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The authors declare that the data presented are original material and have not been previously published, accepted or considered for publication elsewhere; that the manuscript has been approved by all the authors, who have met the requirements for authorship.

ORIGINAL ARTICLE

THE ASSOCIATION OF PRE-OPERATIVE HOSPITAL STAY WITH SURGICAL SITE INFECTION AMONG PEDIATRIC PATIENTS AFTER A CLEAN NEUROSURGICAL OPERATION

ABSTRACT

Background: Surgical site infection (SSI) poses a serious threat in Neurosurgery. The mere presence of SSI would warrant a prompt medical and/ or surgical intervention for the outcome is very poor. This study aims to establish whether a pre-operative hospital stay of >7 days & other risk factors predisposes to surgical site infections.

Methods: Retrospective, cross-sectional study of all pediatric patients who underwent clean neurosurgical procedures for the first time from January 1, 2011 - June 30, 2014, in Philippine General Hospital. The primary outcome was the development of a surgical site infection within 30 days from spine surgery or 90 days from intracranial surgery. Univariate and multivariate logistic regression analyses were performed to show the association of demographic and clinical factors with the development of SSI.

Results: 279 medical charts were available for review. Median age was 1 year (5 days to 18 years old). The overall prevalence rate of SSI was 11.26%. Patients with >7 days pre-operative hospital stay had an incidence rate for SSI of 76.47% compared to 23.53% in patients with $\leq$7 days pre-operative hospital stay (OR 1.61, CI 0.68-3.84, p=0.280).

Conclusions: The incidence of SSI is high compared to other centers. There was no association of preoperative hospital stay with SSI. The association was significant only for the history of nosocomial infection. Early pre-operative clearance and surgery are recommended. Further prospective studies and surveillance are warranted.

KEYWORDS:
Surgical site infection, neurosurgery infection, healthcare associated infection

INTRODUCTION

Surgical site infection represents a big burden of the disease not only to the pediatric patient but to the healthcare facility as well. Globally, the burden of surgical site infection is indeed high. In developed countries, it remains the second most common hospital acquired infection. In developing countries like the Philippines, surgical site infection still remains the leading cause of hospital acquired infection. [1,2] The CDC National Healthcare Safety network, reported in 2011 the overall risk for surgical site infection is 1.9 per 100 procedures. Focusing in craniotomies, the rate for developed countries is 0.56 risks per 100 procedures while for developing countries it is 5.6 per 100 surgical procedures. [1, 3, 4]

The acceptable level of surgical site infection for clean neurosurgical operations among developed countries like the United States with pre-operative antimicrobial prophylaxis is less than 5% [5,6,7]. In children, a retrospective study of Yeung et al. showed a neurosurgical site infection rate of 3.2%.[8] Among the type of surgery it was noted that shunt insertion has high SSI rate as noted in the prospective study done by Kulkarni et al which showed an SSI of 10.4%.[9], multi-prospective cohort study of Simon et al:11%. [10], retrospective study of McGirt et al:11%. [11] and retrospective study of Borqbjerg et al: 7.4%.[12] This was in contrast with the study done by Davis et al showing a low SSI rate of 3.2%.[13] In our resource limited setting, a number of pediatric patients have complicated neurosurgical cases which require prolonged hospital stay prior to surgery. In a systematic review of risk factors associated with surgical site infection by Korol et. al, it was identified in the 12 studies that pre-operative hospital stay is one important risk factor with an overall odds ratio ranging from 1.0-2.0.[14] Every additional stay per day in the hospital would further increase the risk of surgical infection with an odds ratio of 1.1. Among these studies, it was Kaya et al., who mentioned specifically that prolonged pre-operative hospital stay beyond 8 days was associated with increased risk of SSI with an odds ratio of 10. [15] These studies are the same with the retrospective study of Petrica and Mahapatra et al. showing an overall odds ratio of 4.8 (95% CI 1.86-13.09, P=<0.001). [7, 16] However this was in contrast with the prospective study of Patir [17]and a local unpublished study in adults by Domingo[18], done in the same institution which showed that the longer pre-operative hospital stay is not associated with surgical site infection with an odds ratio of 1.02 (95% CI 0.98 – 1.07, P=0.238).

