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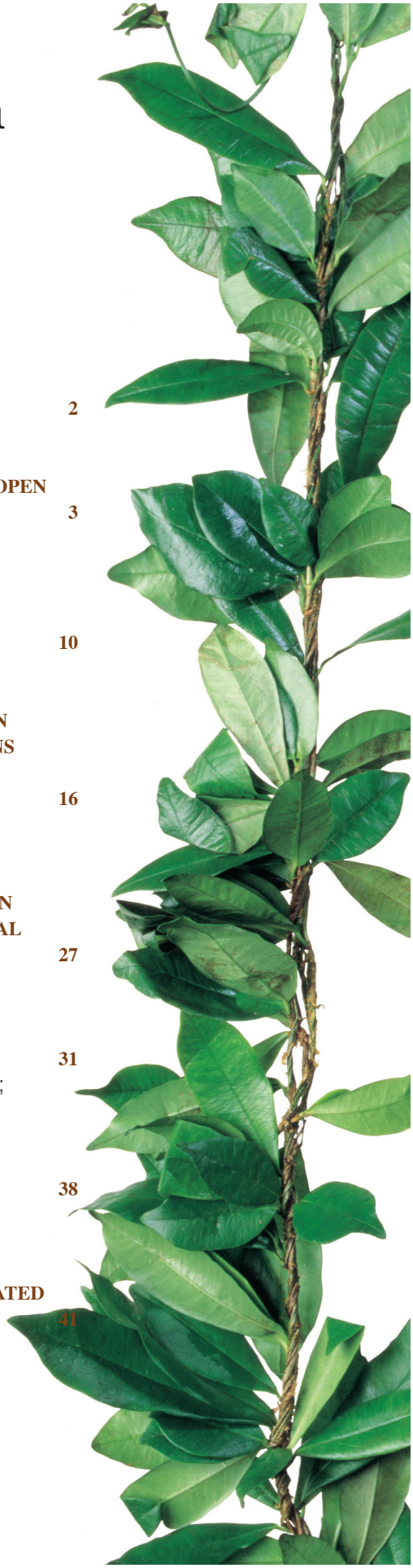

Guest Editors' Message: Original Research from the Department of Surgery

We extend a warm welcome to the readers of the Hawai'i Journal of Health and Social Welfare. This supplemental issue includes original clinical research and case reports authored by medical students and resident physicians from the Department of Surgery of the University of Hawai'i, John A. Burns School of Medicine. The articles in this issue encompass a broad range of surgical specialties and topics including trauma surgery, pediatric surgery, general surgery, endocrine surgery, and ophthalmology. These articles were selected from an array of research presented at the 2020 Hawai'i Chapter of the American College of Surgeons Resident Research Competition.

Our special thanks go out to the many authors and reviewers who contributed to this supplemental issue. In addition, we want to thank Ms. Lori Bland and Mr. Gary Belcher for their tireless support. Lastly, we want to thank Dr. Kenric Murayama for his leadership and vision towards growing a culture of scholarship and discovery in our department. We hope you enjoy this issue.

Aloha,
Stacey Woodruff and Russell Woo

Predictors and Consequences of Unplanned Conversion to Open During Robotic Colectomy: An ACS-NSQIP Database Analysis

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Abstract

Robotic-assisted surgery has become a desired modality for performing colectomy; however, unplanned conversion to an open procedure may be associated with worse outcomes. The purpose of this study is to examine predictors and consequences of unplanned conversion to open in a large, high fidelity data set. A retrospective analysis of 11 061 robotic colectomies was conducted using the American College of Surgeons - National Surgical Quality Improvement Program (ACS-NSQIP) 2012–2017 database. Predictors of conversion and the effect of conversion on outcomes were analyzed by multivariate logistic regression resulting in risk-adjusted odds ratios of conversion and morbidity/mortality. Overall, 10 372 (93.8%) patients underwent successful robotic colectomy, and 689 (6.2%) had an unplanned conversion. Predictors of conversion included age ≥ 65 years, male gender, obesity, functional status not independent, American Society of Anesthesia (ASA) classification IV-V, non-oncologic indication, emergency case, smoking, recent weight loss, bleeding disorder, and preoperative organ space infection. Conversion is an independent risk factor for mortality, overall morbidity, cardiac morbidity, pulmonary morbidity, renal morbidity, venous thromboembolism morbidity, wound morbidity, sepsis, bleeding, readmission, return to the operating room, and extended length of stay (LOS). Unplanned conversion to open during robotic colectomy is an independent predictor of morbidity and mortality.

Keywords

robotic, unplanned, conversion, predictors, colectomy, colorectal

Abbreviations and Acronyms

ACS = American College of Surgeons
AIC = Akaike Information Criterion
ASA = American Society of Anesthesia
BMI = body mass index
COPD = chronic obstructive pulmonary disease
CHF = congestive heart failure
CI = confidence interval
INR = international normalized ratio
LOS = length of stay
NSQIP = National Surgical Quality Improvement Program
OR = odds ratio
ROLARR = robotic vs laparoscopic resection for rectal cancer trial
SSI = surgical site infection
UTI = urinary tract infection
VTE = venous thromboembolism

Introduction

Colectomy is one of the most common general surgery procedures in the United States.[1,2] Since the introduction of laparoscopic colectomy in 1991,[3,4] many studies have shown equivalent or better postoperative and survival outcomes when compared to open procedures.[2,5,6] Laparoscopy is associated with lower morbidity and mortality and a shorter length of hospital stay when compared to open.[6] There are several reported advantages robotic colectomy has over laparoscopic colectomy, including greater control, precision, ergonomics, three-dimensional visualization, endo-wrist maneuverability, and tremor filtering.[2,5,7,8] Because of these advantages, a robotic approach can aid complex procedures.[9] Robotic surgery utilization is rapidly increasing.[10,11]

Unplanned conversion to open during laparoscopic surgery is associated with worse outcomes, including increased operative blood loss, anastomotic leak rate, reoperation, length of hospital stay, and oncologic outcomes.[4,12,13] Further, unplanned conversion causes increased postsurgical complications, such as intra-abdominal abscess, prolonged ileus, and wound infection.[14] Allaix et al reported tumor-related aspects as the most frequent reason for conversion.[13] Recent literature also suggests similar findings of worse outcomes in unplanned conversion to open during robotic surgery.[15]

The risk factors for unplanned conversion to open are essential information surgeons need to guide their decision-making. The purpose of this study is to examine predictors of unplanned robotic conversion to open. Additionally, the purpose of this study is to compare the influence of unplanned robotic conversion on patient outcomes versus successful robotic completed approaches and planned open approaches.

Materials and Methods

Data Source

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a nationwide quality improvement initiative based on high fidelity, professionally curated data. The ACS-NSQIP database contains over 150 data points regarding patient demographics, indications, preoperative comorbidities, laboratory values, and 30-day outcomes on a procedure level basis. The ACS-NSQIP targeted procedure – colectomy database, first released in 2012, contains an additional set of colectomy-specific data points, such as operative approach and tumor characteristics for colon cancer cases. This study was exempt from Institutional Review Board approval as the data contained no patient identifying information.

Patient Selection

A total of 11 060 colectomies conducted via a robotic approach and 63 300 colectomies conducted via a planned open approach during 2013 and 2017 were included. Robotic cases were defined as cases with a value of "Robotic," "Robotic with open assist," and "Robotic with unplanned conversion to open" for the COL_APPROACH data point found in the targeted procedure database. Planned open cases were defined as cases with a value of "Open (planned)." The COL_APPROACH data point was first reported in the 2012 database, but only 1 robotic case was reported that year; thus, the year 2012 was excluded.

Predictor Variables

Patient demographics, indication/operative conditions, preoperative comorbidities, and laboratory values were analyzed as predictor variables. Demographic variables included persons aged ≥65 years, sex, race (eg, White, Black, and Other), and obesity (body mass index [BMI] ≥35 kg/m^2), functional status (independent or not independent), and American Society of Anesthesiologists (ASA) classification (ASA I-II, ASA III, or ASA IV-V). Indications/operative conditions were categorized by oncologic case (non-oncologic or oncologic), and emergency status (emergency, non-emergency). An oncologic case was any colectomy with an indication of colon cancer or colon polyp. Preoperative comorbidities included in the analysis were congestive heart failure (CHF), hypertension, smoking within the past 1 year, dyspnea within the past 30 days, chronic obstructive pulmonary disease (COPD), dialysis, urinary tract infection (UTI), weight loss >10% within the past 6 months, disseminated cancer, history of chemotherapy treatment, bleeding disorder, preoperative transfusion (<72 hours before surgery), non-organ space soft tissue infection (STI) or open wound, organ space STI, preoperative sepsis or septic shock, diabetes, and steroid or immunosuppressive therapy within the past 30 days. Laboratory values analyzed were hypoalbuminemia (albumin <3.5 g/dL), hyperbilirubinemia (bilirubin >1.2 mg/dL), elevated creatinine (creatinine >1.2 mg/dL [male] or 1.1 mg/dL [female]), anemia (hematocrit <30%), elevated international normalized ratio (INR >1.4), thrombocytopenia (platelet <100 000 /mL), and leukocytosis (white blood cell >11 000/mL). Several other preoperative comorbidities are captured in the ACS-NSQIP database but were excluded from this analysis because of a low number of occurrences. Comorbidities excluded from analysis were ventilator requirement within the past 48 hours, pneumonia, renal failure, ascites, dialysis, and UTI. Wound class was excluded because it is not strictly a preoperative predictor.

Outcome Variables

All outcomes reported in the ACS-NSQIP database are 30-day outcomes; thus, all outcomes analyzed in this study were 30-day outcomes. Outcomes analyzed were mortality, overall morbidity, organ system-specific morbidity (neurologic, cardiac, pulmonary, renal, VTE, and wound), sepsis/septic shock, bleeding requiring transfusion, readmission, return to the operating room, and length of hospital stay (LOS) greater than the median. Overall morbidity was defined as the presence of 1or more major postoperative complication. Neurologic morbidity was defined as 1 or more occurrence of stroke. Cardiac morbidity was defined as 1 or more occurrence of cardiac arrest or myocardial infarction (MI). Pulmonary morbidity was defined as 1 or more occurrence of postoperative pneumonia, ventilator requirement >48 hours post-operation, or reintubation. Renal morbidity was defined as one or more occurrence of renal failure or renal insufficiency. VTE morbidity was defined as 1 or more occurrence of deep vein thrombosis (DVT) or pulmonary embolism (PE). Wound morbidity was defined as one or more occurrence of superficial surgical site infection (SSI), deep SSI, organ space SSI, or wound dehiscence.

Statistical Analysis

Bivariate analysis of the distribution of predictor variables by approach and the distribution outcome variables by approach was conducted using Chi-square tests. Multivariate analysis of outcomes was conducted by multivariate logistic regression using models constructed by forward/backward stepwise minimization of Akaike Information Criterion (AIC), starting with fully saturated models and setting the minimum model to include approach as a predictor regardless of the impact on AIC. This resulted in a risk-adjusted odds ratio (OR) and corresponding 95% confidence interval (95% CI) of the analyzed outcome given the specified approach relative to the specified reference approach. This analysis was conducted for the robotic cohort only to calculate the predictors of unplanned conversion to open and the consequences of unplanned conversion to open. This analysis was performed on the unplanned conversion to open combined with the planned open cohorts to calculate the effect of unplanned conversion to open approach relative to planned open approach on outcomes. Statistical significance was assigned to a P value <.05 for bivariate analysis. For multivariate analysis, statistical significance was assigned to risk-adjusted OR whose 95% CI did not include 1. P values are reported for the multivariate analysis to illustrate the importance of each variable to the final model. Statistical analysis was performed using R version 3.5.1.

ACS-NSQIP Disclosure Statement

Hospitals participating in the ACS-NSQIP are the source of the data used in this study; however, the hospitals have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Results

Predictors of Unplanned Conversion to Open

The predictors of unplanned conversion to open during robotic colectomy are presented in Table 1. The 3 strongest predictors are emergency case (OR, 3.45; 95% CI, 1.31-8.11; *P* = .0070), organ space SSI (OR, 2.27; 95% CI, 1.14-5.77; *P* = .0140), and functional status not independent (OR, 2.26; 95% CI, 1.29-3.75; *P* = .0026). Other patient demographic predictors of unplanned conversion to open are persons aged ≥ 65 years (OR, 1.31; 95% CI, 1.11-1.56; *P* = .0019), male (OR, 1.36; 95% CI, 1.16-1.60;

Table 1. Predictors of Unplanned Conversion To Open During Robotic Colectomy

Preoperative Variable	Bivariate Analysis				Multivariate Analysis	
	All n (%)	Successful n (%)	Converted n (%)	*P* value	Adjusted OR of Conversion (95% CI)	*P* value
Total	11 061 (100.0)	10 372 (93.8)	689 (6.2)	-	-	-
Age ≥ 65 years	4453 (40.26%)	4147 (39.98%)	306 (44.41%)	.0217*	**1.31 (1.11-1.56)**	**.0019***
Male	5561 (50.28%)	5176 (49.90%)	385 (55.88%)	.0024*	**1.36 (1.16-1.60)**	**.0002***
Race						
White	9127 (82.52%)	8569 (82.62%)	558 (80.99%)	.4570	-	-
Black	941 (8.51%)	874 (8.43%)	67 (9.72%)		-	-
Other	993 (8.98%)	929 (8.96%)	64 (9.29%)		-	-
Obese (BMI ≥ 30 kg/m^2)	4341 (39.25%)	4005 (38.61%)	336 (48.77%)	1.26E-07*	**1.60 (1.36-1.88)**	**9.60E-09***
Functional status not independent	114 (1.03%)	95 (0.92%)	19 (2.76%)	3.57E-06*	**2.26 (1.29-3.75)**	**.0026***
ASA Classification I-II	5573 (50.38%)	5272 (50.83%)	301 (43.69%)	1.45E-06*	-	-
ASA Classification III	5212 (47.12%)	4858 (46.84%)	354 (51.38%)		1.10 (0.93-1.31)	.2764
ASA Classification IV-V	276 (2.50%)	242 (2.33%)	34 (4.93%)		**1.73 (1.13-2.60)**	**.0094***
Non-oncologic indication	6995 (63.24%)	6626 (63.88%)	369 (53.56%)	5.19E-08*	**1.68 (1.42-2.00)**	**3.84E-09***
Emergency case	27 (0.24%)	20 (0.19%)	7 (1.02%)	2.24E-05*	**3.45 (1.31-8.11)**	**.0070***
CHF within 30 days	49 (0.44%)	47 (0.45%)	2 (0.29%)	.5330	0.37 (0.06-1.24)	.1765
Hypertension requiring treatment	5316 (48.06%)	4947 (47.70%)	369 (53.56%)	.0029*	-	-
Smoke cigarettes within 1 year	1732 (15.66%)	1591 (15.34%)	141 (20.46%)	.0003*	**1.40 (1.14-1.71)**	**.0011***
Dyspnea within 30 days	568 (5.14%)	524 (5.05%)	44 (6.39%)	.1245	-	-
COPD	426 (3.85%)	383 (3.69%)	43 (6.24%)	.0008*	1.29 (0.90-1.81)	.1454
Dialysis	39 (0.35%)	35 (0.34%)	4 (0.58%)	.2972	-	-
UTI	16 (0.14%)	14 (0.13%)	2 (0.29%)	.2990	-	-
Weight loss > 10% in last 6 months	259 (2.34%)	229 (2.21%)	30 (4.35%)	.0003*	**1.74 (1.14-2.58)**	**.0073***
Disseminated cancer	416 (3.76%)	385 (3.71%)	31 (4.50%)	.2928	-	-
Received chemotherapy	1312 (11.86%)	1234 (11.90%)	78 (11.32%)	.6503	1.24 (0.95-1.60)	.1113
Bleeding disorder	240 (2.17%)	210 (2.02%)	30 (4.35%)	4.82E-05*	**1.81 (1.18-2.67)**	**.0043***
Preoperative transfusion (< 72 hours before surgery)	57 (0.52%)	51 (0.49%)	6 (0.87%)	.1783	-	-
Non organ space STI/Wound	61 (0.55%)	54 (0.52%)	7 (1.02%)	.0891	-	-
Organ Space SSI	38 (0.34%)	30 (0.29%)	8 (1.16%)	.0002*	**2.72 (1.14-5.77)**	**.0140***
Sepsis or septic shock	49 (0.44%)	40 (0.39%)	9 (1.31%)	.0004*	-	-
Diabetes	1716 (15.51%)	1601 (15.44%)	115 (16.69%)	.3782	-	-
Steroid or immunosuppressive therapy within 30 days	532 (4.81%)	484 (4.67%)	48 (6.97%)	.0063*	-	-
Albumin < 3.5 g/dL	1056 (9.55%)	945 (9.11%)	111 (16.11%)	1.41E-09*	**1.54 (1.22-1.92)**	**.0002***
Bilirubin > 1.2 mg/dL	279 (2.52%)	257 (2.48%)	22 (3.19%)	.2463	-	-
Creatinine > 1.2 (M) or > 1.1 (F) mg/dL	1053 (9.52%)	964 (9.29%)	89 (12.92%)	.0017*	-	-
Hematocrit < 30%	477 (4.31%)	436 (4.20%)	41 (5.95%)	.0288*	-	-
INR > 1.4	95 (0.86%)	84 (0.81%)	11 (1.60%)	.0302*	-	-
Platelet < 100,000 /µL	64 (0.58%)	58 (0.56%)	6 (0.87%)	.2963	-	-
WBC > 11,000 /µL	606 (5.48%)	541 (5.22%)	65 (9.43%)	2.46E-06*	**1.53 (1.15-2.01)**	**.0030***

P =.0002), obese (OR, 1.60; 95% CI, 1.36-1.88; P <.0001), and ASA classification IV-V (OR, 1.73; 95% CI, 1.13-2.60; P = .0094). Non-oncologic indication, such as diverticulitis or volvulus, is a predictor of unplanned conversion to open (OR, 1.68; 95% CI, 1.42-2.00; P < .0001). Comorbidities that predict unplanned conversion to open are smoking within 1 year of operation (OR, 1.40; 95% CI, 1.14-1.71; P = .0011), weight loss > 10% within the last 6 months (OR, 1.74; 95% CI, 1.14-2.58; P = .0073), and bleeding disorder (OR, 1.81; 95% CI, 1.18-2.67; P = .0043). Laboratory predictors of unplanned conversion to open were hypoalbuminemia (OR, 1.54; 95% CI, 1.22-1.92; P =. 0002) and leukocytosis (OR, 1.53; 95% CI, 1.15-2.01; P = .0030).

Consequences of Unplanned Conversion to Open

The consequences of unplanned conversion to open are presented in Table 2. Unplanned conversion to open is an independent risk factor for all adverse outcomes analyzed except stroke. Notably, unplanned conversion to open is a strong independent risk factor for mortality (OR, 6.10; 95% CI, 3.16-11.33; P < .0001) and overall morbidity (OR, 3.02; 95% CI, 2.52-3.60; P < .0001).

Outcomes of Unplanned Conversion to Open Approach Versus Planned Open Approach

Comparison of outcomes between unplanned conversion to open approach versus planned open approach is presented in Table 3. Compared to patients undergoing a planned open colectomy, patients who had an unplanned conversion from robotic to open colectomy had a risk-adjusted higher rate of overall morbidity (OR, 1.23; 95% CI, 1.04-1.46; P = .0139), renal failure or insufficiency (OR, 2.00; 95% CI, 1.26-3.03; P = .0018), venous thromboembolism (DVT or PE; OR, 1.69; 95% CI, 1.10-2.48; P = .0115), sepsis or septic shock (OR, 1.40; 95% CI, 1.05-1.84; P = .0177), and bleeding requiring transfusion (OR, 1.38; 95% CI, 1.08-1.74; P = .0092). Compared to patients undergoing a planned open colectomy, patients who had an unplanned conversion from robotic to open colectomy had a risk-adjusted lower rate of length of stay greater than the median of 7 days (OR, 0.82; 95% CI, 0.69-0.97; P = .0204).

Table 2. Consequences of Unplanned Conversion To Open for Patients Undergoing Robotic Colectomy

Morbidity/Mortality	Bivariate Analysis				Multivariate Analysis	
	All	Successful	Converted	*P* value	Adjusted OR of M&M for Patients Converted (95% CI)	*P* value
Total	11 061 (100.0)	10 372 (93.8)	689 (6.2)	-	-	-
Mortality	**51 (0.46%)**	**35 (0.34%)**	**16 (2.32%)**	**9.57E-14***	**6.10 (3.16-11.33)**	**2.36E-08***
Overall morbidity	**1559 (14.09%)**	**1334 (12.86%)**	**225 (32.66%)**	**0.00E00***	**3.02 (2.52-3.60)**	**4.90E-34***
Stroke	14 (0.13%)	12 (0.12%)	2 (0.29%)	.2120	1.86 (0.28-7.03)	.4265
Cardiac (Arrest or MI)	**72 (0.65%)**	**61 (0.59%)**	**11 (1.60%)**	**.0014***	**2.34 (1.15-4.35)**	**.0116***
Pulmonary (Pneumonia, Ventilator > 48 hours, or Reintubation)	**192 (1.74%)**	**151 (1.46%)**	**41 (5.95%)**	**0.00E00***	**3.38 (2.30-4.86)**	**1.81E-10***
Renal failure or insufficiency	**120 (1.08%)**	**98 (0.94%)**	**22 (3.19%)**	**3.46E-08***	**2.99 (1.79-4.78)**	**1.06E-05***
VTE (DVT or PE)	**128 (1.16%)**	**103 (0.99%)**	**25 (3.63%)**	**3.77E-10***	**3.53 (2.21-5.42)**	**3.16E-08***
Wound (Superficial SSI, Deep SSI, Organ Space SSI, or Dehiscence)	**735 (6.64%)**	**622 (6.00%)**	**113 (16.40%)**	**0.00E00***	**2.82 (2.25-3.51)**	**8.56E-20***
Sepsis or septic shock	**291 (2.63%)**	**233 (2.25%)**	**58 (8.42%)**	**0.00E00***	**3.30 (2.37-4.52)**	**4.27E-13***
Bleeding requiring transfusion	**467 (4.22%)**	**379 (3.65%)**	**88 (12.77%)**	**0.00E00***	**3.98 (3.01-5.22)**	**9.14E-23***
Readmission	**992 (8.97%)**	**891 (8.59%)**	**101 (14.66%)**	**6.72E-08***	**1.69 (1.33-2.11)**	**8.28E-06***
Return to operating room	**506 (4.57%)**	**455 (4.39%)**	**51 (7.40%)**	**.0002***	**1.60 (1.17-2.16)**	**.0026***
LOS > Median (4 days)	**3445 (31.15%)**	**2973 (28.66%)**	**472 (68.51%)**	**.00E00***	**5.24 (4.41-6.24)**	**4.19E-78***

Table 3. Outcomes of Unplanned Conversion to Open Approach versus Planned Open Approach						
Morbidity/Mortality	**Bivariate Analysis**				**Multivariate Analysis**	
	All	**Open**	**Converted**	***P* value**	**Adjusted OR of M&M for Patients Converted vs Planned Open (95% CI)**	***P* value**
Total	63 989 (100.0)	63 300 (98.9)	689 (1.1)	-	-	-
Mortality	**3953 (6.18%)**	**3937 (6.22%)**	**16 (2.32%)**	**2.37E-05***	1.56 (0.89-2.55)	.0946
Overall morbidity	**28 385 (44.36%)**	**28 160 (44.49%)**	**225 (32.66%)**	**5.07E-10***	**1.23 (1.04-1.46)**	**.0139***
Stroke	354 (0.55%)	352 (0.56%)	2 (0.29%)	.3495	1.12 (0.18-3.54)	.8713
Cardiac (Arrest or MI)	**1816 (2.84%)**	**1805 (2.85%)**	**11 (1.60%)**	**.0485***	1.26 (0.65-2.20)	.4487
Pulmonary (Pneumonia, Ventilator >48 hours, or Reintubation)	**7904 (12.35%)**	**7863 (12.42%)**	**41 (5.95%)**	**2.83E-07***	1.37 (0.98-1.88)	.0575
Renal failure or insufficiency	1869 (2.92%)	1847 (2.92%)	22 (3.19%)	.6696	**2.00 (1.26-3.03)**	**.0018***
VTE (DVT or PE)	2224 (3.48%)	2199 (3.47%)	25 (3.63%)	.8257	**1.69 (1.10-2.48)**	**.0115***
Wound (Superficial SSI, Deep SSI, Organ Space SSI, or Dehiscence)	10 871 (16.99%)	10 758 (17.00%)	113 (16.40%)	.6793	1.15 (0.93-1.40)	.1939
Sepsis or septic shock	**11 401 (17.82%)**	**11 343 (17.92%)**	**58 (8.42%)**	**9.03E-11***	**1.40 (1.05-1.84)**	**.0177***
Bleeding requiring transfusion	**12 463 (19.48%)**	**12 375 (19.55%)**	**88 (12.77%)**	**7.89E-06***	**1.38 (1.08-1.74)**	**.0092***
Readmission	7935 (12.40%)	7834 (12.38%)	101 (14.66%)	.0706	1.22 (0.98-1.50)	.0710
Return to operating room	4737 (7.40%)	4686 (7.40%)	51 (7.40%)	.9994	1.34 (0.99-1.78)	.0457*
LOS > Median (7 days)	**29 354 (45.87%)**	**29 153 (46.06%)**	**201 (29.17%)**	**0.00E00***	**0.82 (0.69-0.97)**	**.0204***

Discussion

This investigation of a large protocol-driven national database shows that when comparing successful robotic completed surgery to unplanned conversion from robotic to open surgery, much worse outcomes in terms of mortality and 30-day morbidity occur. Significantly higher complications in the unplanned conversion to open group include cardiac, pulmonary, and renal complications, venous thromboembolism, wound infection rate, sepsis or septic shock, bleeding requiring transfusion, readmission, return to the operating room, and length of stay. Other categories of complications showed non-significant differences.

