 visits	268 (70.3)
1 visit	61 (16.0)
2 visits	21 (5.5)
3 visits	31 (8.9)
Total visits (ED+inpatient):	2 [1–3]

Table 3

Adjusted relationships between patient-, surgeon- and hospital-level factors and adjusted costs in the first year of life

Predictor:	Results: Complete Cases		Results: Multiple Imputation	
	Percent change in first-year cost above (+) or below (–) baseline [95% CI]	p-value*	Percent change in first-year cost above (+) or below (–) baseline [95% CI]	p-value*
Prematurity				
Yes	16.0 [–0.6, 35.4]	0.06	7.3 [–8.4, 25.7]	0.39
No (ref)	NA	NA	NA	NA
Presence of a non-renal comorbidity				
Yes	24.4 [8.8, 42.3]	0.001	27.6 [14.8, 42.0]	<0.0001
No (ref)	NA	NA	NA	NA
Age category at primary closure				
3 days (ref)	NA	NA	NA	NA
4 – 30 days	1.9 [–14.6, 21.5]	0.84	3.6 [–9.1, 18.2]	0.59
31 – 120 days	56.3 [8.8, 124.5]	0.02	4.2 [–13.8, 25.9]	0.67
Operative Surgeon				
Pediatric or orthopedic surgeon	1.9 [–27.8, 44.7]	0.92	8.52 [–9.2, 29.7]	0.37
Urologist (ref)	NA	NA	NA	NA
Hospital volume (average # primary closures/year)				
Highest quartile (>1.71)	–7.7 [–33.2, 27.4]	0.63	–9.3 [–24.7, 9.1]	0.30
Third quartile (50 th – 75 th %; 0.72–1.7)	–13.4 [–33.5, 12.7]	0.28	–13.5 [–28.5, 4.5]	0.13
Second quartile (25 th – 50 th %; 0.34–0.71)	5.0 [–20.2, 38.1]	0.73	–0.9 [–19.0, 21.4]	0.93
Lowest quartile (0.33) (ref)	NA	NA	NA	NA
Osteotomy				
Yes	5.2 [–14.2, 29.2]	0.62	5.4 [–7.5, 19.9]	0.43
No (ref)	NA	NA	NA	NA
Post-closure ICU admission				
Yes	–5.0 [–24.7, 20.0]	0.67	2.1 [–12.7, 19.3]	0.80
No (ref)	NA	NA	NA	NA
Post-closure LOS				
< 11 days	–47.9 [–60.0, –32.3]	<0.0001	–45.6 [–53.3, –36.8]	<0.0001
11–17 days	–23.7 [–37.2, –7.2]	0.01	–20.6 [–32.0, –7.3]	0.004
18–23 days (ref)	NA	NA	NA	NA
24–31 days	19.9 [0.5, 43.1]	0.04	22.2 [3.8, 43.9]	0.02
>32 days	104.1 [72.8, 141.0]	<0.0001	128.0 [92.3, 170.2]	<0.0001

* Multivariate linear model using Generalized Estimating Equations to account for correlated nature of the data (clustering by hospital)