This study aims to determine whether prolonged pre-operative hospital stay will increase the risk of infectious complications after neurosurgery in Philippine General Hospital. Other demographic characteristics and clinical factors were also investigated for their association with an increased occurrence of postoperative infections.

METHODOLOGY

Study Design: This is a retrospective, analytic, cross-sectional study done at Philippine General Hospital (PGH), Department of Pediatrics and Neurosurgery over the period of 3.5 years.

Study Population: Admitted male and female patients less than 19 years old, who underwent a clean neurosurgical procedure for the first time were included in the study. Patients with multiple surgeries involving other organ systems, or underwent emergency, clean contaminated & dirty neurosurgical procedures, or patients operated outside the PGH and diagnosed with surgical site infection from another hospital were not included in the study.

Data collection: The research was a chart review of pediatric patients in PGH, Department of Pediatrics admitted in Ward 9, 11, Neonatal Intensive Care

Unit (NICU), Pediatric Intensive Care Unit (PICU), Neurosurgery and Surgical Care Unit (NSSCU and Department of Neurosurgery admitted in Ward 6 who underwent a clean neurosurgical procedure for the first time from January 1, 2011 up to June 30, 2014. A list of pediatric patients who underwent clean procedures such as placement of a ventriculoperitoneal shunt, ommaya reservoir, craniotomy, craniectomy & spinal surgery were obtained from the monthly census of the Department of Neurosciences, Section of Neurosurgery, Section of Pediatric Neurology and logbook of operations in the operating room. The list was used as a baseline record to check the case number and dates of admissions and subsequent admissions of the patients in the computer in the emergency room medical records section. Permission to review the charts was obtained from the Hospital Director for Patient Services. Actual chart review of the study subjects at the time of operation & succeeding admissions were reviewed based on the inclusion, exclusion criteria & objectives. One research assistant was hired to extract data from the charts in the medical records to maintain anonymity.

Clinical profile, possible risk factors, and outcomes were collected for each patient. Demographics include age and gender, diagnosis, nutritional status, ward/ location prior to operation and co-morbid illness. Possible risk factors that would contribute to surgical site infection were categorized as follows:

1. Pre –operatively: no. of days of preoperative hospital stay, pre-operative steroids, pre-operative antibiotics given and history of nosocomial infections prior to surgery.

2. Intra-operative parameters: type of surgery as to craniotomy with or without a medical device, craniectomy with or without a medical device, spinal surgery, burr holing with a medical device. Operations with the insertion of a medical device were further subdivided into tube ventriculostomy insertion, ommaya insertion, and ventriculoperitoneal shunt. The duration of the operative procedure is the interval in hours and minutes from the start time of surgery to the surgery finish time. Surgical site infection was described based on the onset of symptoms from the date of surgery where day 1 is the date of the procedure. Symptoms include fever, shunt tract swelling, vomiting, mental status change, purulent discharge from the wound, and erosion of the shunt equipment through the wound or skin, peritonitis. If the patient has several operations on different dates during the observation period of SSI, SSI will be reported closest to the operation performed unless there is evidence that the infection was associated with the different operation. [19]

Identification of the microorganism in the CSF culture which correlates with the signs & symptoms of the patient was interpreted as infection. However, in the absence of growth in the CSF culture results, surgical site infection was entertained if purulent discharge or erosion from the wound, peritonitis and unexplained fever, vomiting, and mental status changes occurred after a recent operation. The outcome of the surgical site infection was determined as either improved, mortality, on treatment or unknown. All data were entered into an Excel database and were subjected to descriptive analyses for demographic, clinical manifestations, laboratory and outcome variables.

