Clinical Neurology and Neurosurgery 120 (2014) 41–44

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Lower complication rates for cranioplasty with peri-operative bundle

Catherine Le[a], Kern H. Guppy[b], Yekaterina V. Axelrod[b], Mark W. Hawk[b], James Silverthorn[b], Maria C. Inacio[c], Paul T. Akins[b,*]

[a] University of California Los Angeles, Neurocritical Care Department, Los Angeles, USA
[b] Kaiser Sacramento Neurosurgery Department, 2025 Morse Avenue, Sacramento, 95825, USA
[c] Kaiser Surgical Implant Registry, 8954 Rio San Diego Drive, Suite 406, San Diego, 92108, USA

ARTICLE INFO

Article history:
Received 1 October 2013
Received in revised form 4 December 2013
Accepted 17 February 2014
Available online 25 February 2014

Keywords:
Craniectomy
Cranioplasty
MRSA infection
Surgical site infection
Care bundles

ABSTRACT

Background: The overall benefits of craniectomy must include procedural risks from cranioplasty. Cranioplasty carries a high risk of surgical site infections (SSI) particularly with antibiotic resistant bacteria. The goal of this study was to measure the effect of a cranioplasty bundle on peri-operative complications.
Methods: The authors queried a prospective, inpatient neurosurgery database at Kaiser Sacramento Medical Center for craniectomy and cranioplasty over a 7 year period. 57 patients who underwent cranioplasties were identified. A retrospective chart review was completed for complications, including surgical complications such as SSI, wound dehiscence, and re-do cranioplasty. We measured cranioplasty complication rates before and after implementation of a peri-operative bundle, which consisted of peri-operative vancomycin (4 doses), a barrier dressing through post-operative day (POD) 3, and de-colonization of the surgical incision using topical chlorhexidine from POD 4 to 7.
Results: The rate of MRSA colonization in cranioplasty patients is three times higher than the average seen on ICU admission screening (19% vs. 6%). The cranioplasty surgical complication rate was 22.8% and SSI rate was 10.5%. The concurrent SSI rate for craniectomy was 1.9%. Organisms isolated were methicillin-resistant *Staphylococcus aureus* (4), methicillin-sensitive *S. aureus* (1), *Propionibacterium acnes* (1), and *Escherichia coli* (1). Factors associated with SSI were peri-operative vancomycin (68.6% vs. 16.7%, $p = 0.0217$). Complication rates without ($n = 21$) and with ($n = 36$) the bundle were: SSI (23.8% vs. 2.8%, $p = 0.0217$) and redo cranioplasty (19% vs. 0%, $p = 0.0152$). Bundle use did not affect rates for superficial wound dehiscence, seizures, or hydrocephalus.
Conclusions: The cranioplasty bundle was associated with reduced SSI rates and the need for re-do cranioplasties.

1. Introduction

Craniectomy can be a life-saving neurosurgical treatment in patients with elevated intracranial pressure (ICP), such as in severe cerebrovascular accidents or traumatic brain injury (TBI). While complication rates for craniectomy are well-described [1–8], less attention has been given to the closely associated reversal procedure, cranioplasty [9–12]. A systematic review of cranioplasty [13] cited a rate of surgical site infections (SSI) ranging from 0 to 21.4% with an average of 7.9%. With a minimum of 18 months of follow-up, Honeybul and Ho noted a 55.5% complication rate after decompressive craniectomy in their subset of patients with TBI and emphasized the significance of delayed complications related to cranioplasty [4]. In the DeCRA trial (Supplementary Appendix Table S1), the surgical complication rate was 20% for craniectomy ($n = 70$) and 21.4% for cranioplasty ($n = 56$), and the surgical site infection (SSI) rate was 7.1% for craniectomy and 14.3% for cranioplasty [14]. The infectious complications of cranioplasty have been attributed to multiple factors, including infection, size of the defect, location of the craniectomy, type of prosthesis used, impaired wound healing, wound closure, and time interval between craniectomy and cranioplasty [15–20].