This study shows that when comparing the planned open surgery group to the unplanned conversion to open group, the conversion group had worse outcomes in terms of 30-day morbidity. There was, however, no difference in mortality. Interestingly, the planned open group on univariate analysis had worse outcomes, including mortality, overall morbidity, cardiac arrest, pulmonary complications, sepsis or septic shock, and bleeding requiring transfusion. However, on multivariate analysis, there was no significant difference in mortality, and the unplanned conversion to open group had worse outcomes for overall morbidity, renal complications, VTE, sepsis or septic shock, and bleeding requiring transfusion. These findings may reflect that the planned open group included patients in poor health; when this was accounted for in the multivariate analysis, the unplanned conversion to open group had worse outcomes. In multivariate analysis, only hospital LOS was shorter in the unplanned conversion to open group. The other categories showed non-significant differences.

Studies of colorectal surgery have shown that minimally invasive surgery has similar oncologic outcomes to open surgery for colorectal surgery.[16-20] A recent report by Justiniano et al revealed decreased hospital utilization compared to open surgery,[22] and Huerta et al showed that operating times can become equivalent to laparoscopic times after completing the learning curve (90 cases for robotic novice, 20 cases for robotic expert).[23]

A number of retrospective, prospective cohort, and meta-analyses show that robotic surgery has a lower conversion to open rate with similar or better complication rates compared to laparoscopic and open surgical approaches.[16,18,24-37] Of note, the largest randomized robotic versus laparoscopic trial, the robotic vs laparoscopic resection for rectal cancer (ROLARR) trial, failed to show a difference in unplanned conversion to open between laparoscopic and robotic surgeries.[21] However, later analysis suggested that when correcting for operator experience, the conversion rate in robotic surgery may have been higher due to surgeon inexperience.[38] Additionally, multiple randomized controlled trials demonstrate that robotic surgeries confer decreased risk of converting to open surgeries than the laparoscopic approach.[39,40]

Unplanned conversion to open procedures has been shown to have worse outcomes, including increased hospital length of stay and unplanned readmission associated with decreased overall survival.[18] Complications associated with conversion included ileus, surgical site infection, and postoperative blood transfusion.[41,42]

A study by Lee et al using the same NSQIP data set used in this study over a shorter period corroborates our results that unplanned conversion to open has worse outcomes than robotic completed surgeries.[15] However, they concluded no difference between unplanned robotic converted to open and planned open. Instead, our data suggest that when controlling for patient factors in the multivariate analysis, robotic conversion to open has worse outcomes than planned open in several categories. Lee et al performed a subgroup analysis dividing groups into colon resection and rectal resection and found no significant differences in the colon resection group but significant differences in the rectal resection group.

In a meta-analysis, specific reasons for unplanned conversion included adhesions, bleeding, local tumor invasion, surgeon inexperience, hollow viscus ischemia, bowel perforation, body habitus (body wall obesity, and visceral obesity, narrow pelvis).[35] A number of preoperative factors shown to increase the risk of unplanned conversion to open include moderate-severe adhesions, coronary artery disease, diabetes, increased ASA class, and surgeon inexperience.[43] In this study, predictors of unplanned conversion were split into 3 categories: (1) high case acuity (eg, emergency, organ space infection, non-oncologic indication, leukocytosis), (2) poor baseline health (eg, functional status not independent, recent weight loss, ASA IV-V, hypoalbuminemia, smoking, $\geq$ 65 years), and (3) technical difficulty (eg, bleeding disorder, obesity, being male).

This study has several limitations. Causal inference cannot be made due to the retrospective observational nature of this study and database completeness issues. Significant predictors were not captured in this database, including surgeon and institutional experience, selection bias affecting operative approaches, robotic platform used (Si, Xi), alternative approaches considered/available, type of anastomosis, location of the pathology, variation in intraoperative anatomy (eg, adhesions, previous surgical history), and perioperative medical care (eg, ERAS protocol). Moreover, unmeasured baseline patient characteristics not captured in this data set may have influenced the rate of conversion and patient outcomes. Finally, the relatively small size of the robotic converted to open cohort may magnify the observed effects of conversion but not reflect clinically relevant differences.

In conclusion, other studies show robotic colorectal surgery is a reasonable alternative to laparoscopic and open surgery, especially when operating in the pelvis. The literature shows that robotic surgery has lower rates of unplanned conversion to open and is similar to better outcomes. However, our study shows unplanned robotic conversion to open portends poorer outcomes than robotic completed and planned open surgeries. Therefore, in high-risk patients, careful consideration of surgical approach, and a thorough discussion of the risks and benefits of the surgical approach options, must be held with patients.

Conflict of Interest

None of the authors identify a conflict of interest.

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"The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors."

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References

1. Wakeam E, Molina G, Shah N, et al. Variation in the cost of 5 common operations in the United States. *Surgery*. 2017;162(3):592-604. doi:10.1016/j.surg.2017.04.016
2. Lorenzon L, Bini F, Balducci G, Ferri M, Salvi PF, Marinozzi F. Laparoscopic versus robotic-assisted colectomy and rectal resection: a systematic review and meta-analysis. *Int J Colorectal Dis*. 2016;31(2):161-173. doi:10.1007/s00384-015-2394-4
3. Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc*. 1991;1(3):144-150.
4. Feigel A, Sylla P. Role of Minimally invasive surgery in the reoperative abdomen or pelvis. *Clin Colon Rectal Surg*. 2016;29(2):168-180. doi:10.1055/s-0036-1580637
5. Papanikolaou IG. Robotic surgery for colorectal cancer: Systematic review of the literature. *Surg Laparosc Endosc Percutaneous Tech*. 2014;24(6):478-483. doi:10.1097/SLE.0000000000000076
6. Batista Rodríguez G, Balla A, Corradetti S, et al. What have we learned in minimally invasive colorectal surgery from NSQIP and NIS large databases? A systematic review. *Int J Colorectal Dis*. 2018;33(6):663-681. doi:10.1007/s00384-018-3036-4
7. Gkegkes ID, Mamais IA, Iavazzo C. Robotics in general surgery: A systematic cost assessment. *J Minim Access Surg*. 2017;13(4):243-255. doi:10.4103/0972-9941.195565
8. Vasudevan V, Reusche R, Wallace H, Kaza S. Clinical outcomes and cost–benefit analysis comparing laparoscopic and robotic colorectal surgeries. *Surg Endosc*. 2016;30(12):5490-5493. doi:10.1007/s00464-016-4910-1
9. Sugerman DT. Robotic surgery. *JAMA*. 2013;310(10):1086. doi:10.1001/jama.2013.75621
10. Wright JD, Tergas AI, Hou JY, et al. Effect of regional hospital competition and hospital financial status on the use of robotic-assisted surgery. *JAMA Surg*. 2016;151(7):612-620. doi:10.1001/jamasurg.2015.5508
11. Bertani E, Chiappa A, Ubiali P, Cossu ML, Arnone P, Andreoni B. Robotic colectomy: is it necessary? *Minerva Chir*. 2013;68(5):445-456.
12. Duraes L de C, Steele SR, Camargo MGM de, et al. Conversion to open from laparoscopic colon resection is a marker for worse oncologic outcomes in colon cancer. *Am J Surg*. 2019;217(3):491-495. doi:10.1016/j.amjsurg.2018.10.042
13. Allaix ME, Furnée EJB, Mistrangelo M, Arezzo A, Morino M. Conversion of laparoscopic colorectal resection for cancer: What is the impact on short-term outcomes and survival? *World J Gastroenterol*. 2016;22(37):8304-8313. doi:10.3748/wjg.v22.i37.8304
14. Moghadamyeghaneh Z, Masoomi H, Mills SD, *et al*. Outcomes of conversion of laparoscopic colorectal surgery to open surgery. *J Soc Laparoendosc Surg*. 2015;18(4). doi:10.4293/JSLS.2014.00230
15. Lee YF, Albright J, Akram WM, Wu J, Ferraro J, Cleary RK. Unplanned robotic-assisted conversion-to-open colorectal surgery is associated with adverse outcomes. *J Gastrointest Surg*. 2018;22(6):1059-1067. doi:10.1007/s11605-018-3706-0
16. Garfinkle R, Abou-Khalil M, Bhatnagar S, *et al*. A comparison of pathologic outcomes of open, laparoscopic, and robotic resections for rectal cancer using the ACS-NSQIP Proctectomy-Targeted Database: a propensity score analysis. *J Gastrointest Surg*. 2019;23(2):348-356. doi:10.1007/s11605-018-3974-8
17. Chapman BC, Edgcomb M, Gleisner A, Vogel JD. Outcomes in rectal cancer patients undergoing laparoscopic or robotic low anterior resection compared to open: a propensity-matched analysis of the NCDB (2010–2015). *Surg Endosc*. Published online 2019. doi:10.1007/s00464-019-07252-5

18. Hyde LZ, Baser O, Mehendale S, Guo D, Shah M, Kiran RP. Impact of surgical approach on short-term oncological outcomes and recovery following low anterior resection for rectal cancer. *Color Dis*. 2019;21(8):932-942. doi:10.1111/codi.14677
19. Jayne DG, Guillou PJ, Thorpe H, et al. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-Year results of the UK MRC CLASICC trial group. *J Clin Oncol*. 2007;25(21):3061-3068. doi:10.1200/JCO.2006.09.7758
20. Green BL, Marshall HC, Collinson F, et al. Long-term follow-up of the Medical Research Council CLASICC trial of conventional versus laparoscopically assisted resection in colorectal cancer. *Br J Surg*. 2013;100(1):75-82. doi:10.1002/bjs.8945
21. Jayne D, Pigazzi A, Marshall H, et al. Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer the ROLARR randomized clinical trial. *JAMA*. 2017;318(16):1569-1580. doi:10.1001/jama.2017.7219
22. Justiniano CF, Becerra AZ, Xu Z, et al. A population-based study of 90-day hospital cost and utilization associated with robotic surgery in colon and rectal cancer. *J Surg Res*. 2020;245(301):136-144. doi:10.1016/j.jss.2019.07.052
23. Huerta S, Meier J, Emuakhagbon VS, et al. A comparative analysis of outcomes of open, laparoscopic, and robotic elective (procto-) colectomies for benign and malignant disease. *J Robot Surg*. 2020;(0123456789). doi:10.1007/s11701-020-01069-4
24. Raskin ER, Keller DS, Gorrepati ML, Akiel-Fu S, Mehendale S, Cleary RK. Propensity-matched analysis of sigmoidectomies for diverticular disease. *J Soc Laparoendosc Surg*. 2019;23(1). doi:10.4293/JSLS.2018.00073
25. Dolejs SC, Waters JA, Ceppa EP, Zarzaur BL. Laparoscopic versus robotic colectomy: a national surgical quality improvement project analysis. *Surg Endosc*. 2017;31(6):2387-2396. doi:10.1007/s00464-016-5239-5
26. Tam MS, Kaoutzanis C, Mullard AJ, et al. A population-based study comparing laparoscopic and robotic outcomes in colorectal surgery. *Surg Endosc*. 2016;30(2):455-463. doi:10.1007/s00464-015-4218-6
27. Halabi WJ, Kang CY, Jafari MD, et al. Robotic-assisted colorectal surgery in the United States: A nationwide analysis of trends and outcomes. *World J Surg*. 2013;37(12):2782-2790. doi:10.1007/s00268-013-2024-7
28. Spinoglio G, Bianchi PP, Marano A, et al. Robotic versus laparoscopic right colectomy with complete mesocolic excision for the treatment of colon cancer: perioperative outcomes and 5-year survival in a consecutive series of 202 patients. *Ann Surg Oncol*. 2018;25(12):3580-3586. doi:10.1245/s10434-018-6752-7
29. Holmer C, Kreis ME. Systematic review of robotic low anterior resection for rectal cancer. *Surg Endosc*. 2018;32(2):569-581. doi:10.1007/s00464-017-5978-y
30. Asklid D, Gerjy R, Hjern F, Pekkari K, Gustafsson UO. Robotic vs laparoscopic rectal tumour surgery: a cohort study. *Color Dis*. 2019;21(2):191-199. doi:10.1111/codi.14475
31. Waters PS, Cheung FP, Peacock O, et al. Successful patient-oriented surgical outcomes in robotic vs laparoscopic right hemicolectomy for cancer – a systematic review. *Color Dis*. Published online 2019:488-499. doi:10.1111/codi.14822
32. Crippa J, Grass F, Dozois EJ, et al. robotic surgery for rectal cancer provides advantageous outcomes over laparoscopic approach. *Ann Surg*. 2020;XX(Xx):1. doi:10.1097/sla.0000000000003805
33. Ahmed J, Cao H, Panteleimonitis S, Khan J, Parvaiz A. Robotic vs laparoscopic rectal surgery in high-risk patients. *Color Dis*. 2017;19(12):1092-1099. doi:10.1111/codi.13783
34. Cui Y, Li C, Xu Z, et al. Robot-assisted versus conventional laparoscopic operation in anus-preserving rectal cancer: A meta-analysis. *Ther Clin Risk Manag*. 2017;13:1247-1257. doi:10.2147/TCRM.S142758
35. Ohtani H, Maeda K, Nomura S, et al. Meta-analysis of robot-assisted versus laparoscopic surgery for rectal cancer. *In Vivo (Brooklyn)*. 2018;32(3):611-623. doi:10.21873/invivo.11283
36. Schootman M, Hendren S, Loux T, Ratnapradipa K, Eberth JM, Davidson NO. Differences in effectiveness and use of robotic surgery in patients undergoing minimally invasive colectomy. *J Gastrointest Surg*. 2017;21(8):1296-1303. doi:10.1007/s11605-017-3460-8
37. Rashidi L, Neighorn C, Bastawrous A. Outcome comparisons between high-volume robotic and laparoscopic surgeons in a large healthcare system. *Am J Surg*. 2017;213(5):901-905. doi:10.1016/j.amjsurg.2017.03.034
38. Corrigan N, Marshall H, Croft J, Copeland J, Jayne D, Brown J. Exploring and adjusting for potential learning effects in ROLARR: A randomised controlled trial comparing robotic-assisted vs. standard laparoscopic surgery for rectal cancer resection. *Trials*. 2018;19(1):1-11. doi:10.1186/s13063-018-2726-0
39. Prete FP, Pezzolla A, Prete F, et al. Robotic versus laparoscopic minimally invasive surgery for rectal cancer: a systematic review and meta-analysis of randomized controlled trials. *Ann Surg*. 2018;267(6):1034-1046. doi:10.1097/SLA.0000000000002523
40. Huang YJ, Kang YN, Huang YM, Wu AT, Wang W, Wei PL. Effects of laparoscopic vs robotic-assisted mesorectal excision for rectal cancer: An update systematic review and meta-analysis of randomized controlled trials. *Asian J Surg*. 2019;42(6):657-666. doi:10.1016/j.asjsur.2018.11.007
41. Bilgin IA, Bas M, Benlice C, et al. Totally laparoscopic and totally robotic surgery in patients with left-sided colonic diverticulitis. *Int J Med Robot Comput Assist Surg*. 2020;16(1):2-7. doi:10.1002/rcs.2068
42. Bastawrous AL, Landmann RG, Liu Y, Liu E, Cleary RK. Incidence, associated risk factors, and impact of conversion to laparotomy in elective minimally invasive sigmoidectomy for diverticular disease. *Surg Endosc*. 2020;34(2):598-609. doi:10.1007/s00464-019-06804-z
43. Bhama AR, Wafa AM, Ferraro J, et al. Comparison of risk factors for unplanned conversion from laparoscopic and robotic to open colorectal surgery using the Michigan Surgical Quality Collaborative (MSQC) Database. *J Gastrointest Surg*. 2016;20(6):1223-1230. doi:10.1007/s11605-016-3090-6

The First Epiretinal Implant for Hereditary Blindness in the Asia-Pacific Region

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Abstract

In February 2013, the Argus® II Retinal Prosthesis System (Second Sight Medical Products, Inc., Sylmar, CA, US) became the first "bionic eye" approved by the FDA to restore useful vision in patients previously blinded by end-stage retinitis pigmentosa, a hereditary, progressive degeneration of the outer retinal photoreceptor cells. The system captures and converts an external optical input into an electrical signal that activates an epiretinal electrode array on the inner surface of the retina. This signal bypasses dysfunctional photoreceptors and directly stimulates the functional inner retina, thus transmitting information to the visual cortex and creating artificial vision. This article describes the first implantation of the Argus II Retinal Prosthesis System in the Asia-Pacific region, which occurred in a deaf and blind 72-year-old Japanese American woman with Usher syndrome. At 57 months after her operation, the patient uses the device daily to perform visual tasks, and the microelectrode array remains in the proper position on the macula. This case demonstrates the long-term safety and efficacy of the Argus II epiretinal implant, which allowed a functionally blind patient to gain meaningful vision.

Keywords

ophthalmology, Argus II, Visual Prosthesis, vision rehabilitation, artificial vision, Usher Syndrome, retinitis pigmentosa, retinal degeneration; low vision

Introduction

Hereditary retinal degenerative diseases result in progressive blindness due to progressive loss of the photoreceptors and retinal pigment epithelial scarring. Until recently, once the photoreceptors were lost, there were not any potential treatments to recover vision. Presently there has been a novel approach to stimulating the retina bypassing the damaged photoreceptors and using microelectrodes. The first artificial vision device approved for retinitis pigmentosa (RP) was the Argus II Retinal Prosthesis System (RPS) (Second Sight Medical Products, Sylmar, CA, USA).[1,2] Often referred to as the "bionic eye," it obtained the CE Mark (approval for use in Europe) in 2011, the US Food and Drug Administration (FDA) approval in 2013, and Health Canada approval in 2014. This device aims to allow potential recovery of visual tasks not possible to completely blind patients with end-stage RP.

RP is a hereditary condition characterized by gradual and progressive death of the photoreceptor cells, ultimately resulting in irreversible blindness. However, the inner retina and optic nerve remain relatively preserved, allowing for potential stimulation of functional ganglion and bipolar cells of the inner retina and transmission through the optic nerve to the visual cortex. Usher syndrome is a disease that presents with a spectrum of vision loss due to RP and varying degrees of hearing loss and vestibular abnormalities. In the literature, substantial clinical heterogeneity has been reported regarding the onset and severity of ocular, hearing, and vestibular function loss.[3–5] Usher syndrome type I is typically characterized by RP with profound deafness and vestibular abnormalities from birth, whereas Usher syndrome type II manifests as congenital RP with severe deafness but normal balance, and type III is characterized by late-onset RP, hearing loss, and deficits in balance. It has been proposed that there may be vestibulo-cochlear and cochlear subtypes of Usher syndrome type I, with or without vestibular abnormalities, respectively.[6]

The Argus II RPS is a sight-restoring analogue to a cochlear implant, which has similarly improved auditory capabilities and quality of life in patients with Usher syndrome.[7] The system is composed of a wearable external unit and a surgically implanted internal unit. Externally, a camera mounted on sunglasses captures real-time images (Figure 1A). A portable computer processes the video input and communicates digitized information to an external transmitting coil at the glasses earpiece. These data are wirelessly transferred from the transmitting coil to a surgically-placed subconjunctival receiving coil and electronics casing that delivers electrical pulses to the 60-channel (6x10) epiretinal microelectrode array (Figure 1B). The microelectrode directly contacts the macula and stimulates viable inner retinal cells, delivering the signal through the optic nerve to the brain where it is perceived as light.

This device has demonstrated improved functioning and quality of life in patients with RP.[8] The combination of deafness and blindness makes the use of the Argus II RPS particularly challenging in patients with Usher syndrome due to communication challenges during rehabilitation. Its long-term safety and efficacy in patients with Usher syndrome has been previously reported only twice in patients with Usher syndrome type II.[9,10] Herein, a 72-year-old woman with Usher syndrome type I and her long-term response to the Argus II RPS 57 months after initial surgery are reported.