I. Operational definitions:

a. Abnormal nutritional status- patients whose weight for age, weight for length and BMI Z score falls below -2 or above 1.

b. Clean neurosurgical procedure- This is a non-emergency neurosurgical procedure wherein the wound is initially closed, uninfected with no inflammation. The respiratory, genitourinary and gastrointestinal tract is not entered during the clean procedure. [1]

c. CSF Shunt- a medical device implanted used to divert CSF from the ventricles of the brain going to the peritoneum

d. Co-morbid illness-a concomitant illness that the patient has before or during admission & before the neurosurgical procedure was performed.

e. Normal Nutritional status- patients who had normal basal metabolic index, normal weight for height with the Z score of 0 to below -1

f. Nosocomial Infection- an infection acquired in the hospital that was not present at the time of admission and operation.

g. Nutritional status- a state of nutrition of the patient by calculating the basal metabolic index (BMI) and categorizing them as to underweight, normal and overweight.

h. Overweight- is defined as having a basal metabolic index of 26-30 or z-score above 2.

i. Obese- Patient's weight for length or basal metabolic index with a Z score of above 3.

j. Pre-operative antibiotics- any antibiotics given 30 minutes prior to surgery computed based on the weight of the patient and the recommended dose.

k. Pre-operative hospital stay – is defined as the number of days of stay in the hospital prior to surgery.

l. Pre-operative steroids- steroids like dexamethasone or prednisone given within 24 hours prior to surgery regardless of the dose and duration.

m. Surgical site infection- This is an infection that develops after a neurosurgical procedure within 30 days after spine surgery & within 90 days for intracranial surgery with or without an implant where the day of the operation is counted as day 1.The diagnosis of SSI was confirmed by the surgeon or attending physician.

n. Underweight- patient's weight for age with a Z score below -2.

o. Wasted - patient's weight for height and BMI with a Z score below -2.

p. Unknown - defined as the outcome of the patient which was undetermined because the patient went home against medical advice while on treatment

Data Processing and Analysis: Data were presented in tabular and graphical forms. For categorical data, frequency/percentages were presented. For quantitative data, means and standard deviation were computed.

To determine the association of demographic and clinical factors with surgical site infection, a univariate and multivariate logistic regression analysis were done. A logistic regression of a binary response variable (SSI) on a binary independent variable (pre-operative hospital stay) with a sample size of 349 pediatric patients of which 60% were in group 1 (> 7 days) and 40% were in group 2 (< 7 days) achieved 80% power at 5% level of significance detected a change in probability of SSI from baseline value of 0.35 to 0.519. This change corresponds to an odds ratio of 2.0. An adjustment was made since multiple regression of the independent variable of interest on the other independent variables is the logistic regression obtained an R-squared of 0.2.

Ethical considerations

This study was submitted for ethics review and was approved by the Research Ethics Board Panel of the same institution last June 18, 2014. The waiver of consent was sought from the Panel and this study was conducted with the approval from the panel. The anonymity of patients was maintained and all patient information was kept confidential by the researcher and used only for the purpose of the study. There is no conflict of interest involved in the conduct of the study.

RESULTS

A total of 302 patients were included in the study from January 1, 2011- June 30, 2014, only 279 charts were available for review from the medical records section with a complete data fulfilling the inclusion criteria of the study. The remaining 23 charts were missing or had incomplete data but were still included in the study with unknown SSI outcome as shown in Table 1.

Among the 302 pediatric neurosurgeries, 187 were males (61.93%) and 115 were females (38.08%). The mean age of the patients was 3.83 ranging from 5 days to 18 years of age. Most the patients belonged to less than 5 years old. Most of them, 222 were well nourished (73.51%) prior to neurosurgery. Most of the patients had a pre-operative stay of > 7 days which was 161 (53.31%) compared to less than 7 days which was 141(46.69%). 247(81.79%) were not given pre-operative steroids. 247 patients (91.72%) did not develop nosocomial infections prior to surgery. Among the type of surgeries, burr holing with a medical device topped the list with 137(45.46%) surgeries. Among the neurosurgeries where a medical device was present in 171(56.62%) of patients, Ventriculoperitoneal shunt insertion was the most common medical device inserted followed by tube ventriculostomy (8.94%) then Ommaya insertion (2.32%). The majority of the neurosurgeries, 231 (76.49%) were done less than 4 hours. Among these, only 34 (1.26%) patients who underwent clean neurosurgery developed surgical site infection.

A large number of patients who developed surgical infections improved with antibiotics and removal of the medical device (73.53%). However, 4 (11.76%) died for the following reasons: 2 due to septic shock and 2 others due to multi-organ dysfunction syndrome. One patient was still admitted with ongoing treatment and the 4 cases wherein the outcome was unknown because these patients went home against medical advice.