Our center previously reported on a modified peri-operative care bundle to reduce the risk of MRSA associated neurosurgical site infections [21]. We developed a similar perioperative bundle for cranioplasty with the goal to make cranioplasties safer. We had observed elevated rates of SSI in our cranioplasty patients and the subsequent need for additional surgeries to remove infected bone flaps and reimplant custom prosthetic flaps. The bundle consisted of prophylactic vancomycin use before and after the surgery,

* Corresponding author. Tel.: +1 916 973 5490; fax: +1 916 973 5826.
E-mail addresses: paul.t.akins@kp.org, akins@surewest.net (P.T. Akins).

http://dx.doi.org/10.1016/j.clineuro.2014.02.009
0303-8467/

meticulous attention to wound closure, a barrier dressing on post-operative day (POD) 1–3 and topical chlorhexidine on POD 4–7. This study analyzes the results of a peri-operative bundle to reduce the complication rates for cranioplasty at a single tertiary care hospital.

2. Materials and methods

The study was approved by the institutional review board. Patients were prospectively entered into an inpatient neurosurgery database. Between 2005 and 2011, all craniectomy and cranioplasty patients were identified. The electronic medical records were reviewed using a standardized tool. This list was cross-referenced to infection control data collected for surgical site infections. The infection control data were collected by dedicated hospital staff that was blinded to use of the peri-operative bundle. Bone flaps were processed sterilely and stored at our facility using cryopreservation. Between 2005 and 2007, the standard of care was determined by the current physician and may vary from one practitioner to the next. The routine practice was that patients received cefazolin (1 g) preoperatively. The scalp incision was usually closed with nylon sutures. Intra-operative cultures were taken from the bone flaps, and then they were soaked in bacitracin prior to reimplantation. Subgaleal drains were routinely placed. The initial surgical dressing was removed on the second postoperative day, and the surgical incision was then usually left open to air or covered with a loose-fitting cotton stocking. The perioperative bundle, which has been shown to reduce complications in other surgeries [22], was regularly implemented in 2007 to reduce SSI rates for cranioplasty. Patients who received the peri-operative bundle were treated with vancomycin (weight-adjusted vancomycin 15 mg/kg given 1 h before skin incision then 1 g IV every 12 h for 48 h with pharmacy-adjusted dose/interval for trough goal of 15–20 μg/mL), received a barrier dressing for three days after the surgery, and then had daily topical chlorhexidine wound decolonization for three days or until hospital discharge. Surgical closure methods were not changed during the study period. Charts were reviewed for prespecified cranioplasty complications (specifically, SSI and causative organisms, wound dehiscence, need for re-do cranioplasty, hydrocephalus, and seizures). To compare patient characteristics, clinical factors, and complication rates of patients who received care without or with the cranioplasty bundle, we used Chi-square test or Fisher exact test when appropriate to compare categorical variables. We used Student's *t*-test for continuous variables. All *p*-values were two-tailed and a *p*-value of 0.05 or less was considered statistically significant. Mantel–Haenszel methods or logistic regressions analyses were not performed due to the small sample size. The published literature was searched using medical subject headings (MeSH) in the National Library of Medicine's (NLM) Medline database for craniectomy, cranioplasty, complications, surgical site infections.