Case Report

A 72-year-old Japanese American woman presented with end-stage RP due to Usher syndrome. She was born with complete bilateral deafness and developed adult-onset nyctalopia at 57 years of age. She had no history of vestibular abnormalities. Her presentation was suggestive of Usher Syndrome type I,

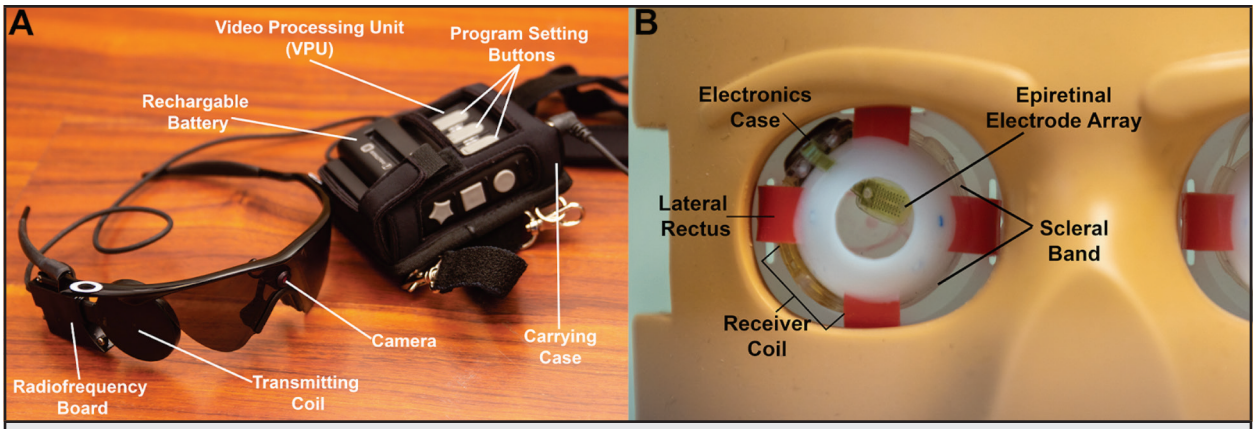

Figure 1. Labeled photograph of the Argus II Retinal Prosthesis System. The external component (A) is composed of a camera mounted on sunglasses and a visual processing unit (VPU). Optical data from the camera are transformed into an electrical signal in the VPU, which is worn on a belt or in a purse. The internal component (B) consists of the receiving coil, electronics casing, scleral band, and the epiretinal microelectrode array. The electrical information from the VPU is transmitted via wireless radiofrequency telemetry to the receiving coil, which is placed under the lateral rectus muscle. The elements of the electronics casing are activated, triggering epiretinal microelectrode activation and retinal nerve fiber layer and ganglion cell stimulation.

although her preserved vestibular function was suggestive of the proposed cochlear subtype.[6] Due to progression of RP, she eventually became functionally blind with no light perception in her right eye and a very minimal ability to sense any light in her left eye. With complete loss of vision, she could no longer communicate through American Sign Language. This required her to converse through tactile sign language, necessitating continuous hand-to-hand contact with a highly skilled interpreter to convey messages. Realistic visual outcomes were discussed with the patient using a professional tactile sign language interpreter who was essential in conveying the device risks and limitations. The patient consented to surgery in the right eye.

Although the Argus II RPS was approved by the FDA in 2013 and in Europe and the Middle East in 2011, there were not any cases of bionic eye surgery throughout the Asia-Pacific region through 2015. The first Argus II surgery in the Asia-Pacific region was performed at the Eye Surgery Center of Hawaii on March 24, 2015. The surgical team included the primary surgeon and author (GK), assistant surgeon, Dr. Troy Tanji, and surgical consultant, Dr. Mark Humayun, who invented the Argus II RPS and was present throughout the surgery. A 360-degree peritomy was performed, and the rectus muscles were isolated. The coil and the sealed electronics case were stabilized on the outside of the eye, the vitrectomy was completed, and the 60-microelectrode implant of the Argus II was positioned over the macula and held in place with a single tack. Pericardial graft material (Innovative Ophthalmic Products, Inc., Costa Mesa, CA) was used to cover the electronics case and coil, and the conjunctiva was carefully closed.[2] Post-operatively, the implant was well positioned over the macula without optic nerve overlap (Figure 2A) and was in close contact with the retinal surface on spectral-domain optical coherence tomography (Figure 2B-2C). The patient recovered well and initiated rehabilitation, which was guided heavily by a tactile sign language interpreter.

Following device programming and fitting, the implant was activated 2 weeks after surgery. The patient immediately reported perceiving "lines of bright lights." She successfully tracked a light source by pointing and walking towards it. She distinguished and identified dark and bright utensils on a table and read large letters from a high-contrast screen. Nine months post-operatively, she followed a pathway of lights on the floor of a dark room with minimal assistance. She was able to distinguish patterns to perform her craft work and locate a person in a room. Rehabilitation continued for 24 months. At 57 months post-implantation, the patient continues to use the device daily to assist her in navigating throughout her house, localizing and sorting light and dark colored items, and identifying fruits on the ground. It remains in excellent position, securely positioned to the retina with a single tack, as noted on ultrawide fundus photography (Figure 3A), and remains in close contact with the retinal surface on spectral-domain optical coherence tomography (Figure 3B-3C).

Discussion

This patient was the first to receive the Argus II RPS in the Asia-Pacific region, including all of Asia, Australia, New Zealand, and the Pacific Islands. She is also the first reported patient with suspected Usher syndrome type I to receive the implant. Given the end-stage nature of her condition, genetic testing was not pursued. Nevertheless, only a few reports of Argus II RPS implantations in patients with Usher syndrome of any subtype are found in the literature. Nadal and Iglesias placed an Argus II RPS into a patient blinded for 20 years by RP due to Usher syndrome type II who demonstrated visual

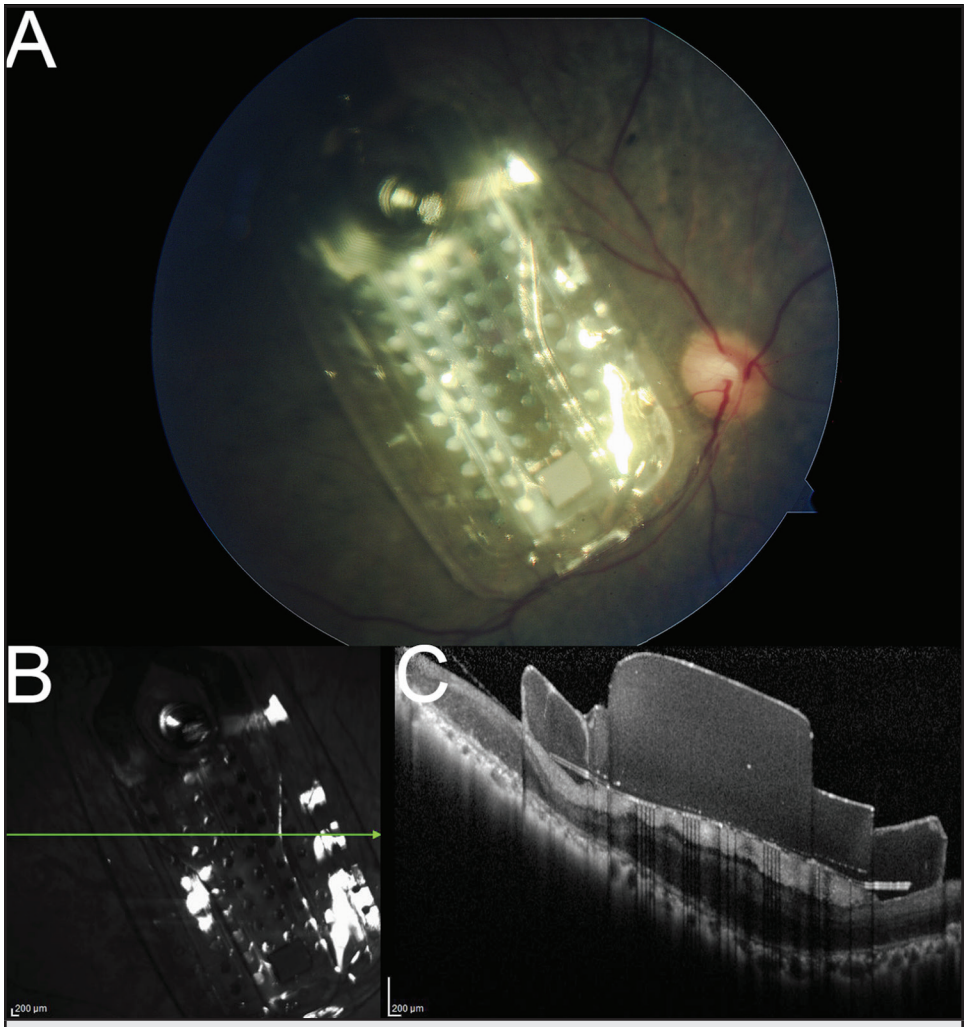

Figure 2. Postoperative images of the Argus II Retinal Prosthesis System in the current patient. Color fundus photograph (A) demonstrates the epiretinal microelectrode array well-positioned over the macula without overlay over the optic nerve head. Photograph (B) shows a green line through the microelectrode array corresponding to the B scan spectral-domain optical coherence tomography (C), which demonstrates stable and close approximation of the microelectrode array to the retinal surface.

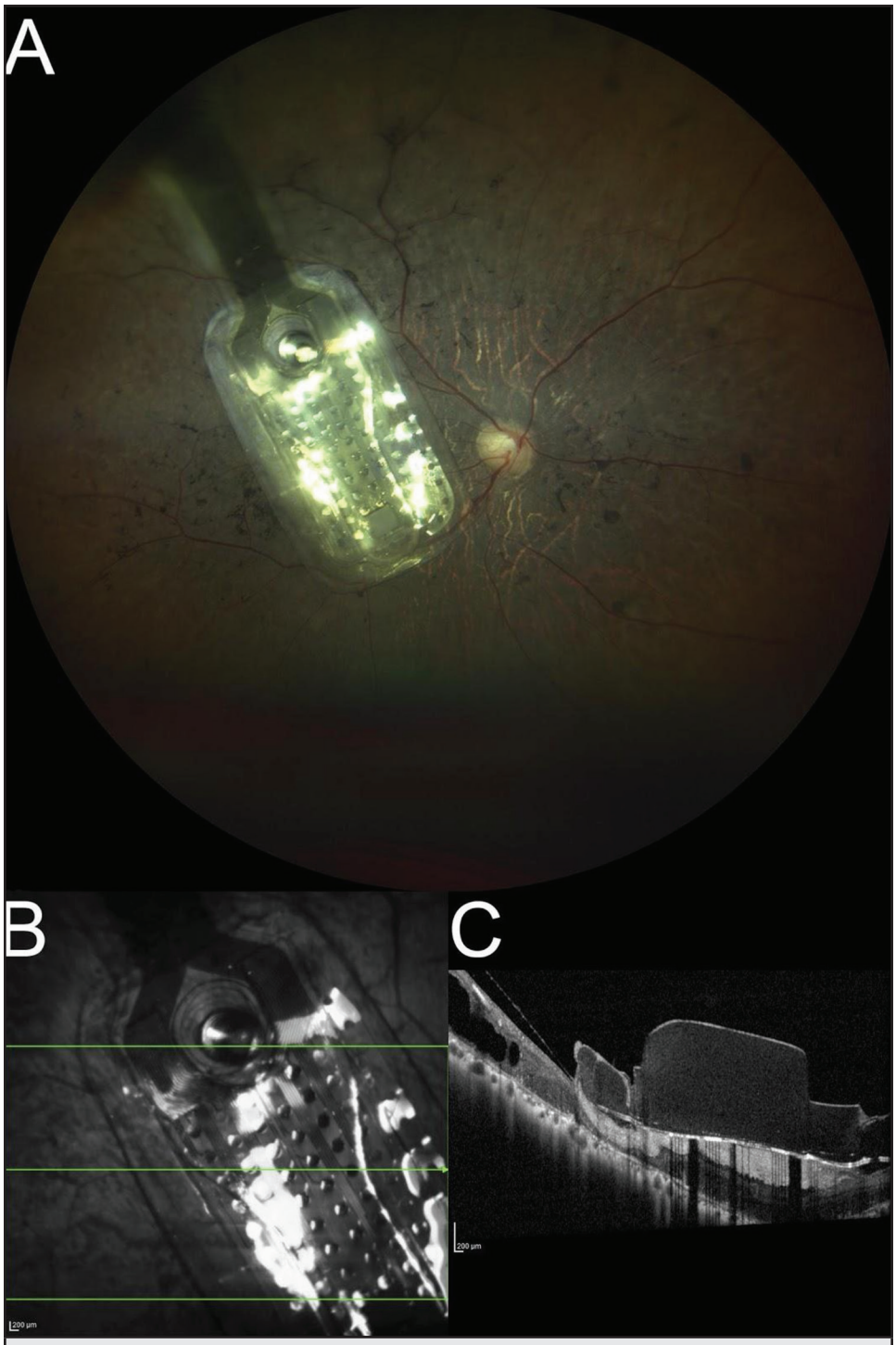

Figure 3. Month 57 postoperative images of the Argus II Retinal Prosthesis System in the current patient. Ultra-wide field fundus photograph (A) shows a stable and well-positioned microelectrode array over the macula without overlay over the optic nerve head using a single tack. Photograph (B) shows a green line through the microelectrode array corresponding to the B scan spectral-domain optical coherence tomography (C), which demonstrates stable and close approximation of the microelectrode array to the retinal surface.

and communicative improvements after device implantation.[9] Demchinsky et al successfully implanted the first Argus II RPS in Russia into a man with Usher syndrome who had bilateral sensorineural hearing loss with some preserved auditory function, although his hearing loss similarly limited rehabilitation methods.[10] However, both studies reported fewer than 16 months of follow-up, whereas the current patient has been monitored over 57 months.

Both of these previous cases, similarly to the current case, emphasized the importance of communication through tactile sign language to accomplish rehabilitation. Tactile signing involves the patient putting his or her hands over the signer's hands to feel the shape, movement, direction, and location of the signs. Initially, the current patient had difficulty understanding how to sweep her entire head from side-to-side when tracking objects and to not gaze straight ahead with her eyes. After a period of guiding the patient's head rotation, the patient understood and was able to identify objects faster and more consistently by using more dynamic motions of her head.

The 5-year safety results of the prospective Argus II RPS clinical trial, which is a similar time frame to the follow-up of the current patient, have been previously reported.[11] Conjunctival erosion or dehiscence was a commonly reported complication that occurred in 23% of cases. Conjunctival dehiscence can occur due to failure of peritomy closure, whereas erosion of the conjunctiva occurs over time with breakdown of the tissue covering the coil or the casing. To minimize this, Tutoplast pericardial tissue was used to cover the elements of the Argus II on the outside of the eye, and there has not been conjunctival erosion or dehiscence in the current patient. The current patient did not experience any of the other serious adverse events reported in the Argus II RPS clinical trial, including hypotony (13.3%), presumed endophthalmitis (10%), need for retack (6.7%), retinal detachment (6.6%), retinal tear, uveitis, keratitis, corneal melt or opacities (3.3% each).[11] Despite being held in place with a single tack, only 2 patients in the study required re-tacking at 5 years. The microelectrode array was also not displaced as evidenced on optical coherence tomography.[12]

Other treatment options for RP are being developed, such as gene therapy. Intravitreal voretigene neparvovec-ryzl (AAV2-hRPE65v2, Spark Therapeutics, Inc. Philadelphia, PA, USA) gene therapy is designed to deliver a normal copy of the *RPE65* gene to the retinal pigment epithelial (RPE) cells that lack a functioning *RPE65* gene. This genetic defect of *RPE65* mutations causes Leber's congenital amaurosis and autosomal recessive RP. Leber's congenital amaurosis is a heterogeneous group of diseases that results in severe vision impairment at a very early age.[13] Furthermore, the Argus II RPS is also being evaluated for people with other retinal conditions, including advanced non-exudative age-related macular degeneration (ClinicalTrials.gov Identifier: NCT02227498). These retinal implants may have potential applications beyond inherited retinal degenerations and may offer sight to a much broader demographic.

The recent expansion of the Argus II RPS into Asia offers a new therapy for patients with RP and other hereditary retinal degenerations. Subsequent to the case in Hawaii, Argus II implantations have been performed in Taiwan[14] and South Korea.[15] The current limitation is cost, as the $150 000 implant is prohibitive for patients and insurance companies.

The limitations of this study is that it only reports on one successful case of ARGUS II implantation and improvement in visual tasks. Larger studies have shown potential complications as noted above. In addition, it reports on an unusual case of implantation in a deaf and blind patient with Usher's syndrome, which may be less generalizable to retinitis pigmentosa patients without hearing loss.

In conclusion, this report documents the long-term efficacy and safety of the first retinal prosthesis in the Asia-Pacific region in a deaf-blind patient with RP due to Usher syndrome type I. The microelectrode array has been stable in position, and there has been no evidence of infection or exposure of the coil or the sealed electronics case. This previously completely blind patient is now able to distinguish dark and light and see people walking into a room. This device shows the potential of using epiretinal implants to stimulate the inner retina to transmit visual images to the optic nerve, even if the outer retina is damaged.

Conflict of Interest

None of the authors identify a conflict of interest.

Acknowledgments

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References

1. Humayun MS, de Juan E Jr, Dagnelie G. The bionic eye: a quarter century of retinal prosthesis research and development. *Ophthalmology*. 2016;123(10S):S89-S97.
2. Finn AP, Grewal DS, Vajzovic L. Argus II retinal prosthesis system: a review of patient selection criteria, surgical considerations, and post-operative outcomes. *Clin Ophthalmol*. 2018;12:1089-1097.
3. Smith RJ, Berlin CI, Hejtmancik JF, *et al.* Clinical diagnosis of the Usher syndromes. Usher Syndrome Consortium. *Am J Med Genet*. 1994;50(1):32-38.
4. Kremer H, van Wijk E, Märker T, Wolfrum U, Roepman R. Usher syndrome: molecular links of pathogenesis, proteins and pathways. *Hum Mol Genet*. 2006;15 Spec No 2:R262-R270.
5. Mathur P, Yang J. Usher syndrome: Hearing loss, retinal degeneration and associated abnormalities. *Biochim Biophys Acta*. 2015;1852(3):406-420.
6. Otterstedde CR, Spandau U, Blankenagel A, Kimberling WJ, Reisser C. A new clinical classification for Usher's syndrome based on a new subtype of Usher's syndrome type I. *Laryngoscope*. 2001;111(1):84-86.
7. Hartel BP, van Nierop JWI, Huinck WJ, *et al.* Cochlear implantation in patients with Usher syndrome type IIa increases performance and quality of life. *Otol Neurotol*. 2017;38(6):e120-e127.
8. Dagnelie G, Christopher P, Arditi A, *et al.* Performance of real-world functional vision tasks by blind subjects improves after implantation with the Argus® II retinal prosthesis system. *Clin Experiment Ophthalmol*. 2017;45(2):152-159.
9. Nadal J, Iglesias M. Long-term visual outcomes and rehabilitation in Usher syndrome type II after retinal implant Argus II. *BMC Ophthalmol*. 2018;18(1):205.
10. Demchinsky AM, Shaimov TB, Goranskaya DN, *et al.* The first deaf-blind patient in Russia with Argus II retinal prosthesis system: what he sees and why. *J Neural Eng*. 2019;16(2):025002.
11. da Cruz L, Dorn JD, Humayun MS, *et al.* Five-year safety and performance results from the Argus II retinal prosthesis system clinical trial. *Ophthalmology*. 2016;123(10):2248-2254.
12. Gregori NZ, Callaway NF, Hoeppner C, *et al.* Retinal anatomy and electrode array position in retinitis pigmentosa patients after Argus II implantation: an international study. *Am J Ophthalmol*. 2018;193:87-99.
13. Xu F, Dong Q, Liu L, *et al.* Novel RPE65 mutations associated with Leber congenital amaurosis in Chinese patients. *Mol Vis*. 2012;18:744-750.
14. Hsu P-C, Chen P-Y, Chung Y-S, *et al.* First implantation of retinal prosthesis in a patient with high myopia after surgery and rehabilitation program in Taiwan. *J Chin Med Assoc*. 2019;82(7):599-602.
15. Farvardin M, Afarid M, Attarzadeh A, *et al.* The Argus-II retinal prosthesis implantation; from the global to local successful experience. *Front Neurosci*. 2018;12:584.

The Effect of Energy Devices, Nerve Monitors, and Drains on Thyroidectomy Outcomes: An American College of Surgeons National Surgical Quality Improvement Project Database Analysis

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Abstract

The effect of energy devices, nerve monitors, and drains on thyroidectomy outcomes has been examined for each tool independently. Current literature supports the routine use of energy devices and nerve monitors and does not support the routine use of drains. The effect of these operative tools is interrelated and should be examined concurrently. The aim of this study was to describe the risk-adjusted effect of each of these tools on thyroidectomy outcomes. A retrospective analysis of 17 985 open thyroidectomy procedures was conducted using the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) 2016–2018 thyroidectomy targeted procedure database. All open thyroidectomies were included. The risk-adjusted effect of energy devices, nerve monitors, and drains on 30-day outcomes was calculated by multiple logistic regression. Energy devices were associated with a decreased risk of hematoma and decreased extended length of stay without increased risk of hypocalcemia or recurrent laryngeal nerve injury. Nerve monitors were associated with a decreased risk of overall morbidity, decreased recurrent laryngeal nerve injury, and decreased extended length of stay without an increased risk of adverse outcomes. Drains were associated with an increased risk of bleeding, reoperation, and extended length of stay without decreasing hematoma. Our results support the routine use of energy devices and nerve monitors for thyroidectomy and do not support the routine use of drains for thyroidectomy.

Keywords

thyroidectomy, outcomes, ACS-NSQIP, hematoma, recurrent laryngeal nerve injury, bleeding, energy device, nerve monitor, drain

Abbreviations and Acronyms

ACS-NSQIP = American College of Surgeons - National Surgical Quality Improvement Program
AIC = Akaike Information Criterion
ASA = American Society of Anesthesiologists
BMI = body mass index
CHF = congestive heart failure
COPD = chronic obstructive pulmonary disease
INR = international normalized ratio
LOS = length of stay
OR = odds ratio
RLN = recurrent laryngeal nerve
SSI = surgical site infection

Introduction

Thyroidectomy is a common procedure performed for a wide variety of indications by different types of specialists. Energy devices, nerve monitors, and drains are commonly, but not universally, used for thyroidectomy procedures.

The literature generally supports the routine use of energy devices. Energy devices have been shown to decrease postoperative hematoma, extended length of stay (LOS), and intraoperative blood loss compared to conventional hemostasis,[1,2] without increasing rates of recurrent laryngeal nerve (RLN) injury.[1,3,4] Despite lack of data supporting the routine use of nerve monitors,[5-8] the American Head and Neck Society has published a consensus statement supporting the routine use of nerve monitors during thyroidectomy.[9] The routine use of drains is not generally supported by the literature. Drains have not been found to decrease the rate of post-thyroidectomy bleeding and hematoma,[10-15] and have been associated with several other adverse outcomes.[11-15]

The effects of energy devices, nerve monitors, and drains have been studied independently. However, their effects are interrelated. For example, energy device use may decrease hematoma rate, which would decrease the need for a drain, but it may also increase the risk of RLN injury, which would increase the need for a nerve monitor. Examining the 3 methods discussed and their outcomes concurrently will provide a more comprehensive basis for decision-making during thyroidectomy. Our goal was to describe the risk-adjusted effect of each of these tools on thyroidectomy outcomes. We hypothesize that energy devices will be associated with decreased rates of hematoma and bleeding, nerve monitors will be associated with a decreased rate of RLN injury, and drains will be associated with an increased rate of hematoma.

Materials and Methods

Data Source

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) is a nationwide quality improvement initiative based on high-fidelity, professionally curated data. The ACS-NSQIP database contains over 150 data points regarding patient demographics, indications, preoperative comorbidities, laboratory values, and 30-day outcomes on a procedure level basis. The ACS-NSQIP targeted procedure – thyroidectomy database, first released in 2016, contains an

additional set of thyroidectomy-specific data points, such as previous neck surgery, concurrent neck dissection, use of energy devices, use of intraoperative nerve monitoring, placement of a drain, postoperative hypocalcemia, postoperative RLN injury, and others. This study was exempt from Institutional Review Board approval as the data contained no patient identifying information.

Patient Selection

A total of 17 985 open thyroidectomies conducted from 2016 to 2018 were included. No further exclusion criteria were applied.

Patient Cohorts

Patients were split into overlapping cohorts based on operative tools used during the procedure. Tools analyzed were energy devices, nerve monitors, and drains. Use of an energy device was derived from the "THY_SCALPEL" variable in the targeted procedure database, which was defined as the use of Harmonic scalpel, LigaSure, or other vessel sealant device. This variable does not capture the use, or non-use, of monopolar energy devices. Use of a nerve monitor was derived from the "THY_ELECTRO" variable in the targeted procedure database, which was defined as the use of intraoperative electrophysiologic or electromyographic RLN monitoring. Use of a drain was derived from the "THY_DRAINUSE" variable in the targeted procedure database, which was defined as the use of any surgical drain.