Table 1. Demographic and clinical profile of pediatric patients who had clean neurosurgical procedures, January 2011 - June 2014

	Frequency (%) n= 302	With surgical site infection (n = 34)	Without surgical site infection (n = 245)
Age (years)			
n	302	34	245
Mean (SD)	3.83 (4.97)	4.62 (4.91)	3.72 (5.02)
Median	1	2	1
Range	5 days – 18 years	5 days – 18 years	5 days – 18 years
≤ 5 years old	219 (72.52)	21 (61.76)	181 (73.88)
6 -10 years old	43 (14.24)	8 (23.53)	32 (13.06)
11 – 18 years old	40 (13.25)	5 (14.71)	32 (13.06)
Sex			
Male	187 (61.92)	23 (67.65)	151 (61.63)
Female	115 (38.08)	11 (32.35)	94 (38.37)
Diagnosis			
Congenital hydrocephalus	63 (20.86)	6 (17.65)	52 (21.22)
Intracranial mass	100 (33.11)	17 (50.00)	73 (29.80)
Nasoethmoidal meningocoele	34 (11.26)	0	33 (13.47)
TB Meningitis	11 (3.64)	1 (2.94)	10 (4.08)
Bilateral Open Lip Schizencephaly	11 (3.64)	2 (5.88)	7 (2.86)

	Frequency (%) n= 302	With surgical site infection (n = 34)	Without surgical site infection (n = 245)
Location			
Ward 6	169 (55.96)	26 (76.47)	179 (73.06)
Ward 9	16 (5.30)	8 (23.53)	66 (26.94)
Ward 11	91 (30.13)		
Others	26 (8.61)		
Nutritional status			
Normal	222 (73.51)	15 (44.12)	143 (58.37)
Underweight	55 (18.21)	2 (5.88)	12 (4.90)
Wasted	6 (1.98)	13 (38.24)	69 (28.16)
Overweight	15 (4.97)	4 (11.76)	21 (8.57)
Obese	4 (1.32)		
Co-morbidities	23 (7.62)		
Urinary tract infection	5 (1.66)	0	5 (2.04)
Community acquired pneumonia	11 (3.64)	2 (5.88)	9 (3.67)
Bronchial asthma	4 (1.32)	0	4 (1.63)
Others	3 (0.99)	1 (2.94)	2 (0.82)
Pre-operative hospital stay			
≤ 7 days	141 (46.69)	8 (23.53)	15 (6.12)
> 7 days	161 (53.31)	26 (76.47)	230 (93.88)
Pre-operative steroids			
Yes	55 (18.21)	9 (26.47)	118 (48.16)
No	247 (81.79)	25 (73.53)	127 (51.84)
Nosocomial infection			
With	25 (8.28)	10 (29.41)	43 (17.55)
Without	277 (91.72)	24 (70.59)	202 (82.45)
Type of Surgery			
Cranio/Craniectomy with device	34 (11.26)	5 (14.71)	26 (10.61)
Cranio/Craniectomy without medical device	67 (22.19)	10 (29.41)	51 (20.82)
Spine surgery	62 (20.53)	6 (17.65)	53 (21.63)
Cranioplasty	2 (0.66)	0	2 (0.82)
Burr holing with medical device	137 (45.36)	13 (38.24)	113 (46.12)
Presence of medical device	171(56.62)		
Tube ventriculostomy	27(8.94)	18(52.94)	139(56.73)
Ommaya insertion	7(2.32)	4(11.76)	23(9.39)
Ventriculoperitoneal shunt insertion	137(45.36)	1(2.94)	6(2.45)
Without medical device	131(43.38)	13(38.2%)	110(44.89)
Duration of surgery			
≤ 4 hours	231 (76.49)	22 (64.71)	193 (78.78)
> 4 hours	71 (23.51)	12 (35.29)	52 (21.22)

Table 2. Outcomes of patients who developed surgical site infections

Outcomes of surgical site infection	Frequency (%) n= 34
Improved	25 (73.53)
Mortality	4 (11.76)
Ongoing treatment	1 (2.94)
Unknown	4 (11.76)

This study used stepwise logistic regression with backward selection strategy. The significance level for addition of a variable in the model was 0.15 and the significance level for removal of a variable in the model was 0.2.