3. Results

We identified 72 craniectomy patients: 10 of whom did not have cranioplasties, 3 had cranioplasties performed outside of our center, and 2 were lost to follow-up. We completed chart reviews on 57 cranioplasty patients: 36 patients were treated with the bundle and 21 patients without the bundle (Table 1). Compliance with the voluntary cranioplasty bundle between 2007 and 2011 was 74%. Baseline demographic information is shown in Table 1. Of the 18 trauma patients, 5 had emergent craniectomy for acute traumatic subdural hematomas, 3 patients with acute traumatic epidural hematomas with associated skull fractures, 4 for refractory elevated intracranial pressure with cerebral contusions with unilateral craniectomies, and 6 patients with refractory elevated intracranial pressure and combined cerebral contusions and severe diffuse axonal injury requiring bilateral craniectomies. Other indications for the initial craniectomy included: tumor ($n=6$); CNS infection ($n=2$); AVM or ruptured cerebral aneurysm (4); non-traumatic, warfarin-associated subdural hematoma (1); and dermoid cyst (1).

Table 1
Patient demographics.

Variable	Total, *n* (%), *n* = 57	No bundle, *n* (%), *n* = 21	With bundle, *n* (%), *n* = 36	*p*-Value
Male	31 (54)	12 (57)	19 (53)	0.789
Age (years)	42.9	45.4	43.2	0.628
MRSA colonization	11 (19)	3 (14)	8 (22)	0.729
Hypertension	18 (32)	6 (29)	12 (33)	0.775
Diabetes mellitus	5 (9)	2 (10)	3 (8)	0.878
Cigarette use	22 (39)	8 (38)	14 (39)	0.953
Alcohol use	4 (7)	3 (14)	1 (3)	0.136

Data including surgical site infections and surveillance for antibiotic-resistant organisms were collected by the infection control department of the hospital. The institutional rate of surgical site infections after craniectomy was 1.9%. The MRSA colonization rate for cranioplasty patients (19%; Table 1) is approximately three times higher than what we observe for patients admitted to our ICU who undergo state-mandated MRSA screening by nares swab (6%). We did not screen patients prior to cranioplasty for MRSA, and patients did not undergo treatments aimed to eradicate MRSA colonization due to high relapse rates with current de-colonization strategies. There was no statistical difference among demographics between patients treated with and without the peri-operative cranioplasty bundle. The lengths of stay for the cranioplasty without and with the bundle were 5.5 days and 7.4 days, respectively.

Of the patients without the bundle, 57% had their own bone flap replaced, 24% had methyl methacrylate, and the remainder had titanium or Biomet microfixation. Of the patients with a bundle, 72% had their own bone flap replaced ($p=0.068$), 5.6% had methyl methacrylate, and the remainder had titanium, polymethyl methacrylate, Biomet microfixation, or porex. Neurosurgical data are listed in Table 2, and no statistical differences between the groups were observed. As listed in Fig. 1, surgical complications (SSI, wound dehiscence, and re-do cranioplasty) and non-surgical complications (hydrocephalus and seizures) were recorded. The total surgical complication rate was 22.8%. SSI occurred in 5 (23.8%) patients in the group without the bundle vs. 1 (2.8%) patient in the group with the bundle ($p=0.0217$). The microbiology data were collected for SSI complicating cranioplasties. Wounds grew out methicillin-resistant *Staphylococcus aureus* (MRSA) (4), methicillin-sensitive *S. aureus* (MSSA) (1), *Escherichia coli* (*E. coli*) (1), and *Propionibacterium acnes* (1). One patient grew out both MSSA and *E. coli*.

4. Discussion

As previously reported, cranioplasty is associated with a high complication rate, including surgical complications (SSI, wound dehiscence, and re-do cranioplasty) and non-surgical complications (hydrocephalus and seizures). The goal of this study was to analyze the effects of a peri-operative bundle on surgical complications. Bundles have been shown to reduce complication rates in other surgeries [11,17,22]. In our study, the peri-operative bundle significantly reduced SSI and re-do cranioplasty rates but did not affect the rates of non-surgical complications such as seizures and hydrocephalus (Fig. 1). Due to the reduced SSI rates, the reduction in re-do cranioplasties contributed to the non-statistical reduction in the implantation of custom prosthetic flaps in the bundle group.

This study has limitations. It was not randomized and relied on a cross-over model. Although MRSA has reached a proportion of