Predictor Variables

Patient demographics/general health, thyroid-specific history/indications, operation details, operative tool use, comorbidities, and pre-operative labs were analyzed as predictor variables. Demographic and general health variables included persons aged ≥ 65 years, sex, obesity (body mass index [BMI] ≥ 30 kg/m^2), functional status (independent or not independent), race (White, Black, or Other), and American Society of Anesthesiologists (ASA) classification (ASA I-II, ASA III, or ASA IV-V). Thyroid-specific history/indications included history of neck surgery and neoplastic indication. Operation details included extent of resection (total/subtotal thyroidectomy, or hemithyroidectomy), neck dissection, concurrent sub-platysmal neck surgery, operation duration, and wound class (class I or not class I). Comorbidities included congestive heart failure (CHF), hypertension, smoking within the past 1 year, dyspnea within the past 30 days, chronic obstructive pulmonary disease (COPD), dialysis, weight loss > 10% within the past 6 months, disseminated cancer, bleeding disorder, diabetes, and steroid or immunosuppressive therapy within the past 30 days. Laboratory values included hypoalbuminemia (albumin < 3.5 g/dL), hyperbilirubinemia (bilirubin > 1.2 mg/dL), elevated creatinine (creatinine > 1.2 mg/dL [male] or 1.1 mg/dL [female]), anemia (hematocrit < 30%), elevated international normalized ratio (INR > 1.4), thrombocytopenia (platelet < 100 000/μL), and leukocytosis (white blood cell > 11 000/μL). All predictor variables were treated as categorical variables, the majority of which were binary except as indicated above. Several other pre-operative comorbidities are captured in the ACS-NSQIP database but were excluded from this analysis because of a low number of occurrences

Outcome Variables

All outcomes reported in the ACS-NSQIP database are 30-day outcomes. Outcomes analyzed were overall morbidity, hypocalcemia, neck hematoma, RLN injury, pulmonary morbidity, wound morbidity, bleeding requiring transfusion, readmission, reoperation, and length of hospital stay (LOS) greater than the median. Neck hematoma and RLN injury were defined as the noted presence of either, regardless of severity. Overall morbidity was defined as the presence of 1 or more major postoperative complications. Pulmonary morbidity was defined as 1 or more occurrences of postoperative pneumonia, ventilator requirement > 48 hours post-operation, or reintubation. Wound morbidity was defined as 1 or more occurrences of superficial surgical site infection (SSI), deep SSI, organ space SSI, or wound dehiscence.

Statistical Analysis

Bivariate analysis of the distribution of predictor variables by operative tool use was conducted using Chi-square tests. Multivariate analysis of the effect of each tool on outcomes was conducted by multiple logistic regression using models constructed by forward/backward stepwise minimization of Akaike Information Criterion (AIC), starting with fully saturated models and setting the minimum model to include energy device use, nerve monitor use, and drain use as predictors regardless of impact on AIC. This resulted in a risk-adjusted odds ratio (OR) and corresponding 95% confidence interval (95% CI) of the specified outcome given the use of each tool. Statistical significance was assigned to P value < .05. Statistical analysis was performed using R version 3.5.1.

ACS-NSQIP Disclosure Statement

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Results

Patient Characteristics

Patient characteristics of energy device and no energy device groups are reported in Table 1. A total of 11 487 cases (63.9%) used energy devices. Patients in the energy device group had a higher rate of total/subtotal thyroidectomy (64.7% vs 59.3%;

$P < .0001$), operation time > median (52.4% vs 45.4%; $P < .0001$), and hypertension (40.4% vs 34.6%; $P < .0001$). Patients in the energy device group had a lower rate of history of neck surgery (9.1% vs 12.5%; $P < .0001$) and neck dissection (23.9% vs 35.0%; $P < .0001$). Patients in the energy device group had no difference in rate of concurrent neck surgery (11.9% vs 12.4%; $P = .3714$), bleeding disorder (1.1% vs 1.2%; $P = .6585$), elevated INR (0.44% vs 0.46%; $P = .8161$), and thrombocytopenia (0.39% vs 0.35%; $P = .6510$).

Patient characteristics of nerve monitor and no nerve monitor groups are reported in Table 2. A total of 11 352 cases (63.1%) used nerve monitors. Patients in the nerve monitor group had a higher rate of obesity (47.7% vs 42.6%; $P < .0001$), total thyroidectomy (64.1% vs 60.4%; $P = .0027$), neck dissection (29.5% vs 25.2%; $P < .0001$), and operative time > median (54.1% vs 42.7%; $P < .0001$). Patients in the nerve monitor group had a lower rate of concurrent neck surgery (11.5% vs 13.0%; $P = .0038$). Patients in the nerve monitor group had no difference in rate of history of neck surgery (10.4% vs 10.2%; P=v.8098), and neoplastic indication (61.7% vs 63.2%; $P = .2246$).

Patient characteristics of drain and no drain groups are reported in Table 3. In total, 5029 cases (28.0%) used drains. Patients in the drain group had a higher rate of obesity (51.8% vs 43.5%; $P < .0001$), total thyroidectomy (73.8% vs 58.5%; $P < .0001$), neck dissection (32.2% vs 26.3%; $P < .0001$), operation time > median (69.4% vs 42.3%; $P < .0001$), wound class II-IV (3.2% vs 2.1%; $P < .0001$), hypertension (43.1% vs 36.4%; $P < .0001$), smoking (16.9% vs 13.4%; $P < .0001$), preoperative dyspnea (9.9% vs 5.7%; $P < .0001$), COPD (3.4% vs 2.2%; $P < .0001$), and thrombocytopenia (0.58% vs 0.30%; $P = .0069$). Patients in the drain group had a lower rate of neoplastic indication (59.3% vs 63.4%; $P = .0020$). Patients in the drain group had no difference in rate of history of neck surgery (10.8% vs 10.1%; $P = .1957$), concurrent neck surgery (11.5% vs 12.3%; $P = .2134$), bleeding disorder (1.3% vs 1.0%; $P = .0832$), and elevated INR (0.52% vs 0.42%; $P = .3166$).

Operative Tool Usage

The distribution of operative tools used for thyroidectomy is depicted in Figure 1. The most used combination is energy devices and nerve monitors (33.3%). The next 3 most used combinations are energy devices only (13.9%), nerve monitors only (12.3%), and all 3 tools (12.1%). The three least commonly used combinations were energy devices and drains (4.5%), drains and nerve monitors (5.4%), and drains only (5.9%). None of the 3 tools were used in 12.5% of cases.

Outcomes

Results of our bivariate (unadjusted) outcomes analysis for energy devices are reported in Table 4. Patients in the energy device group had a lower rate of hematoma (1.6% vs 2.2%; $P = .0112$), pulmonary morbidity (0.60% vs 0.89%; $P = .0267$), wound morbidity (0.65% vs 0.92%; $P = .0490$), and LOS > median (10.2% vs 21.4%; $P < .0001$). Patients in the energy device group had no difference in rate of overall morbidity (15.1% vs 16.2%; $P = .0586$), any RLN injury (6.2% vs 5.8%; $P = .3118$), and bleeding requiring transfusion (0.20% vs 0.26%; $P = .3200$). Patients in the energy device group did not have a higher rate of any of the analyzed adverse outcomes.

Results of our bivariate (unadjusted) outcomes analysis for nerve monitors are reported in Table 5. Patients in the nerve monitor group had a lower rate of overall morbidity (14.9% vs 16.5%; $P = .0096$), RLN injury (5.6% vs 6.7%; $P = .0056$), pulmonary morbidity (0.60% vs 0.89%; $P = .0274$), and LOS > median (11.6% vs 18.8%; $P < .0001$). Patients in the nerve monitor group did not have a higher rate of any of the analyzed adverse outcomes.

Results of our bivariate (unadjusted) outcomes analysis for drains are reported in Table 6. Patients in the drain group had a higher rate of overall morbidity (18.9% vs 14.2%; $P < .0001$), hypocalcemia (8.9% vs 7.1%; $P = .0001$), any RLN injury (7.7% vs 5.4%; $P < .0001$), pulmonary morbidity (1.3% vs 0.46%; $P < .0001$), wound morbidity (0.99% vs 0.66%; $P = .0216$), bleeding requiring transfusion (0.50% vs 0.12%; $P < .0001$), readmission (3.3% vs 2.6%; $P = .0096$), reoperation (2.0% vs 1.2%; $P < .0001$), and LOS > median (29.6% vs 8.2%; $P < .0001$). Patients in the drain group had no difference in rate of hematoma (2.0% vs 1.8%; $P = .3874$). Patients in the drain group did not have a lower rate of any of the analyzed adverse outcomes.

Results of our multivariate (risk-adjusted) outcomes analysis for energy devices, nerve monitors, and drains are reported in Table 7. These results are graphically depicted in forest plots in Figures 2–4. Energy devices were found to be independently associated with a decreased risk of hematoma (OR, 0.72; 95% CI, 0.57-0.92; $P = .0090$), and LOS > median (OR, 0.62; 95% CI, 0.56-0.69; P<v.0001). Energy devices were not associated with an increased risk of any of the analyzed adverse outcomes, including hypocalcemia (OR, 0.98; 95% CI, 0.86-1.11; $P = .7401$) and RLN injury (OR, 1.11; 95% CI, 0.97-1.29; $P = .1363$). Nerve monitors were found to be independently associated with a decreased risk of overall morbidity (OR, 0.86; 95% CI, 0.79-0.94; $P = .0011$), RLN injury (OR, 0.75; 95% CI, 0.65-0.85; $P < .0001$), pulmonary morbidity (OR, 0.65; 95% CI, 0.44-0.98; $P = .372$), and LOS > median (OR, 0.71; 95% CI, 0.64-0.78; $P < .0001$). Nerve monitors were not associated with an increased risk of any of the analyzed adverse outcomes. Drains were found to be independently associated with an increased risk of overall morbidity (OR, 1.12; 95% CI, 1.02-1.23; $P = .0136$), any RLN injury (OR, 1.20, 95% CI, 1.05-1.38; $P = .0084$), pulmonary morbidity (OR, 1.80; 95% CI, 1.22-2.65; $P = .0030$), bleeding requiring transfusion (OR, 2.48; 95% CI, 1.21-5.20; $P = .0138$), reoperation (OR, 1.40; 95% CI, 1.07-1.81; $P = .0117$), and LOS > median (OR, 3.78; 95% CI, 3.42-4.19; $P < .0001$). Drains

Table 1. Patient Characteristics of No Energy Device and Energy Device Groups				
Predictor Variable	**All n (%)**	**No Energy Device n (%)**	**Energy Device n (%)**	***P* value[a]**
Total	17 985 (100.0)	6498 (36.1)	11 487 (63.9)	-
Demographics/general health				
Age ≥ 65 years	3974 (22.1)	1461 (22.5)	2513 (21.9)	.4091
Male	3988 (22.2)	1583 (24.4)	2405 (20.9)	<.0001*
Obese (BMI ≥ 30 kg/m^2)	8242 (45.8)	2621 (40.3)	5621 (48.9)	<.0001*
Functional status not independent	93 (0.5)	38 (0.6)	55 (0.5)	.3891
Race				
White	9914 (55.1)	2425 (37.3)	7489 (65.2)	<.0001*
Black	2597 (14.4)	592 (9.1)	2005 (17.5)	
Other	5474 (30.4)	3481 (53.6)	1993 (17.4)	
ASA Classification				
Class I-II	11 554 (64.2)	4290 (66.0)	7264 (63.2)	<.0001*
Class III	6052 (33.7)	2049 (31.5)	4003 (34.9)	
Class IV-V	379 (2.1)	159 (2.5)	220 (1.9)	
Thyroid-specific history/indications				
History of neck surgery	1854 (10.3)	810 (12.5)	1044 (9.1)	<.0001*
Neoplastic indication	11 195 (62.3)	4302 (66.2)	6893 (60.0)	<.0001*
Operation details				
Total or subtotal thyroidectomy	11 283 (62.7)	3854 (59.3)	7429 (64.7)	<.0001*
Neck dissection	5022 (27.9)	2276 (35.0)	2746 (23.9)	<.0001*
Concurrent neck surgery	2169 (12.1)	804 (12.4)	1365 (11.9)	.3714
Operation time > median (103 minutes)	8971 (49.9)	2953 (45.4)	6018 (52.4)	<.0001*
Wound class not 1-clean	428 (2.4)	167 (2.6)	261 (2.3)	.2275
Other tool use				
Nerve monitor used	11 352 (63.1)	3181 (49.0)	8171 (71.1)	<.0001*
Drain used	5029 (28.0)	2038 (31.4)	2991 (26.0)	<.0001*
Comorbidities				
CHF within 30 days	77 (0.4)	24 (0.4)	53 (0.5)	.3433
Hypertension requiring treatment	6889 (38.3)	2250 (34.6)	4639 (40.4)	<.0001*
Smoke cigarettes within 1 year	2587 (14.4)	872 (13.4)	1715 (14.9)	.0099*
Dyspnea within 30 days	1242 (6.9)	416 (6.4)	826 (7.2)	.0513
COPD	457 (2.5)	158 (2.4)	299 (2.6)	.4954
Dialysis	80 (0.4)	27 (0.4)	53 (0.5)	.6418
Weight loss > 10% in last 6 months	112 (0.6)	40 (0.6)	72 (0.6)	1.0
Disseminated cancer	179 (1.0)	77 (1.2)	102 (0.9)	.0622
Bleeding disorder	200 (1.1)	75 (1.2)	125 (1.1)	.6585
Diabetes	2419 (13.5)	785 (12.1)	1634 (14.2)	.0002*
Steroid or immunosuppression within 30 days	505 (2.8)	177 (2.7)	328 (2.9)	.6431
Preoperative labs				
Albumin < 3.5 g/dL	426 (2.4)	148 (2.3)	278 (2.4)	.5451
Bilirubin > 1.2 mg/dL	178 (1.0)	51 (0.8)	127 (1.1)	.0423*
Creatinine > 1.2 (M) or > 1.1 (F) mg/dL	974 (5.4)	298 (4.6)	676 (5.9)	.0003*
Hematocrit < 30%	187 (1.0)	64 (1.0)	123 (1.1)	.5431
INR > 1.4	80 (0.4)	30 (0.5)	50 (0.4)	.8161
Platelet < 100 000 /μL	68 (0.4)	23 (0.4)	45 (0.4)	.615
WBC > 11 000 /μL	678 (3.8)	232 (3.6)	446 (3.9)	.2987

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; M, male; F, female; INR, international normalized ratio; WBC, white blood cell count.

Table 2. Patient Characteristics of No Nerve Monitor and Nerve Monitor Groups				
Predictor Variable	**All n (%)**	**No Nerve Monitor n (%)**	**Nerve Monitor n (%)**	***P* value[a]**
Total	17 985 (100.0)	6633 (36.9)	11 352 (63.1)	-
Demographics/general health				
Age ≥ 65 years	3974 (22.1)	1500 (22.6)	2474 (21.8)	.2637
Male	3988 (22.2)	1552 (23.4)	2436 (21.5)	.0079*
Obese (BMI ≥ 30 kg/m^2)	8242 (45.8)	2824 (42.6)	5418 (47.7)	<.0001*
Functional status not independent	93 (0.5)	33 (0.5)	60 (0.5)	.8295
Race				
White	9914 (55.1)	3117 (47.0)	6797 (59.9)	<.0001*
Black	2597 (14.4)	656 (9.9)	1941 (17.1)	
Other	5474 (30.4)	2860 (43.1)	2614 (23.0)	
ASA Classification				
Class I-II	11 554 (64.2)	4322 (65.2)	7232 (63.7)	<.0001*
Class III	6052 (33.7)	2138 (32.2)	3914 (34.5)	
Class IV-V	379 (2.1)	173 (2.6)	206 (1.8)	
Thyroid-specific history/indications				
History of neck surgery	1854 (10.3)	679 (10.2)	1175 (10.4)	.8098
Neoplastic indication	11 195 (62.3)	4191 (63.2)	7004 (61.7)	.2246
Operation details				
Total or subtotal thyroidectomy	11 283 (62.7)	4007 (60.4)	7276 (64.1)	.0027*
Neck dissection	5022 (27.9)	1671 (25.2)	3351 (29.5)	<.0001*
Concurrent neck surgery	2169 (12.1)	865 (13.0)	1304 (11.5)	.0038*
Operation time > median (103 minutes)	8971 (49.9)	2832 (42.7)	6139 (54.1)	<.0001*
Wound class not 1-clean	428 (2.4)	140 (2.1)	288 (2.5)	.0714
Other tool use				
Nerve monitor used	11 487 (63.9)	3316 (50.0)	8171 (72.0)	<.0001*
Drain used	5029 (28.0)	1883 (28.4)	3146 (27.7)	.4132
Comorbidities				
CHF within 30 days	77 (0.4)	24 (0.4)	53 (0.5)	.3433
Hypertension requiring treatment	6889 (38.3)	2406 (36.3)	4483 (39.5)	.0007*
Smoke cigarettes within 1 year	2587 (14.4)	918 (13.8)	1669 (14.7)	.1424
Dyspnea within 30 days	1242 (6.9)	492 (7.4)	750 (6.6)	.0455*
COPD	457 (2.5)	150 (2.3)	307 (2.7)	.0656
Dialysis	80 (0.4)	33 (0.5)	47 (0.4)	.4884
Weight loss > 10% in last 6 months	112 (0.6)	29 (0.4)	83 (0.7)	.0186*
Disseminated cancer	179 (1.0)	67 (1.0)	112 (1.0)	.8769
Bleeding disorder	200 (1.1)	73 (1.1)	127 (1.1)	.8836
Diabetes	2419 (13.5)	881 (13.3)	1538 (13.6)	.643
Steroid or immunosuppression within 30 days	505 (2.8)	176 (2.7)	329 (2.9)	.3562
Preoperative labs				
Albumin < 3.5 g/dL	426 (2.4)	148 (2.2)	278 (2.5)	.366
Bilirubin > 1.2 mg/dL	178 (1.0)	61 (0.9)	117 (1.0)	.4378
Creatinine > 1.2 (M) or > 1.1 (F) mg/dL	974 (5.4)	355 (5.4)	619 (5.5)	.7905
Hematocrit < 30%	187 (1.0)	70 (1.1)	117 (1.0)	.8795
INR > 1.4	80 (0.4)	31 (0.5)	49 (0.4)	.8174
Platelet < 100 000 /µL	68 (0.4)	27 (0.4)	41 (0.4)	0615
WBC > 11 000 /µL	678 (3.8)	258 (3.9)	420 (3.7)	.5242

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; M, male; F, female; INR, international normalized ratio; WBC, white blood cell count.

Table 3. Patient Characteristics of No Drain and Drain Groups				
Predictor Variable	**All n (%)**	**No Drain n (%)**	**Drain n (%)**	***P* value[a]**
Total	17 985 (100.0)	12 956 (72.0)	5029 (28.0)	-
Demographics/general health				
Age ≥ 65 years	3974 (22.1)	2752 (21.2)	1222 (24.3)	<.0001*
Male	3988 (22.2)	2631 (20.3)	1357 (27.0)	<.0001*
Obese (BMI ≥ 30 kg/m^2)	8242 (45.8)	5637 (43.5)	2605 (51.8)	<.0001*
Functional status not independent	93 (0.5)	55 (0.4)	38 (0.8)	.0056*
Race				
White	9914 (55.1)	7102 (54.8)	2812 (55.9)	<.0001*
Black	2597 (14.4)	1786 (13.8)	811 (16.1)	
Other	5474 (30.4)	4068 (31.4)	1406 (28.0)	
ASA Classification				
Class I-II	11 554 (64.2)	8728 (67.4)	2826 (56.2)	<.0001*
Class III	6052 (33.7)	4007 (30.9)	2045 (40.7)	
Class IV-V	379 (2.1)	221 (1.7)	158 (3.1)	
Thyroid-specific history/indications				
History of neck surgery	1854 (10.3)	1311 (10.1)	543 (10.8)	.1957
Neoplastic indication	11 195 (62.3)	8212 (63.4)	2983 (59.3)	.002*
Operation details				
Total or subtotal thyroidectomy	11 283 (62.7)	7574 (58.5)	3709 (73.8)	<.0001*
Neck dissection	5022 (27.9)	3404 (26.3)	1618 (32.2)	<.0001*
Concurrent neck surgery	2169 (12.1)	1589 (12.3)	580 (11.5)	.2134
Operation time > median (103 minutes)	8971 (49.9)	5480 (42.3)	3491 (69.4)	<.0001*
Wound class not 1-clean	428 (2.4)	266 (2.1)	162 (3.2)	<.0001*
Other tool use				
Nerve monitor used	11 487 (63.9)	8496 (65.6)	2991 (59.5)	<.0001*
Drain used	11 352 (63.1)	8206 (63.3)	3146 (62.6)	.5582
Comorbidities				
CHF within 30 days	77 (0.4)	57 (0.4)	20 (0.4)	.6139
Hypertension requiring treatment	6889 (38.3)	4721 (36.4)	2168 (43.1)	<.0001*
Smoke cigarettes within 1 year	2587 (14.4)	1737 (13.4)	850 (16.9)	<.0001*
Dyspnea within 30 days	1242 (6.9)	742 (5.7)	500 (9.9)	<.0001*
COPD	457 (2.5)	288 (2.2)	169 (3.4)	<.0001*
Dialysis	80 (0.4)	60 (0.5)	20 (0.4)	.6165
Weight loss > 10% in last 6 months	112 (0.6)	68 (0.5)	44 (0.9)	.006*
Disseminated cancer	179 (1.0)	83 (0.6)	96 (1.9)	<.0001*
Bleeding disorder	200 (1.1)	133 (1.0)	67 (1.3)	.0832
Diabetes	2419 (13.5)	1614 (12.5)	805 (16.0)	<.0001*
Steroid or immunosuppression within 30 days	505 (2.8)	346 (2.7)	159 (3.2)	.0742
Preoperative labs				
Albumin < 3.5 g/dL	426 (2.4)	246 (1.9)	180 (3.6)	<.0001*
Bilirubin > 1.2 mg/dL	178 (1.0)	137 (1.1)	41 (0.8)	.1334
Creatinine > 1.2 (M) or > 1.1 (F) mg/dL	974 (5.4)	671 (5.2)	303 (6.0)	.0268*
Hematocrit < 30%	187 (1.0)	120 (0.9)	67 (1.3)	.0144*
INR > 1.4	80 (0.4)	54 (0.4)	26 (0.5)	.3166
Platelet < 100 000 /μL	68 (0.4)	39 (0.3)	29 (0.6)	.0069*
WBC > 11 000 /μL	678 (3.8)	463 (3.6)	215 (4.3)	.0325*

[a] Asterisk (*) represents statistical significance at P value <0.05. Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; M, male; F, female; INR, international normalized ratio; WBC, white blood cell count.