The significance of the main effects of the different independent variables on surgical site infection was determined by univariate analysis. The process should begin with a univariate analysis to have an idea of the nature of strength of association of each independent variables and the outcome variable. Univariate test of any variable resulting to a *p-value* ≤ 0.25 was considered a candidate for the multivariable model. Since some of the variables did not reach significance level *p-value* ≤ 0.25 in the univariate analysis, a model that included significant variables was constructed. The variables included in the model were then subjected to multivariate logistic regression analysis. Using the stepwise backward selection, the results of the analysis is shown in Table 4.

Univariate and Multivariate Analysis

The univariate analysis showed a significant risk for developing SSI for the preoperative hospital stay, age in years, intracranial mass, pre-operative steroids, history of nosocomial infection prior to neurosurgery and duration of operation (in hours). On the other hand, other factors such as sex, congenital hydrocephalus, comorbidities, nutritional status, location prior to surgery and type of surgery did not show any significance (Table 3). All variables with a p value of <0.25 were included in the full model of multivariate analysis. The association was significant only for the history of nosocomial infection. The other factors (preoperative hospital stay, intracranial mass, and duration of operation in hours) was not significant (Table 4).

DISCUSSION

Hospitalized pediatric patients who underwent a clean elective neurosurgery like adults are supervised after surgery for any signs of SSI. Children are not miniature adults, they are said to be immunodeficient thus making them a vulnerable group.[19]

This study involved 302 patients who were admitted to the PGH Department of Pediatrics - from January 1, 2014 – June 30, 2014. The number of subjects didn't reach the required sample size of 350 subjects based on the sample size estimation computation. The majority of the subjects were 0-5 years old.

In adults, the reported acceptable level of surgical site infection should be less than 5% although several studies have reported rates higher than this. The study of Buang reported,7.7%,[20] and Petrica reported,5.46%[7,] and the prospective study of Erman was 6.2%.[21] An unpublished study was done in adults by Domingo et al. in this institution showed the SSI rate of 5.59% [18] which was similar to other researches. A retrospective study of Yeung et al. which also involved children showed SSI prevalence of 3.2% [8] which is in contrast to our study which showed a high overall prevalence SSI rate of 11.26%.

Table 3. Results of Univariate analysis

	Standard error	Odds Ratio	95% CI	p-value
Preoperative hospital stay				
≤ 7 days				
> 7 days	1.06	2.58	1.157 – 5.756	0.021
Age (years)				
0 – 5				
6 – 10	0.99	2.15	0.879 – 5.283	0.240
>= 11	0.72	1.35	0.474 – 3.830	
Sex				
Female				
Male	0.51	1.30	0.607 – 2.792	0.498
Intracranial mass	0.87	2.36	1.140 – 4.869	0.021
Congenital Hydrocephalus	0.38	0.80	0.313 – 2.022	0.631
Co-morbidities	0.71	1.09	0.306 – 3.878	0.896
Nutritional status				
Normal				
Abnormal	0.36	0.83	0.360 – 1.935	0.673
Location prior to surgery				
Ward 6				
Ward 9	1.29	1.59	0.324 – 7.781	0.484
Ward 11	0.730	1.80	0.810 – 3.983	
Others	1.106	1.82	0.550 – 5.994	
Pre-operative Steroids	0.81	1.96	0.872 – 4.390	0.103
History of nosocomial infection prior to neurosurgery	2.28	4.72	1.826 – 12.188	0.001
Duration of OR (hours)				
0 – 4				
≥ 5	0.79	2.02	0.940 – 4.360	0.072
Type of surgery				
Cranio/Craniectomy with medical device				
Cranio/Craniectomy without medical device	0.61	1.02	0.316 – 3.294	0.563
Spine surgery	0.38	0.59	0.164 – 2.109	
Cranioplasty	-	1.00	0.196 – 1.826	
Burr holing with a medical device	0.34	0.60	0.074 – 0.510	

Table 4. Results of Multiple Logistic Regressions

	Standard error	Odds Ratio	95% CI	p-value
Preoperative hospital stay **≤ 7 days** **> 7 days**	**0.71**	**1.61**	**0.68 – 3.84**	**0.280**
Intracranial mass	0.94	2.16	0.92 – 5.07	0.078
History of nosocomial infection prior to neurosurgery	2.98	5.49	1.89 – 15.93	0.002
Duration of OR **0 – 4** **≥ 5**	0.79	1.76	0.73 – 4.24	0.205