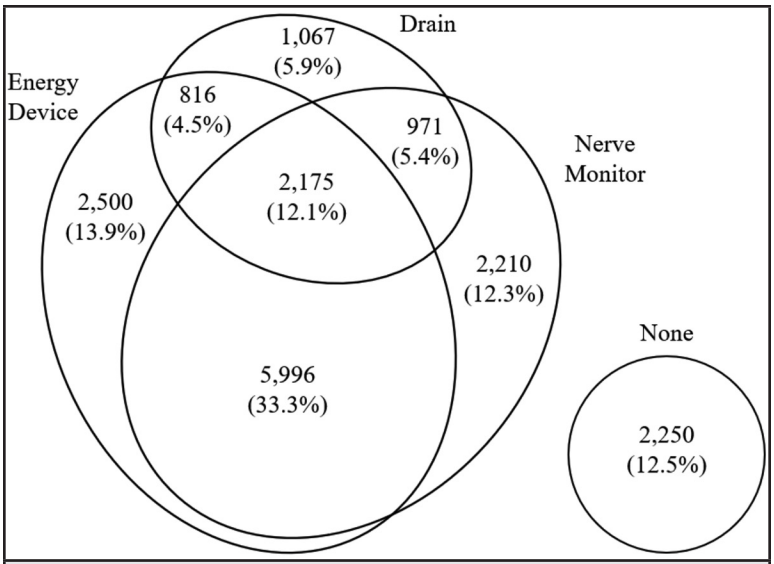

Figure 1. Euler Diagram of Tools Used for Thyroidectomy (N = 17 985)

Table 4. Bivariate (Unadjusted) Outcomes Analysis for Energy Devices

Outcome	All n (%)	No Energy Device n (%)	Energy Device n (%)	*P* value[a]
Total	17 985 (100.0)	6498 (36.1)	11 487 (63.9)	-
Overall morbidity	2791 (15.5)	1056 (16.3)	1735 (15.1)	.0586
Hypocalcemia	1365 (7.6)	524 (8.1)	841 (7.3)	.0807
Any hematoma	326 (1.8)	140 (2.2)	186 (1.6)	.0112*
Any RLN Injury	1084 (6.0)	376 (5.8)	708 (6.2)	.3118
Pulmonary morbidity (Pneumonia, Ventilator > 48 hours, Reintubation)	127 (0.7)	58 (0.9)	69 (0.6)	.0267*
Wound morbidity (Superficial SSI, Deep SSI, Organ Space SSI, Dehiscence)	135 (0.8)	60 (0.9)	75 (0.7)	.049*
Bleeding requiring transfusion	40 (0.2)	17 (0.3)	23 (0.2)	.32
Readmission	499 (2.8)	178 (2.7)	321 (2.8)	.8521
Reoperation	254 (1.4)	96 (1.5)	158 (1.4)	.6015
LOS > Median (1 day)	2556 (14.2)	1387 (21.4)	1169 (10.2)	<.0001*

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: RLN, recurrent laryngeal nerve; SSI, surgical site infection; LOS, length of stay.

Table 5. Bivariate (Unadjusted) Outcomes Analysis for Nerve Monitors

Outcome	All n (%)	No Nerve Monitor n (%)	Nerve Monitor n (%)	*P* value[a]
Total	17 985 (100.0)	6633 (36.9)	11 352 (63.1)	-
Overall morbidity	2791 (15.5)	1095 (16.5)	1696 (14.9)	.0096*
Hypocalcemia	1365 (7.6)	527 (8.0)	838 (7.4)	.1781
Any hematoma	326 (1.8)	125 (1.9)	201 (1.8)	.5658
Any RLN Injury	1084 (6.0)	444 (6.7)	640 (5.6)	.0056*
Pulmonary morbidity (Pneumonia, Ventilator > 48 hours, Reintubation)	127 (0.7)	59 (0.9)	68 (0.6)	.0274*
Wound morbidity (Superficial SSI, Deep SSI, Organ Space SSI, Dehiscence)	135 (0.8)	54 (0.8)	81 (0.7)	.4759
Bleeding requiring transfusion	40 (0.2)	18 (0.3)	22 (0.2)	.3272
Readmission	499 (2.8)	194 (2.9)	305 (2.7)	.3535
Reoperation	254 (1.4)	95 (1.4)	159 (1.4)	.8966
LOS > Median (1 day)	2556 (14.2)	1245 (18.8)	1311 (11.5)	<.0001*

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: RLN, recurrent laryngeal nerve; SSI, surgical site infection; LOS, length of stay.

Table 6. Bivariate (Unadjusted) Outcomes Analysis for Drains				
Outcome	**All n (%)**	**No Drain n (%)**	**Drain n (%)**	***P* value[a]**
Total	17 985 (100.0)	12 956 (72.0)	5029 (28.0)	-
Overall morbidity	2791 (15.5)	1842 (14.2)	949 (18.9)	<.0001*
Hypocalcemia	1365 (7.6)	919 (7.1)	446 (8.9)	.0001*
Any hematoma	326 (1.8)	228 (1.7)	98 (2.0)	.3874
Any RLN Injury	1084 (6.0)	698 (5.4)	386 (7.7)	<.0001*
Pulmonary morbidity (Pneumonia, Ventilator > 48 hrs, Reintubation)	127 (0.7)	60 (0.5)	67 (1.3)	<.0001*
Wound morbidity (Superficial SSI, Deep SSI, Organ Space SSI, Dehiscence)	135 (0.8)	85 (0.7)	50 (1.0)	.0216*
Bleeding requiring transfusion	40 (0.2)	15 (0.1)	25 (0.5)	<.0001*
Readmission	499 (2.8)	333 (2.6)	166 (3.3)	.0096*
Reoperation	254 (1.4)	154 (1.2)	100 (2.0)	<.0001*
LOS > Median (1 day)	2556 (14.2)	1066 (8.2)	1490 (29.6)	<.0001*

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: RLN, recurrent laryngeal nerve; SSI, surgical site infection; LOS, length of stay.

Table 7. Multivariate Outcomes Analysis						
Outcome	**Energy Device**		**Nerve Monitor**		**Drain**	
	OR (95% CI)	***P* value[a]**	**OR (95% CI)**	***P* value[a]**	**OR (95% CI)**	***P* value[a]**
Overall Morbidity	0.99 (0.90-1.09)	.8294	0.86 (0.79-0.94)	.0011*	1.12 (1.02-1.23)	.0136*
Hypocalcemia	0.98 (0.86-1.11)	.7401	0.92 (0.82-1.05)	.2075	1.00 (0.88-1.14)	.9519
Any hematoma	0.72 (0.57-0.92)	.0090*	0.98 (0.77-1.24)	.8472	0.87 (0.67-1.12)	.2796
Any RLN Injury	1.11 (0.97-1.29)	.1363	0.75 (0.65-0.85)	<.0001*	1.20 (1.05-1.38)	.0084*
Pulmonary morbidity (Pneumonia, Ventilator >48 hrs, Reintubation)	0.75 (0.50-1.12)	.1516	0.65 (0.44-0.98)	.0372*	1.80 (1.22-2.65)	.0030*
Wound morbidity (Superficial SSI, Deep SSI, Organ Space SSI, Dehiscence)	1.06 (0.73-1.57)	.7521	1.04 (0.73-1.51)	.8206	1.30 (0.90-1.85)	.1599
Bleeding requiring transfusion	1.39 (0.66-2.99)	.3936	0.90 (0.43-1.92)	.7901	2.48 (1.21-5.20)	.0138*
Readmission	1.02 (0.84-1.24)	.8516	0.87 (0.72-1.05)	.1405	1.05 (0.86-1.28)	.6329
Reoperation	0.99 (0.75-1.32)	.9324	0.97 (0.74-1.27)	.8044	1.40 (1.07-1.81)	.0117*
LOS > Median (1 day)	0.62 (0.56-0.69)	<.0001*	0.71 (0.64-0.78)	<.0001*	3.78 (3.42-4.19)	<.0001*

[a] Asterisk (*) represents statistical significance at *P* value <.05. Abbreviations: CI, confidence interval; RLN, recurrent laryngeal nerve; SSI, surgical site infection; LOS, length of stay.

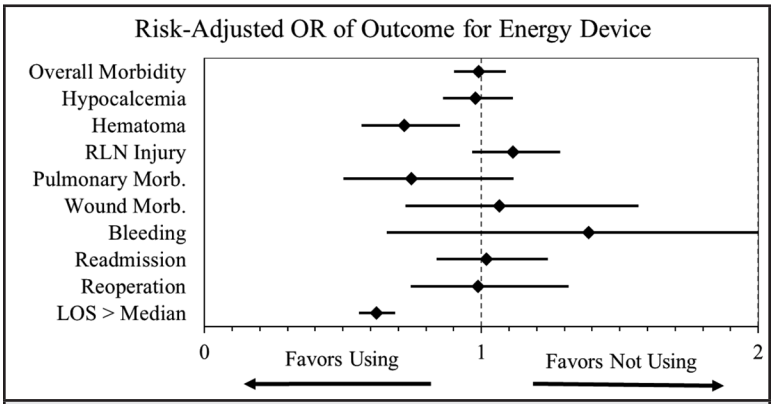

Figure 2. Forest plot of Odds Ratios for Energy Devices

Abbreviations: OR, odds ratio; RLN, recurrent laryngeal nerve; LOS, length of stay.

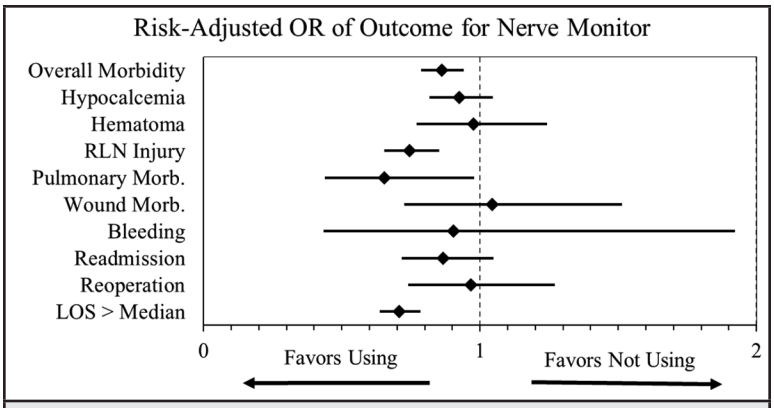

Figure 3. Forest plot of Odds Ratios for Nerve Monitors

Abbreviations: OR, odds ratio; RLN, recurrent laryngeal nerve; LOS, length of stay.

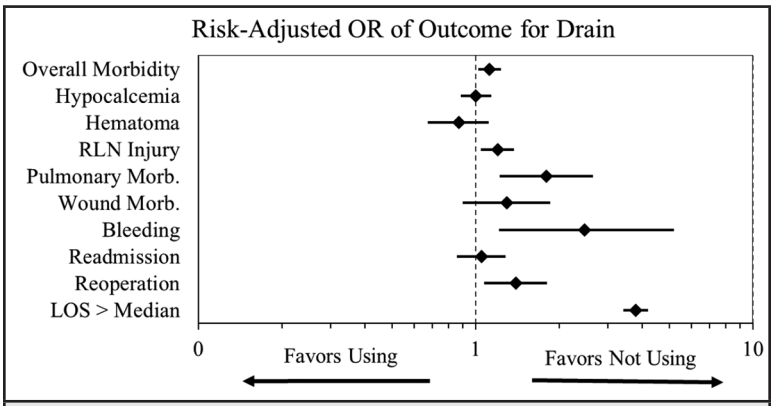

Figure 4. Forest plot of Odds Ratios for Drains

Abbreviations: OR, odds ratio; RLN, recurrent laryngeal nerve; LOS, length of stay.

were not associated with a decreased risk of any of the analyzed adverse outcomes, including hematoma (OR, 0.87; 95% CI, 0.67-1.12; *P*= .2796) and wound morbidity (OR, 1.30; 95% CI, 0.90-1.85; *P*=.1599).

Discussion

We have found that energy devices are associated with a decreased rate of hematoma and decreased LOS greater than the median without an increase in hypocalcemia, RLN injury, or any other adverse outcome. This is consistent with some studies that have shown a lower rate of both hematoma and extended LOS.[1] In fact, energy devices have been shown to have a lower volume of intraoperative blood loss when compared to conventional hemostasis,[2] and it has been estimated that the number needed to treat with an energy device to avoid 1 hematoma is 74.[1] However, others have found no significant difference in postoperative hematoma rate with energy devices compared to conventional hemostasis,[16] and Carlander et al found a higher rate of topical hemostatic agents used with energy devices.[4] Our results are also consistent with other studies finding no difference in RLN injury between energy devices and conventional hemostasis.[1,3,4] In fact, energy devices have been shown to be safe in a porcine model if used greater than 2 mm from the RLN.[17] We found no association between energy devices and hypocalcemia, which is in contrast to others who have found higher[4] and lower[2] rates of hypocalcemia. Although the literature has somewhat mixed results, our results support the routine use of energy devices for thyroidectomy.

We have found that nerve monitors are associated with a decreased rate of overall morbidity, RLN injury, pulmonary morbidity, and LOS greater than the median without an increase in any other adverse outcome. This is in contrast to many other studies on the subject. A large Cochrane review, published in 2019, found no difference in permanent RLN palsy, transient RLN palsy, transient hypoparathyroidism, and operative time between nerve monitor use and visual nerve identification.[5] Several studies have shown no reduction in risk of RLN injury with nerve monitors compared to direct visual identification of the RLN.[6,7] Surprisingly, Chung et al found that nerve monitor use was associated with an increased risk of RLN injury in

partial thyroidectomy and lower rates of RLN injury in total thyroidectomy.[8] Nerve monitor use is associated with a learning curve of approximately 60–90 cases before rates of complication decline,[18] and hospital volume may also influence the effectiveness of nerve monitors as lower rates of RLN injury have been associated with hospitals where more than half of the cases used nerve monitors.[8] Nonetheless, the American Head and Neck Society has published a consensus statement that nerve monitoring can provide more information than sight alone during thyroidectomy.[9] They further state that in cases of loss of nerve monitor signal, the surgeon should consider staging the contralateral procedure to limit the risk of bilateral vocal cord paralysis.[9] Also, a Markov chain analysis by Al-Quarayshi et al found that nerve monitoring during thyroidectomy costs $46 427.97 per quality-adjusted life-year saved and is the preferred strategy in 85.8% of the population.[19] Our results, combined with the consensus statement of the American Head and Neck Society, support the routine use of nerve monitors for thyroidectomy.

We have found that drains are associated with an increased rate of overall morbidity, any RLN injury, pulmonary morbidity, bleeding requiring transfusion, reoperation, and LOS greater than the median without a decrease in hematoma or any other adverse outcome. This finding is consistent with many other studies on the subject. Some have found that drain use is associated with an increased rate of postoperative bleeding and hematoma,[10] and others have found that drain use is not associated with a decreased rate of postoperative hematoma.[11–15] Drain use is also associated with several other adverse outcomes such as unplanned intubation, extended LOS, hypoparathyroidism, transient RLN injury, postoperative pain, wound infection, and LOS.[11–15] Even Halstead, in 1913, in an article about thyroidectomy said, "Hemostasis is attended to with scrupulous care, and the wounds are closed without drainage."[20] Our results, combined with much of the literature on the subject, do not support the routine use of drains for thyroidectomy.

This study has several limitations. First, its retrospective nature precludes conclusions of causality. Specifically, many factors go into a surgeon's decision to use a drain. Many of those factors were captured by the ACS-NSQIP database and analyzed in our study, but there are many others that were not, including known and unknown factors. Another weakness concerns the completeness of data in the ACS-NSQIP database, particularly pre-operative lab values for thrombocytopenia and coagulopathy. Patients with incomplete values were assumed to be normal, but it is entirely possible that some of the patients with bleeding/hematoma complications had thrombocytopenia and/or coagulopathy, and their complications ended up being associated with drain use rather than their underlying, uncaptured, thrombocytopenia/coagulopathy. Finally, as is the case with any retrospective database analysis, many relevant data points are not captured in the database including, but not limited to, drain type and suction, anticoagulation/antiplatelet therapy, specific type of energy device and nerve monitor, topical hemostatic agent use, surgeon training, and surgeon and hospital volume.

We have found several associations between the surgical tools studied and thyroidectomy outcomes. Energy devices are associated with a decreased rate of hematoma and decreased LOS greater than the median without an increase in hypocalcemia or RLN injury. Nerve monitors are associated with a decreased rate of overall morbidity, decreased RLN injury, decreased pulmonary morbidity, and decreased LOS greater than the median. Drains are associated with an increased rate of overall morbidity, increased RLN injury, increased pulmonary morbidity, bleeding requiring transfusion, reoperation, and LOS greater than the median without a decrease in hematoma. Our results support the routine use of energy devices and nerve monitors and do not support the routine use of drains.

Conflict of Interest

None of the authors identify a conflict of interest.

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References

1. Siu JM, McCarty JC, Gadkaree S, et al. Association of vessel-sealant devices vs conventional hemostasis with postoperative neck hematoma after thyroid operations. *JAMA Surg* 2019;154:e193146. doi:10.1001/jamasurg.2019.3146
2. Ramouz A, Rasihashemi SZ, Safaeiyan A, Hosseini M. Comparing postoperative complication of LigaSure Small Jaw instrument with clamp and tie method in thyroidectomy patients: a randomized controlled trial [IRCT2014010516077N1]. *World J Surg Oncol* 2018;16:154. doi:10.1186/s12957-018-1448-9
3. Uludag SS, Teksoz S, Arikan AE, et al. Effect of energy-based devices on voice quality after total thyroidectomy. *Eur Arch Oto-Rhino-Laryngology* 2017;274:2295–2302. doi:10.1007/s00405-016-4444-0
4. Carlander J, Wagner P, Gimm O, et al. Risk of complications with energy-based surgical devices in thyroid surgery: a national multicenter register study. *World J Surg* 2016;40:117–123. doi:10.1007/s00268-015-3270-7
5. Cirocchi R, Arezzo A, D'Andrea V, et al. Intraoperative neuromonitoring versus visual nerve identification for prevention of recurrent laryngeal nerve injury in adults undergoing thyroid surgery. *Cochrane Database Syst Rev* 2019;1:CD012483. doi:10.1002/14651858.CD012483.pub2
6. Mizuno K, Takeuchi M, Kanazawa Y, et al. Recurrent laryngeal nerve paralysis after thyroid cancer surgery and intraoperative nerve monitoring. *Laryngoscope* 2019;129:1954–1960. doi:10.1002/lary.27698
7. Henry BM, Graves MJ, Vikse J, et al. The current state of intermittent intraoperative neural monitoring for prevention of recurrent laryngeal nerve injury during thyroidectomy: a PRISMA-compliant systematic review of overlapping meta-analyses. *Langenbeck's Arch Surg* 2017;402:663–673. doi:10.1007/s00423-017-1580-y
8. Chung TK, Rosenthal EL, Porterfield JR, Carroll WR, Richman J, Hawn MT. Examining national outcomes after thyroidectomy with nerve monitoring. *J Am Coll Surg* 2014;219:765–770. doi:10.1016/j.jamcollsurg.2014.04.013
9. Fundakowski CE, Hales NW, Agrawal N, et al. Surgical management of the recurrent laryngeal nerve in thyroidectomy: American Head and Neck Society Consensus Statement. *Head Neck* 2018;40:663–675. doi:10.1002/hed.24928
10. Tabaqchali MA, Hanson JM, Proud G. Drains for thyroidectomy/parathyroidectomy: fact or fiction? *Ann R Coll Surg Engl* 1999;81:302–305. http://www.ncbi.nlm.nih.gov/pubmed/10645171. Accessed November 10, 2019.
11. Maroun CA, El Asmar M, Park S, et al. Drain placement in thyroidectomy is associated with longer hospital stay without preventing hematoma. *Laryngoscope* 2019:lary.28269. doi:10.1002/lary.28269
12. Li L, Chen H, Tao H, et al. The effect of no drainage in patients who underwent thyroidectomy with neck dissection. *Medicine (Baltimore)* 2017;96:e9052. doi:10.1097/MD.0000000000009052
13. Portinari M, Carcoforo P. The application of drains in thyroid surgery. *Gland Surg* 2017;6:563–573. doi:10.21037/gs.2017.07.04
14. Schietroma M, Pessia B, Bianchi Z, et al. Thyroid surgery: to drain or not to drain, that is the problem - a randomized clinical trial. *ORL* 2017;79:202–211. doi:10.1159/000464137
15. Tian J, Li L, Liu P, Wang X. Comparison of drain versus no-drain thyroidectomy: a meta-analysis. *Eur Arch Oto-Rhino-Laryngology* 2017;274:567–577. doi:10.1007/s00405-016-4213-0
16. Hua N, Quimby AE, Johnson-Obaseki S. Comparing hematoma incidence between hemostatic devices in total thyroidectomy: a systematic review and meta-analysis. *Otolaryngol Neck Surg* 2019;161:770–778. doi:10.1177/0194599819865248
17. Applewhite MK, White MG, James BC, et al. Ultrasonic, bipolar, and integrated energy devices: comparing heat spread in collateral tissues. *J Surg Res* 2017;207:249–254. doi:10.1016/j.jss.2016.06.077
18. Zhao N, Bai Z, Teng C, Zhang Z. Learning curve for using intraoperative neural monitoring technology of thyroid cancer. *Biomed Res Int* 2019;2019:1–6. doi:10.1155/2019/8904736
19. Al-Qurayshi Z, Kandil E, Randolph GW. Cost-effectiveness of intraoperative nerve monitoring in avoidance of bilateral recurrent laryngeal nerve injury in patients undergoing total thyroidectomy. *Br J Surg* 2017;104:1523–1531. doi:10.1002/bjs.10582
20. Halsted WS. IV. (I) The excision of both lobes of the thyroid gland for the cure of Graves's Disease. (II) The preliminary ligation of the thyroid arteries and of the inferior in preference to the superior artery. *Ann Surg* 1913;58:178–182. doi:10.1097/00000658-191308000-00004

Predictors of Morbidity Following Enterostomy Closure in Infants: An American College of Surgeons Pediatric National Surgical Quality Improvement Program Database Analysis

Reid Sakamoto MD; John Vossler MD, MS, MBA; and Russell Woo MD, FACS

Abstract

Optimal timing of enterostomy closure in infants is poorly defined, and clinical practice is based mainly on surgeon preference. This study aims to determine the predictors of morbidity in infants < 365 days old undergoing enterostomy reversal. A retrospective analysis of the American College of Surgeons National Surgical Quality Improvement Program Pediatric (ACS-NSQIP Peds) database was conducted from 2012–2017, including all laparoscopic and open enterostomy reversals in patients < 365 days old. Predictors of overall morbidity were analyzed by bivariate and multivariate logistic regression analysis with statistical significance at P < .05. We identified 2415 cases with an overall morbidity rate of 30.5%. Bivariate analysis identified that younger age, lower weight, prematurity, pulmonary disease, previous cardiac surgery, preoperative nutritional support, preoperative steroids, and preoperative transfusion were associated with overall morbidity for enterostomy closure. On multivariate analysis, prematurity < 30 weeks at birth (odds ratio [OR], 1.49; 95% confidence interval [CI]; 1.07-2.08), pulmonary disease (OR, 1.31; 95% CI, 1.01-1.71), and preoperative nutritional support (OR, 2.46; 95% CI 1.99-3.05) were independently associated with overall morbidity. Age and weight at the time of enterostomy closure were not independently associated with overall morbidity on multivariate analysis. Prematurity < 30 weeks at birth, presence of pulmonary disease, and preoperative need for nutritional support were independent predictors of overall morbidity in patients < 365 days old undergoing enterostomy reversal. Given the high rate of overall morbidity in this population, further research into the matter is warranted.

Keywords

pediatric, neonate, infant, enterostomy, enterostomy reversal

Abbreviations and Acronyms

ACS-NSQIP = American College of Surgeons National Surgical Quality Improvement Program
ACS-NSQIP Peds = American College of Surgeons National Surgical Quality Improvement Program Pediatric
CPT = current procedural terminology

Introduction

Enterostomy formation is often necessary for the treatment of several acute life-threatening conditions in the infant population.[1–3] These conditions include necrotizing enterocolitis, spontaneous intestinal perforation, and meconium obstruction, which may be fatal without surgical intervention.[1,4] Despite optimal management, enterostomy formation is a source of long-term morbidity in the infant population and may result in complications such as stoma prolapse, intestinal obstruction, stoma retraction, stoma ischemia, fluid and electrolyte losses, and poor weight gain in up to 41% of patients.[1,5–7]

Optimal timing of closure of enterostomy is controversial and conflicting evidence exists on best practice. Several studies have suggested using specific weight cut-offs to identify patients who are safe for enterostomy closure.[1,8,9] However, patients who have failure to thrive due to a nutritionally restrictive enterostomy may find it difficult to attain these specific weight goals. Other authors have suggested waiting a certain amount of time from enterostomy creation until reversal to ensure safe closure.[10–13] Advocates of late closure report fewer adhesions and reduced inflammation as a benefit to delaying stoma closure. Regardless, good nutritional status and a stable medical condition are preferable for ostomy reversal.[4] Due to this conflicting data and lack of prospective randomized controlled trials on this topic, closure timing is often left up to the surgeon's experience and preference.

To date, there is no large data series reporting on the timing of enterostomy closure and factors associated with morbidity and mortality. It would be useful to determine a set of predictors that could guide the timing of enterostomy takedown in infants. This study aims to determine risk factors associated with morbidity and mortality for the takedown of enterostomy in the infant population.

Materials and Methods

Data Collection

Data were collected from the American College of Surgeons National Surgical Quality Improvement Program Pediatric (ACS-NSQIP Peds) Registry. ACS-NSQIP Peds collects 94 data points from children less than 18 years who undergo major surgical procedures. Outcome data is collected for 30 days postoperatively. Institutional Review Board approval was not obtained as the NSQIP registry is a publicly available and de-identified data set.

Cohort Selection

A retrospective review of the ACS-NSQIP Peds database was performed from 2012 to 2017 to evaluate variables associated with morbidity in pediatric patients undergoing ostomy reversal. We included all patients under 365 days old undergoing laparoscopic and open enterostomy reversal. Included were all patients with current procedural terminology (CPT) codes 44227, 44620, 44625, and 44626.

Cohort Characteristics

Patient characteristics and outcomes were collected as part of the ACS-NSQIP Peds database. Patient characteristics included age, weight, prematurity, neurologic disorder, major cardiac risk factor, previous cardiac surgery, structural pulmonary abnormality, pulmonary disease, need for pulmonary support, preoperative nutritional support, preoperative transfusion (< 72 hours before surgery), and preoperative steroids. Age was further divided into 3 separate categories: 0–30 days, 1–3 months, and 3–12 months. Prematurity was further divided into groups of < 30 weeks, 31–36 weeks, and > 36 weeks (term). Similarly, weight was divided into 3 separate categories: < 2 kg, 2–4 kg, and > 4 kg.

Outcomes

The primary outcome of this study was defined as 30-day morbidity as a result of enterostomy closure. Morbidity was defined by the presence of at least 1 of the following postoperative complications: death, pulmonary complication, renal complication, cerebrovascular accident, intraventricular hemorrhage, seizure, cardiac arrest, pneumonia, reintubation, hemorrhage, renal failure or insufficiency, deep vein thrombosis, sepsis, urinary tract infection, central line-associated bloodstream infection, dehiscence, surgical site infection, reoperation, and readmission.

Statistical Analysis

Bivariate analysis of predictors of morbidity was performed using Chi-square test or *t*-test of proportions as appropriate. Multivariate analysis of predictors of morbidity was performed by multiple logistic regression resulting in risk-adjusted odds ratios for the outcome of interest given each risk factor. Statistical significance was assigned to a $P < .05$. Statistical analysis was performed with R version 3.5.1.

ACS-NSQIP Disclosure Statement

The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Results

From 2012 to 2017, a total of 2415 open or laparoscopic enterostomy reversals were performed on infants < 365 days old. Sixty-two percent of these patients were male, and the average age at time of enterostomy takedown was 152 days old (± 87 days). We were not able to extract data on time from enterostomy formation until takedown. The average weight at enterostomy takedown was 5.10 kg (± 2.38 kg).

In total, 30.5% of patients in our study population had any morbidity (Table 1). The most frequent morbidities encountered were bleeding, infection, and the need for reoperation. We found that children at younger ages at enterostomy reversal had higher rates of morbidity. This finding was significant on bivariate analysis; however, this relationship was not maintained on multivariate analysis. Additionally, there was a higher rate of morbidity in patients when enterostomy closure occurred at lower weights.

Similarly, this relationship was significant on bivariate analysis but was not significant on multivariate analysis. Compared to children born at term, premature infants had significantly higher morbidity rates at ostomy reversal on bivariate analysis. However, only prematurity < 30 weeks was significantly associated with morbidity (Table 2). These data suggest that reversing enterostomies at a lower weight may not confer increased morbidity.

On bivariate analysis, underlying neurologic disorder (35%; $P < .05$), major or severe cardiac risk factor (34.9%; $P = .02$), previous cardiac surgery (42.8%; $P < .05$), pulmonary disease (47.2%; $P < .05$), respiratory support (51.1%; $P < .05$), preoperative nutritional support (46.9%; $P < .05$), preoperative transfusion within 72 hours of surgery (42.4%; $P < .05$), and preoperative steroid use (53.1%, $P < .05$) were significantly associated with any morbidity. On multivariate analysis, however, only prior pulmonary disease (odds ratio [OR], 1.31; 95% confidence interval [CI], 1.01-1.71) and the need for preoperative nutritional support (OR, 2.46; 95% CI 1.99-3.05) were found to be significantly associated with morbidity (Table 2).

Discussion

Our study sought to identify predictors of morbidity and mortality in pediatric patients < 365 days old undergoing enterostomy closure. Our findings from multivariate analysis indicated that prematurity < 30 weeks, presence of pulmonary disease, and the need for perioperative nutrition were significantly associated with increased morbidity and mortality. Interestingly, age and weight at time of reversal were not significantly associated with increased morbidity on multivariate analysis.

There have been several studies assessing individual risk factors associated with enterostomy closure in the pediatric patient. To our knowledge, this is the first large data series that examines variables associated with morbidity in infants < 365 days old undergoing enterostomy reversal. Currently, there is poor evidence to direct ostomy closure in the pediatric population.[11] Often, a weight of 2.0–2.5 kg is used as a threshold to direct timing for enterostomy closure.[1,4] This practice, however, has recently come into question.

Several retrospective studies have established the safety of ostomy reversal at weights < 2.0 kg without increasing morbidity or mortality.[6,9,14] Talbot et al examined a cohort of 89 patients

Table 1. Bivariate Analysis of Demographic Features and Preoperative Risk Factors Versus Morbidity In Children < 365 Days Old				
Variables	**Total**	**No Morbidity n (%)**	**Any Morbidity n (%)**	***P* value**
All Patients	2415	1679 (69.5)	736 (30.5)	--
Age				
3–12 months	1198	948 (79.1)	250 (20.9)	<.05
1–3 months	267	192 (72.0)	75 (28.0)	
Neonate (0–30 days)	949	539 (56.8)	410 (43.2)	
Weight				
>4 kg	1405	1103 (78.5)	302 (21.5)	<.05
2–4 kg	889	516 (58.0)	373 (42.0)	
<2 kg	121	60 (50.0)	61 (50.0)	
Birth type				
Term (>36 weeks)	979	749 (81.1)	185 (18.9)	<.05
Premature (31–36 weeks)	555	397 (71.5)	158 (28.5)	
Premature (<30 weeks)	881	488 (55.4)	393 (44.6)	
Preoperative risk factors				
Neurologic disorder	535	344 (64.3)	191 (35.7)	<.05
Major/severe cardiac risk factor	473	308 (65.1)	165 (34.9)	.02
Previous cardiac surgery	276	158 (57.2)	118 (42.8)	<.05
Structural pulmonary abnormality	124	78 (62.9)	46 (37.1)	.10
Pulmonary disease				
(including asthma)	631	333 (52.8)	298 (47.2)	<.05
Ventilator, trachea, or O2 support	401	196 (48.9)	205 (51.1)	<.05
Preoperative nutritional support	979	520 (53.1)	459 (46.9)	<.05
Preoperative transfusion				
(<72 hours)	217	125 (57.6)	92 (42.4)	<.05
Preoperative steroids	96	45 (46.9)	51 (53.1)	<.05

<6 months of age who underwent ostomy reversal. Patients were divided into four groups based on weight at reversal (<2 kg, 2.01–2.5 kg, 2.51–3.5 kg, and >3.5 kg). They found no significant difference in postoperative morbidity associated with ostomy reversal at lower weights compared to higher weights.[9] Lucas et al examined the NSQIP-Pediatric database from 2012 to 2015 to determine risk factors for adverse outcomes. Similar to our findings, they determined that closure at <2 kg was not associated with an increased risk of 30-day mortality after enterostomy closure.[14]

Our findings demonstrate that closure of enterostomy at lower weights is feasible and is not associated with increased morbidity. Prematurity <30 weeks, existing pulmonary disease, and the need for perioperative nutritional support were the only factors associated with increased morbidity on enterostomy reversal. These findings should prompt surgeons to avoid using an arbitrary weight cut-off in determining appropriateness for enterostomy reversal. Instead, modifiable factors such as nutritional optimization and resolution of pulmonary disease should dictate the timing of reversal.

This study is limited by its retrospective database design; thus, the causality of risk factors affecting outcomes cannot be concluded. Individual factors of patients were unable to be ascertained or investigated further. The indication for ostomy and the type of ostomy formed was not able to be determined during data collection. We were limited by the variables collected in the NSQIP database, and all outcomes and morbidities were only available within 30 days of surgery. In addition, determining whether ostomy takedown was performed electively versus urgently for an ostomy-related complication could improve our analysis. Future investigation into specific risk factors resulting in common complications could better equip surgeons in the preoperative evaluation of an infant's preparedness for enterostomy reversal.

In conclusion, we have identified several risk factors that are associated with morbidity in children <365 days old undergoing enterostomy reversal. Our findings suggest that an arbitrary weight or age cut-off may not be associated with operative morbidity in this population. The decision on the timing of enterostomy takedown will likely continue to be based on sur-

Table 2. Multivariate Analysis of Predictors of Morbidity In Children < 365 Days Old			
Variables	**OR**	**95% CI**	***P* value**
Age			
3–12 months	Reference	--	
1–3 months	1.28	0.91-1.80	.15
Neonate (0–30 days)	1.31	0.97-1.77	.08
Weight			
>4 kg	Reference	--	
2–4 kg	1.04	0.78-1.39	.77
<2 kg	1.25	0.78-2.01	.34
Birth type			
Term (>36 weeks)	Reference	--	
Premature (31–36 weeks)	1.25	0.93-1.68	.13
Premature (<30 weeks)	1.49	1.07-2.08	.02
Preoperative risk factors			
Neurologic disorder	1.21	0.97-1.51	.08
Major/severe cardiac risk factor	0.96	0.76-1.21	.07
Previous cardiac surgery	1.12	0.84-1.49	.44
Structural pulmonary abnormality	1.16	0.76-1.74	.48
Pulmonary disease			
(including asthma)	1.31	1.01-1.71	.05
Ventilator, trachea, or O2 support	1.20	0.90-1.59	.21
Preoperative nutritional support	2.46	1.99-3.05	<.05
Preoperative transfusion			
(<72 hours)	0.92	0.67-1.25	.60
Preoperative steroids	1.14	0.73-1.77	.57

Abbreviations: CI, confidence interval; OR, odds ratio.

geon preference and experience; however, this study describes additional factors to consider before proceeding to surgery.

Conflict of Interest

None of the authors identify a conflict of interest.

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References

1. Lee J, Kang MJ, Kim HS, et al. Enterostomy closure timing for minimizing postoperative complications in premature infants. *Pediatr Neonatol*. 2014;55(5):363-368. doi:10.1016/j.pedneo.2014.01.001
2. Chong C, van Druten J, Briars G, et al. Neonates living with enterostomy following necrotising enterocolitis are at high risk of becoming severely underweight. *Eur J Pediatr*. 2019;178(12):1875-1881. doi:10.1007/s00431-019-03440-6
3. Christian VJ, Polzin E, Welak S. Nutrition management of necrotizing enterocolitis. *Nutr Clin Pract*. 2018;33(4):476-482. doi:10.1002/ncp.10115
4. Yang YJ. The optimal timing of enterostomy closure in preterm infants. *Pediatr Neonatol*. 2014;55(5):333-334. doi:10.1016/j.pedneo.2014.06.001
5. Bethell G, Kenny S, Corbett H. Enterostomy-related complications and growth following reversal in infants. *Arch Dis Child Fetal Neonatal Ed*. 2017;102(3):F230-F234. doi:10.1136/archdischild-2016-311126
6. Kargl S, Wagner O, Pumberger W. Ileostomy complications in infants less than 1500 grams – frequent but manageable. *J Neonatal Surg*. 2016;6(1):4. doi:10.21699/jns.v6i1.451
7. Rothstein FC, Halpin TC, Kliegman RJ, Izant RJ. Importance of early ileostomy closure to prevent chronic salt and water losses after necrotizing enterocolitis. *Pediatrics*. 1982;70(2):249-253.
8. Yang HB, Han JW, Youn JK, Oh C, Kim HY, Jung SE. The optimal timing of enterostomy closure in extremely low birth weight patients for acute abdomen. *Sci Rep*. 2018;8(1):2-11. doi:10.1038/s41598-018-33351-9
9. Talbot LJ, Sinyard RD, Rialon KL, et al. Influence of weight at enterostomy reversal on surgical outcomes in infants after emergent neonatal stoma creation. *J Pediatr Surg*. 2017;52(1):35-39. doi:10.1016/j.jpedsurg.2016.10.015
10. Banerjee DB, Vithana H, Sharma S, Tsang TTM. Outcome of stoma closure in babies with necrotising enterocolitis: early vs late closure. *Pediatr Surg Int*. 2017;33(7):783-786. doi:10.1007/s00383-017-4084-5
11. Struijs MC, Sloots CEJ, Hop WCJ, Tibboel D, Wijnen RMH. The timing of ostomy closure in infants with necrotizing enterocolitis: A systematic review. *Pediatr Surg Int*. 2012;28(7):667-672. doi:10.1007/s00383-012-3091-9
12. Struijs MC, Poley MJ, Meeussen CJHM, Madern GC, Tibboel D, Keijzer R. Late vs early ostomy closure for necrotizing enterocolitis: Analysis of adhesion formation, resource consumption, and costs. *J Pediatr Surg*. 2012;47(4):658-664. doi:10.1016/j.jpedsurg.2011.10.076
13. Al-Hudhaif J, Phillips S, Gholum S, Puligandla PP, Flageole H. The timing of enterostomy reversal after necrotizing enterocolitis. *J Pediatr Surg*. 2009;44(5):924-927. doi:10.1016/j.jpedsurg.2009.01.028
14. Lucas DJ, Gosain A. Association of Comorbidities with Adverse Outcomes After Enterostomy Closure in Premature Neonates. *JAMA Surg*. 2018;153(8):776-778. doi:10.1001/jamasurg.2018.0874

Cookiecutter Shark-Related Injuries: A New Threat to Swimming Across the Ka‘iwi Channel

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Abstract

In a 5-month period in 2019, 3 long-distance swimmers sustained cookiecutter shark-related injuries while attempting to cross the Ka‘iwi Channel between the Hawaiian Islands of O‘ahu and Moloka‘i. This report is the first case series of cookiecutter shark bites on live humans. A retrospective review of the State of Hawai‘i Division of Aquatic Resources Shark Incidents List was conducted between March 1, 2019, and July 31, 2019. Trauma registry data and medical records were reviewed in patients treated for cookiecutter shark bites at The Queen’s Medical Center in Honolulu, Hawai‘i. All 3 patients sustained nonfatal cookiecutter shark bite circular wounds measuring between 8–13 cm in diameter. They were injured swimming over waters with depths of greater than 2000 feet at night. Patients had prolonged transport times to the emergency department (ED), averaging 73 minutes, due to their injuries occurring on the open water. All were hemodynamically stable upon ED arrival and did not require blood products. Tetanus toxoid was updated, and prophylactic antibiotic coverage, including doxycycline for Vibrio spp., was administered. Two of 3 patients were treated with operative management. Open water swimmers crossing the deep waters between the Hawaiian Islands at night are most at risk for cookiecutter shark bites. Wounds may penetrate down to and through the fascial level. Immediate life-saving hemorrhage control administered by personnel accompanying the swimmers on the open water is important for preventing morbidity and mortality. Antibiotic prophylaxis for marine bacteria is recommended.

Keywords

Hawai‘i, shark, bite

Abbreviations and Acronyms

ABI = ankle-brachial index
CDC = Centers for Disease Control and Prevention
CK = creatinine kinase
DAR = Division of Aquatic Resources
DLNR = Department of Land and Natural Resources
ED = emergency department
EMS = Emergency Medical Services
OR = operating room
PCP = primary care provider
PO = oral
POD = postoperative day
QMC = The Queen’s Medical Center
SIT = Shark-Induced Trauma
Td = tetanus-diphtheria
Tdap = tetanus, diphtheria, and pertussis

Background

Cookiecutter sharks (*Isistius* spp.) are best known for their unique bite and feeding habits that leave a distinctive shallow, smooth, circular, concave wound resembling the cut-out of a cookie cutter. These small, elusive, nocturnal predators are known to feed on a variety of prey, including sharks, whales, rays, sea turtles, and other large pelagic species. Nearly all prior reports of human injuries attributed to the cookiecutter shark have described characteristic wounds on corpses found in the open ocean off the coasts of Comoros, Tanzania, Japan, and Kaua‘i, Hawai‘i.[1–4] In March 2009, the first documented attack on a live human involved an adult long-distance swimmer attempting to cross the ‘Alenuihāhā Channel between the Hawaiian Islands of Hawai‘i and Maui at night.[5] Ten years later, 3 long-distance open ocean swimmers sustained cookiecutter shark bites while attempting to cross the Ka‘iwi Channel between the Hawaiian Islands of O‘ahu and Moloka‘i over 5 months in 2019. This case series describes the unique injuries sustained from the cookiecutter shark, the unique circumstances of these injuries, and subsequent treatment.

Methods

A prior 10-year retrospective review of the State of Hawai‘i Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) Shark Incidents List identified an unusual series of 3 cookiecutter shark-related injuries between March and July 2019.[6] After institutional review board approval, all data associated with these cookiecutter shark cases in the Shark Incidents List were reviewed, including date and time, location, victim’s activity, water depth, treatment facility, injury description, shark species, and shark size. All patients presented to The Queen’s Medical Center (QMC) in Honolulu, Hawai‘i, a Level 1 trauma center. Trauma registry data and medical records were reviewed retrospectively for clinical data, including patient demographics, treatment provided, and patient outcomes.

Results

Case 1: A male, domestic, non-Hawai‘i resident in his 50s with no significant past medical history was swimming the Ka‘iwi Channel when he suddenly felt pain in his lower abdomen around 3:30 AM, approximately 9.5 hours into his swim. Initial thoughts were that he suffered a jellyfish sting; however, when pulled out of the water by the escort kayak, they noted a

circular bleeding wound just below his umbilicus. The incident occurred approximately 12 miles east-southeast of Koko Head in clear water over 2000 feet in depth (Figure 1). The length of the cookiecutter shark was unknown. Pressure was applied to the wound with a towel, and Emergency Medical Services (EMS) was notified. The patient was brought to shore and then transported by ambulance to QMC, arriving approximately 1 hour and 5 minutes after the bite occurred.

On arrival in the emergency department (ED), his vital signs were within normal limits. Focused Assessment with Sonography for Trauma (FAST) exam was negative for intraperitoneal fluid. Labs were only notable for leukocytosis to 12.57 $x10^3$/mL and mild elevation of creatinine kinase (CK) of 828 IU/L. Tetanus-diphtheria (Td) vaccine, intravenous (IV) doxycycline 100 mg, and IV ceftriaxone 2 g were empirically administered. After evaluation by the trauma team, he was taken emergently to the operating room (OR) for exploration of the penetrating abdominal wound and control of bleeding. The 8-cm circular wound went through the skin and subcutaneous tissues, through the rectus muscle and fascia, down to the level of preperitoneal fat with active bleeding from intramuscular vessels (Figure 2). The peritoneal cavity was not violated. Bleeding was controlled with suture ligation and electrocautery, the fascia closed primarily, and skin left open with a wet-to-dry dressing applied. No blood products were administered. He was discharged on postoperative day (POD) 2 with oral (PO) doxycycline 100 mg every 12 hours, PO ciprofloxacin 500 mg every 12 hours, and continued local wound care. Follow-up was arranged with providers near his home for definitive treatment, where he returned 2 days later.

Case 2: A male, domestic, non-Hawai‘i resident in his 20s with no significant past medical history was swimming the Ka‘iwi Channel when he suddenly felt pain in the left posterior shoulder around 1:00 AM, approximately 7 hours into his swim. The incident occurred approximately 12 miles east-southeast of Koko Head, about the same location as the previous case (Figure 1). The length of the cookiecutter shark was estimated at 1 foot based on wound size. The patient received wound care with blood clotting materials on the main boat. Once ashore, he was transported by ambulance to QMC, arriving approximately 1 hour and 24 minutes after injury.

On arrival in the ED, vital signs were within normal limits, and labs were notable for leukocytosis to 16.56 $x10^3$/mL. Due to penicillin allergy, IV clindamycin 600 mg, IV doxycycline 100 mg, and IV ciprofloxacin 400 mg were empirically administered. Tetanus, diphtheria, and pertussis (Tdap) vaccine was updated. On examination by the ED physician, no active bleeding was noted in the 13-cm circular wound with exposed muscle (Figure 3). In the afternoon, a complex wound repair with multiple layer closure was performed in the OR by the consulted plastic surgeon. The patient was discharged POD 1 with five days of PO doxycycline 100 mg twice a day and PO clindamycin 300 mg 4 times a day. He flew home on the day of discharge, instructed to follow up with his primary care provider (PCP).

Case 3: A male international visitor in his 40s with no significant past medical history was swimming the Ka‘iwi Channel when he sustained a cookiecutter shark bite to the left inner thigh around 10:25 PM, approximately 7 hours into his swim. Initially pulled from the water via escort kayak, he was brought to the main boat, where a tourniquet was applied around 10:30 PM. The incident occurred approximately 11 miles east-southeast of Sandy’s Beach in clear water over 2000 feet in depth (Figure 1). The length of the cookiecutter shark is unknown. Once ashore, he was transported by ambulance to QMC, arriving approximately 1 hour and 10 minutes after injury.

On arrival in the ED, vital signs were within normal limits, and labs were notable for leukocytosis to 17.5 $x10^3$/mL. The trauma team evaluated him, and the tourniquet was removed shortly after ED arrival, approximately 1 hour and 12 minutes after application. Td vaccine and IV cefazolin 2 g were administered. An 8 cm circular wound with exposed muscle to the upper inner left thigh without active bleeding was identified (Figure 4). Ankle-brachial index (ABI) was 0.8 and equivalent in bilateral lower extremities such that no further vascular workup was obtained. The wound was irrigated in the ED, and a wet-to-dry dressing was applied. He was discharged from the ED with 10 days of PO doxycycline 100 mg every 12 hours and local wound care instructions. After a wound check 3 days later, he was cleared to return to his home country with instructions to follow up with his PCP.