* Length of hospital stay was forced into the model since it is the main independent factor

Several published studies regarding the association of risk factors in developing surgical site infection such as pre-operative stay, duration of operation and pre-operative antibiotics still remain unclear. However, results of our univariate analysis showed that sex, congenital hydrocephalus, comorbidities, nutritional status, ward location prior to surgery and type of surgery were not independent risk factors in the development of neurosurgical site operation. Although, our study showed that age, intracranial mass, pre-operative steroids, duration of operation (hours) were independent risk factors for the development of neurosurgical site infection in the univariate analysis but these risk factors were not statistically significant in the logistic regression model.

A large number of studies showed an association of preoperative hospital stay with neurosurgical site infection. [14,15, 22-32] In every additional stay per day in the hospital would further increase the risk of surgical infection with an odds ratio of 1.02-1.1 [7,18,22-28].This was in contrast to our study and the study of Patir.[23] showing that there is no association between length of preoperative stay with surgical site infection. Surgeries like burr holing with a medical device inserted had high SSI rates which are consistent with the SSI rates documented in reported literature like Kulkarni et al had SSI rate of 10.4%[9], Simon et al:11% [10], McGirt et al: 11% [11] and Borqbjerg et al: 7.4%.[12] Our study showed that presence of a medical device had 52.94% infection rate which was in contrast with the study done by Davis et al with 3.2% SSI rate.[13] However, our univariate analysis revealed that Burr holing with a medical device has an odds ratio of 0.34 and not statistically significant.

One important factor that was prominent in our study which showed a statistically significant result in relation to SSI is the history of nosocomial infection prior to neurosurgery with an odds ratio of 5.49, 95% CI 1.89-15.93, p value=0.002. The presence of the following possible contributory factors in the development of nosocomial infections which is the significant factor in developing SSI. Among these is the presence of co-morbidities, prolonged pre-operative clearance thus prolonged pre-operative hospital stay prior to surgery and the nutritional status of the patient. These factors were not included in my study.This study was not able to examine the association between nosocomial infection and preoperative hospital stay thus further studies are needed. The prolonged pre hospital stay of our pediatric patients was due to the complicated neurosurgical cases which needed medical management prior to surgery.

Our study had several limitations since this is a retrospective collection of data which may produce bias at different levels since there may be incomplete documentation in the medical records. One limitation is the safekeeping of medical charts in this institution because quite a number of charts were unavailable for review or missing. The outcome cannot be determined if there is possibly higher infection rate. Documentation by the clinicians was also lacking like the height which was not indicated in the charts thus only weight for age was computed to assess nutritional status. These patients were not followed up after discharge from the hospital thus the true prevalence of surgical site infection might actually be higher than reported. In view of these, we recommend that a prospective cohort study is done.

CONCLUSION

This study concluded that there is no association between a pre-operative hospital stay with surgical site infection among pediatric patient seen in PGH who underwent a clean neurosurgical operation. The overall prevalence rate of Pediatric neurosurgical site infection in this institution was at 11.26% which is high compared to the published literature. The following demographic & clinical profiles such as age, sex, diagnosis, nutritional status, ward location, pre-operative steroids, adherence to pre-operative antibiotics, type of surgery, duration of operation were not associated with the development of SSI. Only the history of nosocomial infections is directly related to SSI. Operation with foreign body insertion procedures had the highest SSI rate of 56.62%.Among the 34 patients who developed SSI, 73.53% eventually improved with most of them had no microorganisms identified in cerebrospinal fluid. Fever is the most common presenting symptom among 70.59% of patients and symptom occurred usually in 2 months. Important to note that majority of the CSF studies of a patient with neurosurgical infection were negative (55.8%). Greater awareness is needed and appropriate use of recommended antibiotic is the cornerstone in reducing morbidity and mortality.

RECOMMENDATIONS

Further prospective surveillance is warranted to be able to accurately identify the reliable risk factors of neurosurgical site infection and actively report these events once documented.

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