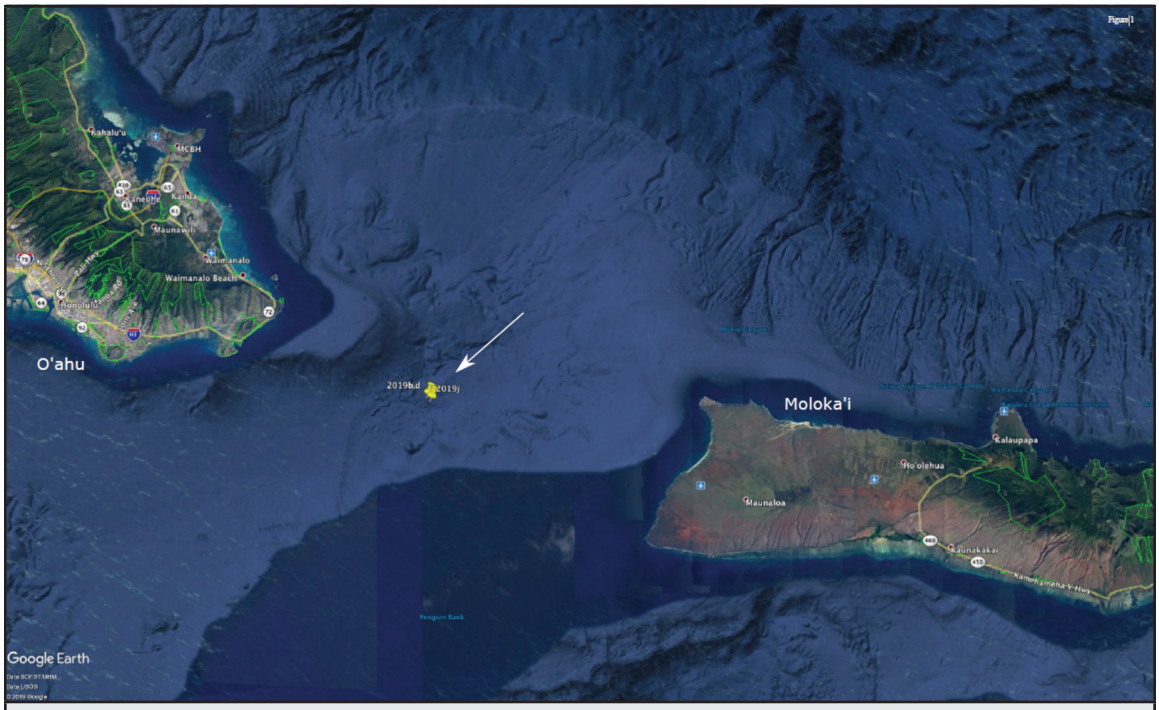

Figure 1. Map showing location of all 3 incidents, noted by thumbtacks with arrow pointing toward them. (Courtesy of the Division of Aquatic Resources, Hawai'i Department of Land and Natural Resources.)

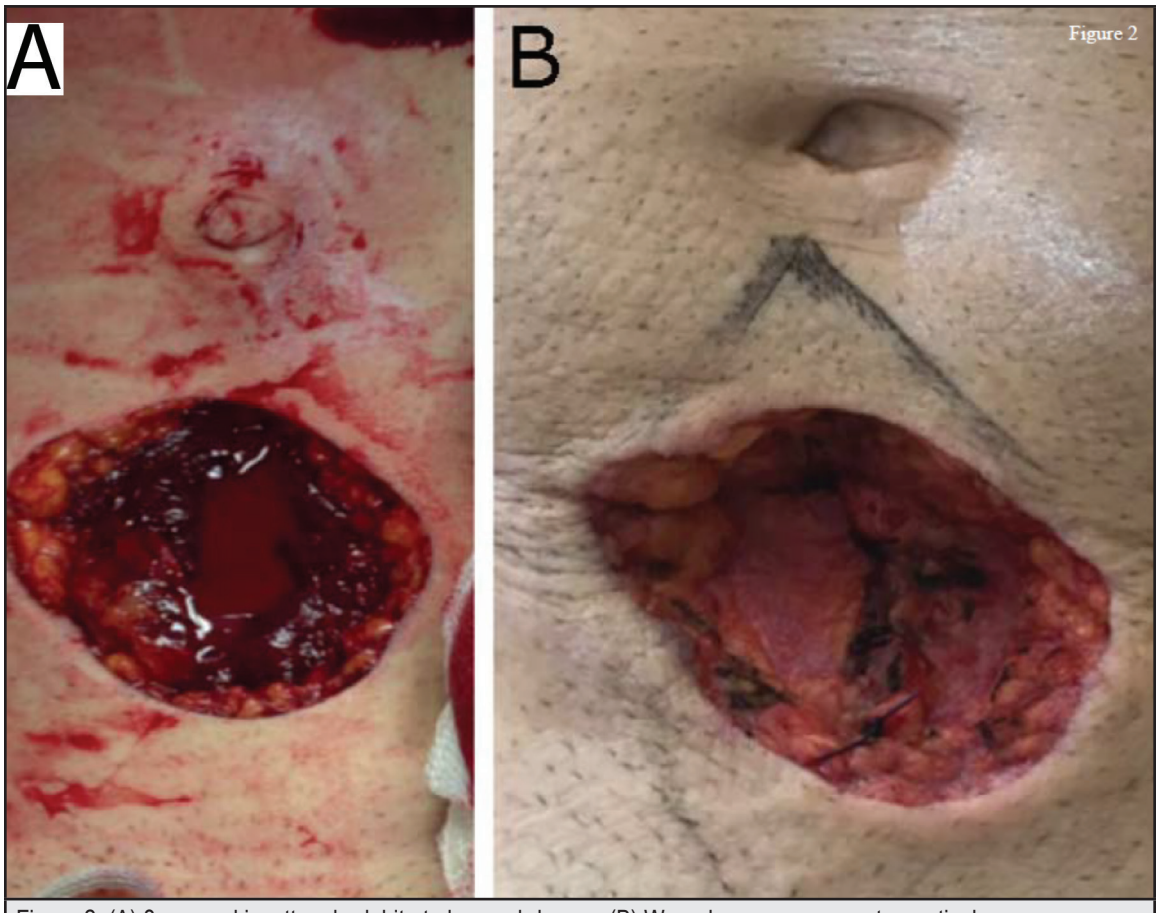

Figure 2. (A) 8-cm cookiecutter shark bite to lower abdomen. (B) Wound appearance postoperatively.

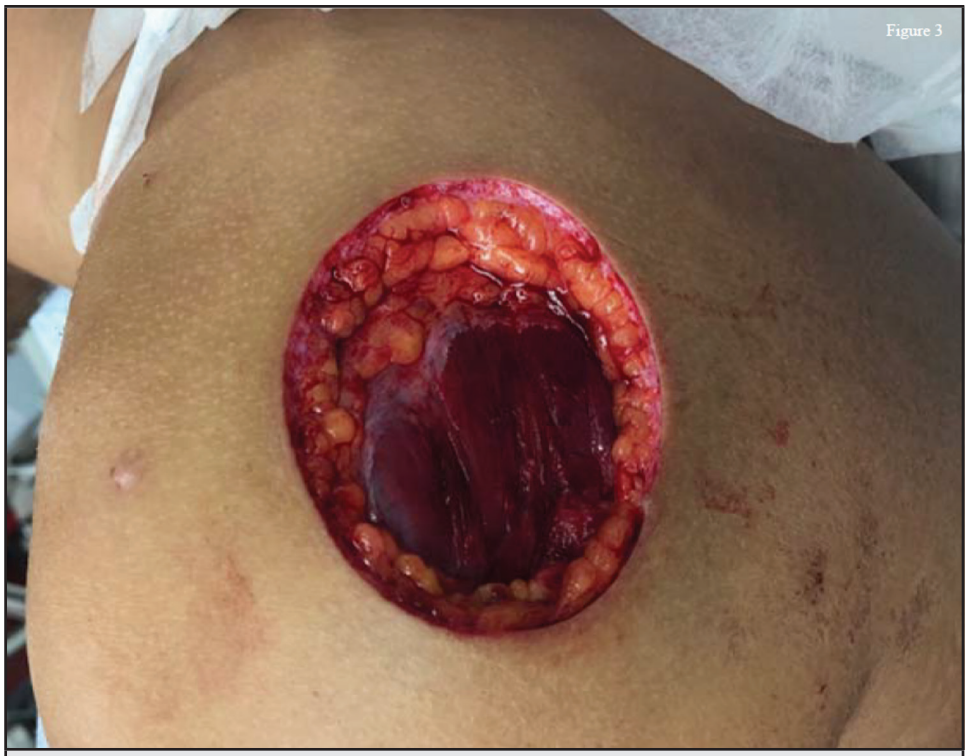

Figure 3. 13-cm cookiecutter shark bite to the posterior left shoulder.

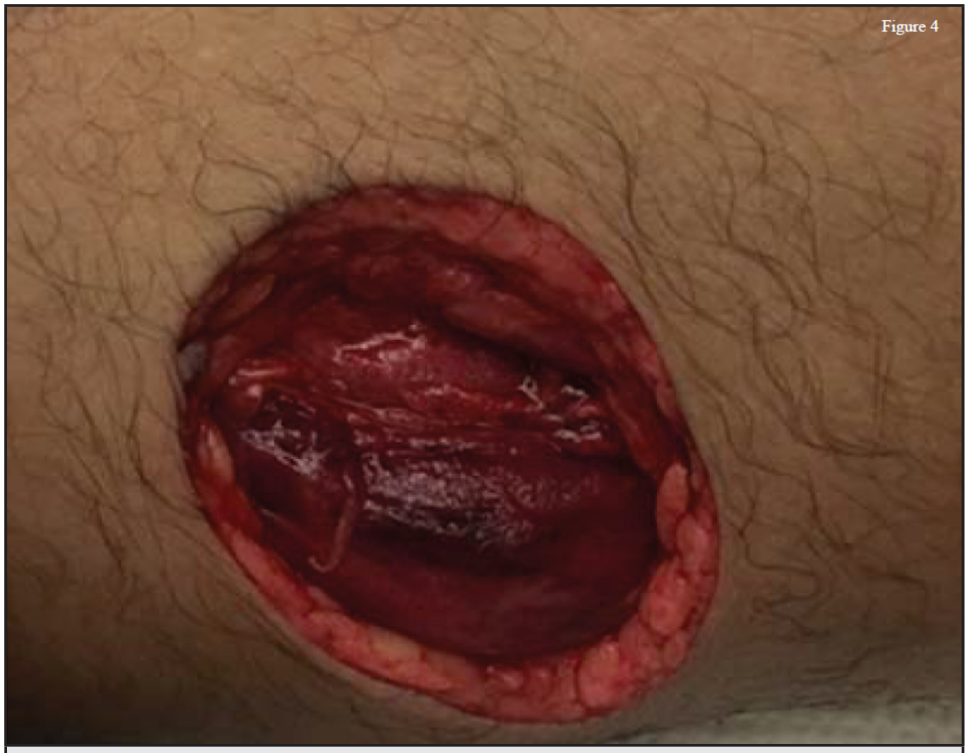

Figure 4. 8-cm cookiecutter shark bite to the inner left thigh.

Figure 5. Stop the Bleed basic principles.[9]

Discussion

This report is the largest published series of cookiecutter shark attacks on live humans and only the second description of such events to date. Ka‘iwi Channel swimmers typically depart from La‘au Point on Moloka‘i between 6:30 PM and 7:30 PM to minimize sun exposure.[7] The timing of this channel crossing coincides with the nocturnal surface feeding activity of the cookiecutter shark. These predators are known to exhibit “hit and run” feeding behavior, taking bites from large pelagic prey while also consuming smaller prey whole. The only other reported case of a cookiecutter shark injury on a live human speculated that boat illumination might have attracted prey, including the purple-back squid, and subsequently, a cookiecutter shark.[5] All 3 victims sustained circular, relatively superficial soft tissue injuries in the middle of the Ka‘iwi Channel in nearly identical locations.

Cookiecutter sharks leave distinctive round or oval scooped-out wounds in their prey, but the exact mechanism of their unique feeding pattern is unknown.[5] The Shark-Induced Trauma (SIT) scale allows for assessment of the injury severity and risk for mortality specific to a shark bite.[8] Factors such as initial blood pressure, location of the injury, debility of the injury, and complexity of the treatment are included in this evaluation. The SIT scores for the 3 incidents are detailed in Table 1. The plug of flesh removed by the cookiecutter shark penetrated through the skin, subcutaneous fat, fascia, and muscle in all 3 cases. Although relatively superficial compared to injuries inflicted by a tiger or great white shark, these wounds remain potentially life-threatening from blood loss and anatomic location of the injury. All patients experienced prolonged times between the time of injury to the first contact with EMS (average 50 minutes) and arrival to the ED (average 1 hour, 13 minutes) due to the remote location of injury on the open ocean. Stop the Bleed techniques for immediate hemorrhage control (Figure 5),[9] including direct pressure and tourniquet were employed by support crew in all cases. These imperative maneuvers may have contributed to the absence of hypotension or the need for blood transfusion on arrival to the ED.

In the specific management of potential infectious complications, *Vibrio* spp. are the most prevalent bacteria in seawater[10] and have previously been cultured from the teeth of a great white shark.[11] *Vibrio* spp. are typically susceptible to doxycycline,[11] and all patients received this as part of their broad-spectrum prophylactic antibiotic regimen against marine bacteria. Guidelines for treating *Vibrio vulnificus* wound infections from the Centers for Disease Control and Prevention (CDC) offer a regimen including doxycycline 100 mg PO/IV twice a day for 7–14 days and a third-generation cephalosporin.[12] Coverage for gram-positive organisms such as *Staphylococcus aureus* and *Streptococcus pyogenes* should also be considered.[10] As there are no clear guidelines for infection prophylaxis, duration and choice of antibiotic regimen after shark injury may vary as observed. Although leukocytosis was present on ED arrival, the wounds did not show evidence of infection and the leukocytosis resolved before discharge in the patients admitted to the hospital. Long-term follow-up was unavailable as all patients returned home after visiting Hawa‘i to swim the Ka‘iwi Channel.

Table 1. Patient Characteristics

	Location of Wound	Size of Wound (cm, in diameter)	SIT Level
Case 1	Infraumbilical region of abdomen	8	3
Case 2	Posterior left shoulder	13	2
Case 3	Inner left thigh	8	2

The Ka‘iwi Channel, also known as the Moloka‘i Channel, is approximately 26 miles of open ocean between the Hawaiian Islands of O‘ahu and Moloka‘i. With a maximum depth approximated at 2300 feet, the combination of wind, strong currents, and large swells make it a popular destination for ocean-based competition. Swimming the Ka‘iwi Channel is a prestigious feat for open water swimmers, with only 5 relay teams and 69 solo swimmers having successfully completed the crossing to date.[13] It ranks among the Ocean’s Seven, a marathon challenge of open ocean swims across the globe, including the English Channel, Catalina Channel, Strait of Gibraltar, North Channel, Cook Strait, and Tsugaru Strait.[14] The abrupt spike in cookiecutter shark-related injuries in the Ka‘iwi Channel is curious not only for its novelty but for the lack of prior cases despite a number of individuals in the water over several decades. A sudden series of attacks by these efficient ocean predators raise the thought of the ‘rogue shark’ theory popularized by the movie *Jaws*.[15] Based on the variation in wounds sustained, however, at least 2 different sharks may have been involved. The sharks may have been drawn in by other prey or may have been responding to sensory cues by the swimmer or support crafts; the exact reasons for these unusual attacks remain unclear. If now conditioned to identify this slow-moving “prey” at the surface, the cookiecutter shark may pose a continued threat and additional level of difficulty to an already daunting challenge. Future cookiecutter shark-related injuries may be anticipated as numerous swimmers tracked in the Ocean’s Seven database have yet to complete the Ka‘iwi Channel.[14]

Conclusion

A typical beachgoer enjoying the sun and warm Hawaiian waters need not worry about an attack from the cookiecutter shark. For experienced open water swimmers crossing deep waters of the Ka‘iwi Channel midway between islands in the dark of night, however, the risk of circular cut-outs of subcutaneous tissue is real. As these injuries occur far from definitive care, immediate life-saving Stop the Bleed equipment and education may be essential for personnel assisting the swimmers on this journey. Wounds may penetrate down to and through the fascial

level depending on the location of injury and individual patient characteristics. Administration of broad-spectrum prophylactic antibiotic coverage, including doxycycline for *Vibrio* spp., and updating tetanus toxoid are recommended.

Conflict of Interest

None of the authors identify a conflict of interest.

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References

1. Makino Y, Tachihara K, Ageda S, Arao T, Fuke C, Miyazaki T. Peculiar circular and C-shaped injuries on a body from the sea. *Am J Forensic Med Pathol*. 2004;25(2):169-171. doi:10.1097/01.paf.0000127390.07879.62
2. Ribéreau-Gayon A, Carter DO, Regan S. New evidence of predation on humans by cookiecutter sharks in Kauai, Hawaii. *Int J Legal Med*. 2018;132(5):1381-1387. doi:10.1007/s00414-018-1786-8
3. Ribéreau-Gayon A, Rando C, Schuliar Y, *et al*. Extensive unusual lesions on a large number of immersed human victims found to be from cookiecutter sharks (Isistius spp.): an examination of the Yemenia plane crash. *Int J Legal Med*. 2017;131(2):423-432. doi:10.1007/s00414-016-1449-6
4. Hayashi T, Higo E, Orito H, Ago K, Ogata M. Postmortem wounds caused by cookie-cutter sharks (Isistius species): an autopsy case of a drowning victim. *Forensic Sci Med Pathol*. 2015;11(1):119-121. doi:10.1007/s12024-014-9597-9
5. Honebrink R, Buch R, Galpin P, Burgess GH. First documented attack on a live human by a cookiecutter shark (Squaliformes, Dalatiidae: Isistius sp.). *Pacific Sci*. 2011;65(3):365-374. doi:10.2984/65.3.365
6. Scala VA, Hayashi MS, Kaneshige J, Haut ER, Ng K, Furuta S. Shark-related injuries in Hawai'i treated at a level 1 trauma center. *Trauma Surg Acute Care Open*. 2020;5(1):1-6. doi:10.1136/tsaco-2020-000567
7. Molokai Channel Swim. Molokai Kaiwi Channel Swim. Available from: https://molokaichannelswim.com/frequently-asked-questions. Published March 2019. Accessed February 20, 2020.
8. Lentz AK, Burgess GH, Perrin K, Brown JA, Mozingo DW, Lottenberg L. Mortality and management of 96 shark attacks and development of a shark bite severity scoring system. *Am Surg*. 2010;76(1):101-106.
9. American College of Surgeons. Stop the Bleed. Available from: https://www.stopthebleed.org/. Published December 2015. Accessed June 5, 2020.
10. Noonburg GE. Management of extremity trauma and related infections occurring in the aquatic environment. *J Am Acad Orthop Surg*. 2005;13(4):243-253. doi:10.5435/00124635-200507000-00004
11. Buck JD, Spotte S, Gadbaw JJ. Bacteriology of the teeth from a great white shark: Potential medical implications for shark bite victims. *J Clin Microbiol*. 1984;20(5):849-851.
12. Centers for Disease Control and Prevention. Management of Vibrio Vulnificus Wound Infections. Vibrio Species Causing Vibriosis. Available from: https://www.cdc.gov/vibrio/healthcare.html#wounds. Published June 2016. Accessed July 16, 2020.
13. Ka'iwi Channel Association. Ka'iwi Channel Association. Available from: https://www.kaiwichannelassociation.com/. Published November 2013. Accessed June 5, 2020.
14. Marathon Swimmers Federation. Oceans Seven. LongSwims Database. Available from: https://longswims.com/oceans-seven/. Published April 2020. Accessed June 5, 2020.
15. Spielberg S. *Jaws*. Universal Pictures; 1975.

Enormous Gallstone Discovered in the Setting of Acute-on-chronic Cholecystitis

Reid C. Mahoney MD; Scott R. Marison Jr. BA; Ashley D. Marumoto MD; and Daphne E. Hemmings MD, FACS

Abstract

Biliary disease is a common surgical problem. A unique case of a 53-year-old male with an enormous gallstone precluding safe laparoscopic cholecystectomy is presented. The patient was a 53-year-old male who presented to the emergency department with a 1-day history of abdominal pain for which clinical findings were consistent with acute cholecystitis. A laparoscopic cholecystectomy was attempted, but could not be safely completed due to an enormous gallstone prohibiting attainment of the critical view of safety. The stone measured 12.2 cm x 5.2 cm x 5.2 cm. Although biliary disease is very common and its management well documented, it is rare to uncover stones larger than 5 centimeters in diameter. Clinicians should be aware that enormous gallstones require prompt surgical intervention if discovered in the elective setting to minimize future morbidity should cholecystitis develop; early elective cholecystectomy should be considered upon discovery of large gallstones to prevent encountering a gallbladder with decreased mobilization in the setting of inflamed tissues.

Keywords

Cholecystitis, enormous gallstone, critical view of safety

Introduction

Gallbladder disease, including cholelithiasis, is a problem frequently encountered by physicians and surgeons in the United States, including Hawai‘i. It is paramount that physicians in Hawai‘i be aware that many variations of gallbladder disease exist, including patients with enormous gallstones. A case study is presented that involves a patient from the Pacific Islands with an enormous gallstone that required a unique surgical approach. This patient encounter can be utilized to treat patients more effectively in Hawai‘i and the United States that have similar pathology.

Case Description

The patient was a 53-year-old male with no significant past medical or surgical history who presented with 1-day duration of colicky right upper quadrant abdominal pain associated with nausea, vomiting, and anorexia. He was afebrile and hemodynamically stable. Abdominal examination revealed mild distension, moderate right upper quadrant tenderness, and a palpable gallbladder upon deep palpation. The patient displayed a positive Murphy's sign. Laboratory evaluation revealed leukocytosis (WBCs: 19000), as well as elevated AST (167), ALT (122), ALP (334); total bilirubin was within normal limits (1.1). Notably, the patient had presented with acute abdominal pain to an outside hospital 1 week prior, at which time an abdominal CT scan demonstrated a large gallstone within the gallbladder without evidence of acute cholecystitis (Figure 1). At the time of initial presentation, outpatient follow-up was recommended.

A diagnosis of cholecystitis was discussed with the patient and he was consented for a laparoscopic cholecystectomy acknowledging an increased likelihood of converting to an open procedure due to the size of his gallstone. The procedure began laparoscopically, which allowed for lysis of dense adhesions and medial and lateral dissection of the gallbladder. After progressing to the hepatocystic triangle, the critical view of safety could not be achieved due to the severe inflammation as well as limited gallbladder mobility because of the enormous stone. As such, the procedure was converted to an open cholecystectomy. A subtotal fenestrating cholecystectomy was performed, with a small area of infundibulum cauterized and left in situ, as it was densely adherent to the common bile duct. Final pathology revealed a fibrotic gallbladder with thickened walls and evidence of acute cholecystitis, as well as a single, irregular, 185-gram gallstone measuring 12.2 cm x 5.2 cm x 5.2 cm (Figure 2).

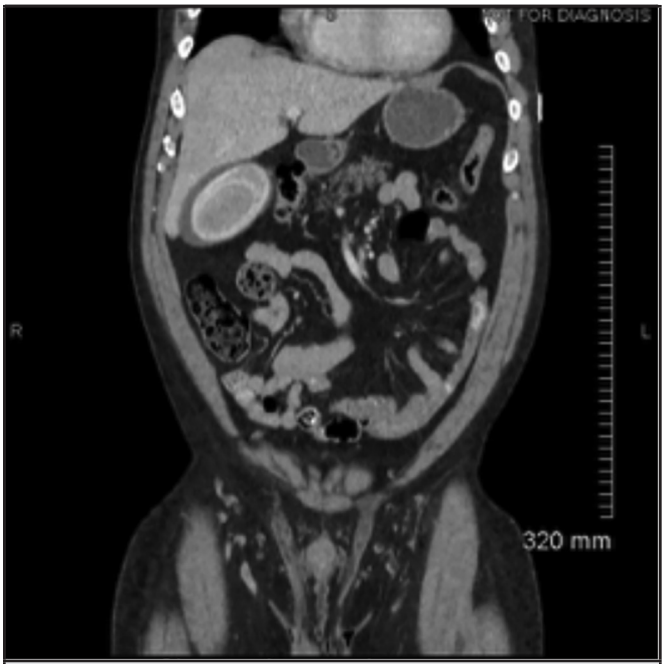

Figure 1. Abdominal CT Reveals an Enormous Gallstone

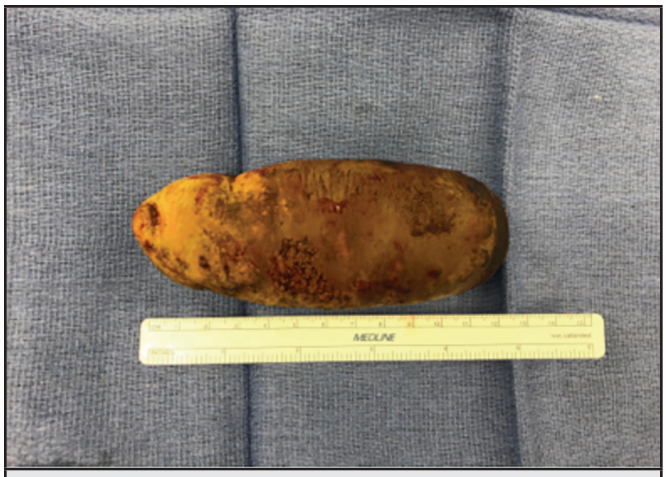

Figure 2. Single Enormous Gallstone

The patient had an uneventful post-operative course. There was no evidence of bile leak, and his right upper quadrant drain was removed on post-operative day 2. He was discharged on post-operative day 3.

Discussion

The incidence of gallstones is estimated to be 1 in 200 people each year, with 1%-4% annually progressing to various biliary pathologies including biliary colic, cholecystitis, or choledocholithiasis.[1,2] As the population continues to age and rates of obesity rise, the incidence is anticipated to increase.[3] Allowing a period of "cooling off" for the gallbladder was once a tenant of gallbladder surgery. Although there is still variation in presentation and a significant role for surgeon decision-making, recent studies have shown improved outcomes for early intervention. A 2011 paper by Banz et al demonstrated that delayed laparoscopic cholecystectomy (occurring after 48 hours from hospital admission) resulted in significantly increased postoperative complications, longer postoperative hospital stay, and higher conversion/re-operation rates. [4]

Laparoscopic cholecystectomy was first performed by Dr. Mühe in 1985 and is now one of the most commonly performed procedures in the United States, with approximately 300 000 cholecystectomies performed annually.[5,6] A laparoscopic approach to gallbladder disease is associated with less post-operative morbidity (including lower pneumonia and wound infection rates), lower mortality, and shorter hospital stays.[2] Interestingly, a meta-analysis of open and laparoscopic cholecystectomy did not show a significant difference between the 2 types of procedures in rates of bile leakage, intraoperative blood loss, or operative times.[2] Laparoscopy is considered standard of care and should be attempted when safe. However, obtaining the critical view of safety is a mandatory component of the procedure and is aimed at preventing serious injury.[7,8] This requires clearing the hepatocystic triangle of fat and fibrous tissue, exposing the cystic plate, and identifying 2, and only 2, structures that enter the gallbladder.[9] Failure to obtain a critical view of safety prompts serious consideration for an alternative operative approach, such as subtotal cholecystectomy or conversion to open cholecystectomy.[8]

The rate of conversion from laparoscopic cholecystectomy to open cholecystectomy is estimated to be between 3% and 30%, with most studies estimating rates of 2%-5%. The rate of conversion is believed to be higher when performed for acute cholecystitis.[2,10-12] The most common reason for conversion is difficult dissection of Calot's triangle.[13] Multiple studies have identified risk factors for conversion to an open cholecystectomy. Patient factors associated with higher rates of conversion to open cholecystectomy include: elevated BMI, hypertension, diabetes, prior abdominal surgery, duration of symptoms greater than 72 hours, gallbladder wall thickness greater than 4 mm, presence of choledocholithiasis, and impacted stone at the gallbladder neck .[13-16] Large gallstones may lead to inflammation and wall thickening, which not only makes it difficult for the surgeon to grasp the gallbladder and provide necessary anatomic exposure,[17] but also obscures visualization and makes dissection planes more difficult to identify.

Gallstones exceeding 5 cm are rare occurrences.[10] Two case reports have described gallstones between 6 and 9.5 cm.[10,17] Although Xu et al[10] reported that a laparoscopic approach was possible with a 9.5 centimeter gallstone, the size of the current patient's gallstone and the severe inflammation made completion of the operation laparoscopically a dangerous endeavor. Although the size of the gallstone itself may not prohibit completion of cholecystectomy laparoscopically, when performed in the setting of inflammation, obtaining the critical view becomes even more difficult. Patients discovered to have large gallstones should be referred for early elective surgical intervention to prevent future complications and difficulties. Intervention in the elective setting was emphasized in a case report by Freeman et al[1] that involved an incidentally discovered 4.5-cm gallstone that resulted in gallstone ileus 9 months after discovery. Additionally, large gallstones have been shown to increase the risk of developing gallbladder cancer.[18] Rates of adenocarcinoma among patients with gallstones larger than 3 cm have been estimated to be as high as 4% at 20 years after discovery, which translates to a relative risk of adenocarcinoma development of 10.1.[19] Therefore, it is recommended to perform elective surgery for appropriate patients who have gallstones larger than 3 cm.

This case not only describes one of the largest gallstones in medical literature, but also serves to endorse early cholecystectomy when enormous gallstones are discovered. If identified in the acute setting, consideration for an alternative approach is necessary.

Conclusion

A case of acute cholecystitis in a 53-year-old male found to have a single 185-gram gallstone measuring 12.2 cm x 5.2 cm x 5.2 cm requiring treatment with a laparoscopic converted to open subtotal cholecystectomy is presented. Clinicians must be aware that enormous gallstones exist and require prompt and sometimes alternative interventions for remediation of disease.

Lessons to Be Learned

Obtaining the "critical view of safety" is a mandatory component of laparoscopic cholecystectomy. Should this not be achieved due to inflammation, anatomy, or an enormous gallstone, an alternative approach should be utilized. To prevent morbidity, early elective cholecystectomy should be recommended when enormous gallstones are identified.

Conflict of Interest

None of the authors identify a conflict of interest.

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References

1. Freeman MH, Mullen MG, Friel CM. The progression of cholelithiasis to gallstone ileus: Do large gallstones warrant surgery? *Journal of Gastrointestinal Surgery*. 2016;20(6):1278-1280.
2. Coccolini F, Catena F, Pisano M, et al. Open versus laparoscopic cholecystectomy in acute cholecystitis. Systematic review and meta-analysis. *International Journal of Surgery*. 2015;18:196-204.
3. Stinton LM, Shaffer EA. Epidemiology of gallbladder disease: cholelithiasis and cancer. *Gut Liver*. 2012;6(2):172-187.
4. Banz V, Gsponer T, Candinas D, Güller U. Population-based analysis of 4113 patients with acute cholecystitis: defining the optimal time-point for laparoscopic cholecystectomy. *Annals of Surgery*. 2011;254(6):964-970.
5. Wakabayashi G, Iwashita Y, Hibi T, et al. Tokyo Guidelines 2018: surgical management of acute cholecystitis: safe steps in laparoscopic cholecystectomy for acute cholecystitis (with videos). *Journal of Hepato-Biliary-Pancreatic Sciences*. 2018;25(1):73-86.
6. Reynolds W Jr. The first laparoscopic cholecystectomy. *Journal of the Society of Laparoscopic & Robotic Surgeons*. 2001;5(1):89-94.
7. Gupta V, Jain G. Safe laparoscopic cholecystectomy: Adoption of universal culture of safety in cholecystectomy. *World Journal of Gastrointestinal Surgery*. 2019;11(2):62–84.
8. Strasberg SM. A three-step conceptual roadmap for avoiding bile duct injury in laparoscopic cholecystectomy: an invited perspective review. *Journal of Hepato-Biliary-Pancreatic Sciences*. 2019;26(4):123-127.
9. Conrad C, Wakabayashi G, Asbun HJ, et al. IRCAD recommendation on safe laparoscopic cholecystectomy. *Journal of Hepato-Biliary-Pancreatic Sciences*. 2017;24(11):603-615.
10. Xu X, Hong T, Zheng C. Giant gallstone performed by emergency laparoscopic cholecystectomy. *International Journal of Surgery Case Report*. 2013;4(12):1163-1164.
11. Sanabria JR, Gallinger S, Croxford R, Strasberg SM. Risk factors in elective laparoscopic cholecystectomy for conversion to open cholecystectomy. *Journal of the American College of Surgeons*. 1994;179(6):696-704.
12. Fried GM, Barkun JS, Sigman HH, et al. Factors determining conversion to laparotomy in patients undergoing laparoscopic cholecystectomy. *American Journal of Surgery*. 1994;167(1):35-41.
13. Hu ASY, Menon R, Gunnarsson R, de Costa A. Risk factors for conversion of laparoscopic cholecystectomy to open surgery - A systematic literature review of 30 studies. *American Journal of Surgery*. 2017;214(5):920-930.
14. Kama NA, Doganay M, Dolapci M, Reis E, Atli M, Kologlu M. Risk factors resulting in conversion of laparoscopic cholecystectomy to open surgery. *Surgical Endoscopy*. 2001;15(9):965-968.
15. Brodsky A, Matter I, Sabo E, Cohen A, Abrahamson J, Eldar S. Laparoscopic cholecystectomy for acute cholecystitis: can the need for conversion and the probability of complications be predicted? A prospective study. *Surgical Endoscopy*. 2000;14(8):755-760.
16. Hadad SM, Vaidya JS, Baker L, et al. Delay from symptom onset increases the conversion rate in laparoscopic cholecystectomy for acute cholecystitis. *World Journal of Surgery*. 2007;31(6):1298-1301.
17. Banigo A. Huge gallstone complicating laparoscopic cholecystectomy. *BMJ Case Reports*. 2013;2013:bcr2012007012.
18. Csendes A, Becerra M, Rojas J, Medina E. Number and size of stones in patients with asymptomatic and symptomatic gallstones and gallbladder carcinoma: a prospective study of 592 cases. *Journal of Gastrointestinal Surgery*. 2000;4(5):481-485.
19. Diehl AK. Gallstone size and the risk of gallbladder cancer. *Journal of the American Medical Association*. 1983;250(17):2323-2326.

First Case of Subretinal Ocular Angiostrongyliasis Associated with Retinal Detachment in the United States

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Abstract

Angiostrongylus cantonensis, commonly known as the rat lungworm, is mostly found in Asia, the Pacific Basin, and the Caribbean, but is also endemic in Hawai'i, especially on the Island of Hawai'i. Ocular angiostrongyliasis is an uncommon but previously reported complication associated with permanent vision loss. This is the first reported case of ocular angiostrongyliasis involving the retina or posterior segment of the eye in the US. A 24-year-old male from Chicago visited the Island of Hawai'i, where he worked on a farm and ate a vegetarian diet. When he returned to Chicago, he became sick and was hospitalized for eosinophilic meningitis. One month later, he developed a retinal detachment which required surgical repair involving a pars plana vitrectomy. During the reattachment of the retina during surgery, a live motile was identified nematode in the subretinal space. An endolaser probe immobilized and killed the nematode, and it was subsequently extracted through the sclerotomy. Thermal scars around all retinal holes including the retinotomy site were made to stabilize the retina, and perfluoropropane gas was injected to achieve temporary tamponade. Thereafter, the patient's cerebrospinal fluid returned positive for angiostrongylus cantonensis antibodies. During extended follow-up, the patient eventually lost all vision in the affected eye due to recurrent retinal detachment. This case of ocular angiostrongyliasis demonstrates the importance of obtaining travel history from endemic areas, knowing the risk of developing eosinophilic meningitis, and understanding the risk of permanent vision loss in cases involving the retina.

Keywords

angiostrongyliasis, rat lungworm, retinal detachment, ocular, eosinophilic meningitis, case report, Hawai'i, subretinal, posterior segment

Abbreviations and Acronyms

CDC = Centers for Disease Control and Prevention
CSF = cerebrospinal fluid
MRI = magnetic resonance imaging

Introduction

Ocular angiostrongyliasis is an uncommon complication occurring in 1.2% of infections caused by *Angiostrongylus cantonensis* commonly known as the rat lungworm.[1,2] Eosinophilic meningitis has been reported in half of the human ocular angiostrongyliasis cases, and common symptoms include headache, neck pain, paresthesia, and fever.[1] *A. cantonensis* is estimated to cause 29% of eosinophilic meningitis cases in Hawai'i.[3] Parasitic infections, a major source of ocular disease throughout the world, have become increasingly more common in nonendemic areas due to increased global travel.[4]

The life cycle of *A. cantonensis* begins in the pulmonary arteries of rats where the eggs are laid by adult worms. Subsequently, the first-stage larvae migrate to the pharynx and are swallowed and excreted. The intermediate hosts, typically snails or slugs, ingest the rat feces and become infected. Ultimately, humans acquire the infection by ingestion of infective larvae found on or in snails, snail tracks, slugs, shellfish, and raw vegetables. The infective larvae migrate to the brain and mature, frequently causing eosinophilic meningitis which may lead to death.[5]

A. cantonensis has an expanding range of endemicity that includes Southeast Asia, the Pacific Islands, South and Central America, and the Caribbean.[6] Currently, Hawai'i is the epicenter for angiostrongyliasis in the United States due to the proliferation of the mollusk *Parmarion martensis*, a highly effective intermediate host that transmits the disease to humans and other susceptible animals.[7] Additionally, the high consumption of local produce and use of rainwater for harvesting likely elevates the risk of acquiring angiostrongyliasis, particularly on the east side of Hawai'i Island.[8] Between 2007 to 2017, a total of 82 cases of *A. cantonensis* infections were identified in Hawai'i.[9]

Ocular angiostrongyliasis has been reported in Asia, South America, and North America[2,10-13] The first case of ocular angiostrongyliasis in the United States was described in Miami, FL, and involved a nematode that had infiltrated the anterior chamber of the eye.[14] After a review of the existing literature, this is the first reported case of ocular angiostrongyliasis involving the retina in the United States.

Case Report

A 24-year-old male presented to a Chicago hospital with a 1-day history of fever and headaches. He also complained of painful lower extremity paresthesia, bilateral leg weakness, and significant weight loss. The patient had recently moved from Hawai'i back to Chicago following a 14-month stay in Hawai'i where he adopted a vegetarian diet and became sick while working on a farm. Previously, the patient was otherwise healthy without any significant past medical history. The cytology of blood and cerebrospinal fluid (CSF) were remarkable for eosinophilia. The brain magnetic resonance imaging (MRI) was within normal limits, but the spine MRI identified the presence of transverse myelitis. The stool sample contained no ova or parasites. The patient was diagnosed with eosinophilic meningitis and treated empirically with ivermectin and high-dose corticosteroids.

One month later, the patient suddenly developed unilateral vision loss, and a complete ophthalmologic exam was performed. Visual acuity in the right eye was limited to the ability to count the examiner's fingers, and the left eye was 20/20. Slit lamp examination revealed the absence of inflammatory cells in the anterior chamber with 1+ pigmented cells in the anterior vitreous. Dilated fundus examination revealed a rhegmatogenous retinal detachment with significant epiretinal membranes on the surface of the retina consistent with proliferative vitreoretinopathy. A retinal detachment repair involving a pars plana vitrectomy using a standard 3-port 23-gauge vitrectomy was planned. Following removal of the vitreous and the epiretinal membranes, perfluorocarbon liquid was used to reattach the retina and express out the subretinal fluid, due to the liquid's high specific gravity.

As the retina was reattached, a live motile nematode in the subretinal space inferonasal to the optic disc became visible. Transmitted heat through the endolaser probe thermal laser was used to immobilize and kill the subretinal nematode, and a retinotomy was performed to access the subretinal space. The nematode was grasped using microforceps and retrieved from the eye through the sclerotomy after removing the 23-gauge trocar [Figure 1]. A fluid-air exchange followed by air-gas exchange was performed using perfluoropropane gas (C3F8) to allow for support of the retina by intraocular tamponade temporarily. Laser was applied to the retinotomy site as well as the peripheral retina to create a thermal scar around all retinal holes, while also stabilizing the peripheral retina.

Subsequently, the patient's CSF returned positive for angiostrongylus cantonensis antibodies via testing at the Centers for Disease Control and Prevention (CDC). On extended follow-up, the patient suffered recurrent retinal detachment, which persisted despite further vitreoretinal surgeries. At most recent follow-up, the patient's visual acuity in the right eye had decreased to light perception with hypotony with an intraocular pressure of 5 mmHg with early phthisis. The unaffected left eye has normal vision with no evidence of any infection.

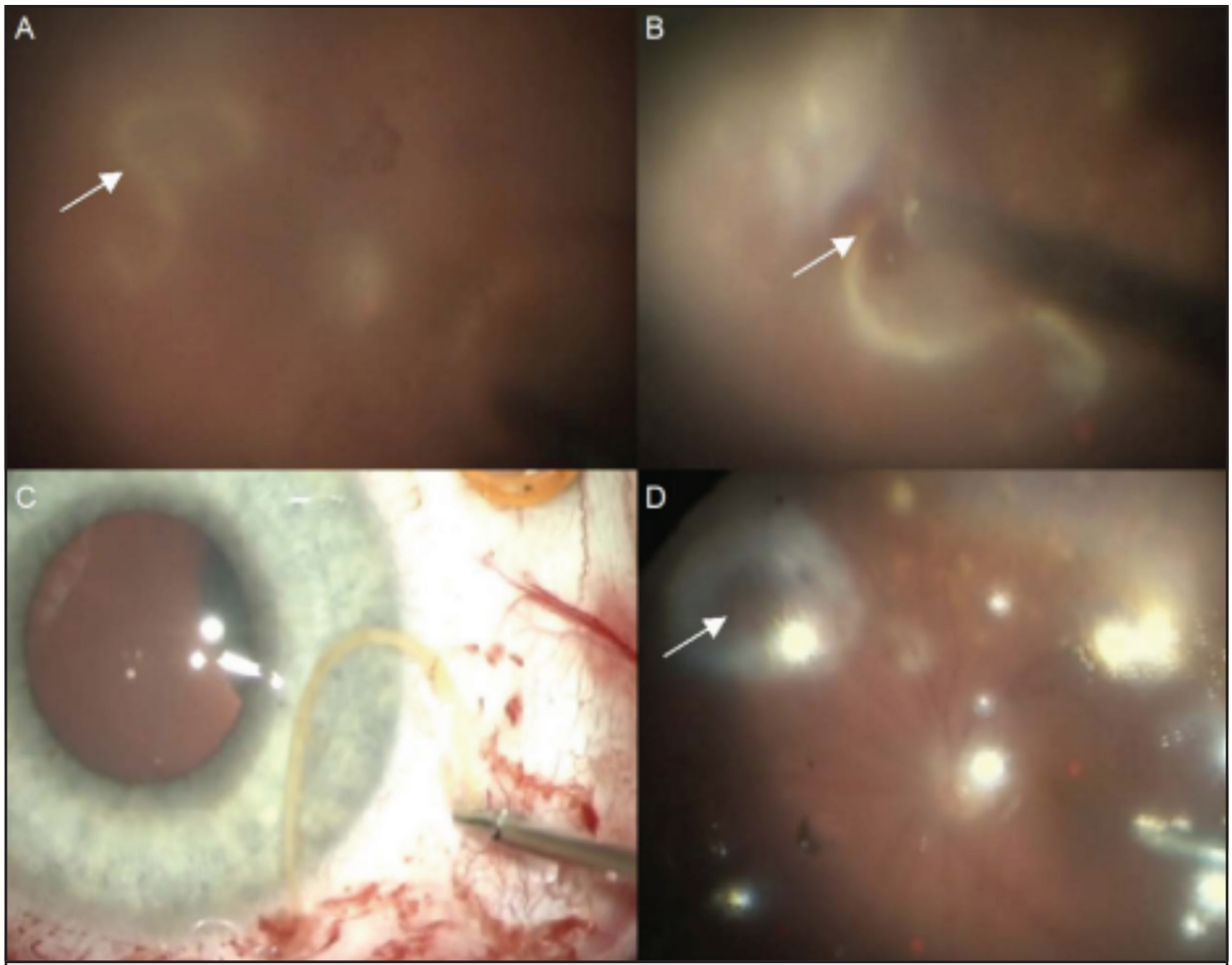

Figure 1. Intraoperative Photos of Surgical Technique. (A) Visualization of inferonasal subretinal nematode (arrow). (B) Retinotomy (arrow) made to access subretinal space. (C) Nematode on the conjunctiva following removal through sclerotomy. (D) Laser of retinotomy site (arrow) following extraction.

Discussion

Ocular angiostrongyliasis is a rare but potentially sight-threatening infection caused by *A. cantonensis*. A high index of suspicion should be maintained in patients recently diagnosed with eosinophilic meningitis who present with ocular symptoms such as vision loss. Additionally, a recent history of travel to endemic areas and high-risk dietary behaviors may further help to identify parasitic infection and *A. cantonensis* infection. Eosinophilia in the CSF has been reported in many cases, and angiostrongyliasis is one of the most common causes of eosinophilic meningitis.[15] MRI findings are typically unremarkable but may demonstrate non-specific findings such as cerebral edema, meningeal enhancement, and hyperintense signal lesions.[16] The use of highly sensitive and specific enzyme-linked immunosorbent assays is currently not widespread, although the CDC testing in this case confirmed angiostrongyliasis antibodies.[17] Ocular complications depend on the location and extent of infiltration and have included uveitis, macular edema, panophthalmitis, papilledema, optic neuritis, optic nerve compression, and orbital inflammation.[4] In case reports by Sinawat et al, fundus examination associated with optic neuritis in ocular angiostrongyliasis included abnormalities in the retinal pigment epithelium, retinal and macular edema, and subretinal tracks.[12]

The route taken by *A. cantonensis* to enter the eye is unknown, although it is postulated that the nematode may enter the eye via the optic nerve sheath, through the central retinal artery, or directly from the ocular surface. One theory is that the nematode may travel along the surface and base of the brain leading to the meningitic symptoms. Upon reaching the optic nerve, the nematode may travel between the nerve and sheath to reach the retina by moving through the lamina cribosa.[12]

Treatment of ocular angiostrongyliasis includes reducing pain and inflammation while immobilizing and removing the helminth. A 2-week course of systemic corticosteroids has been shown to significantly improve headaches, duration of headaches, and number of repeat lumbar punctures.[18] The use of anthelminthic medications to treat acute eosinophilic meningitis requires further investigation in terms of both efficacy and side-effect profile. In a study of 71 patients with acute eosinophilic meningitis, albendazole has been shown to decrease the duration of disease and reduce the use of acetaminophen without any associated serious side effects.[19] However, anthelminthics should be used with caution because necrotic parasite tissue may release toxic substances and further exacerbate intraocular inflammation.[20,21] Nevertheless, albendazole remains the anthelminthic of choice compared to other benzimidazoles due to its better penetration into the central nervous system.

The definitive treatment of ocular angiostrongyliasis involves surgical removal of the parasite. In most cases of ocular angiostrongyliasis, there is only 1 nematode in the eye, and the nematode is usually still alive.[1] The surgical technique for removal of the nematode is dependent on the location of the nematode. If the nematode is in the anterior chamber, an approach through a corneal incision has been effective at removing the nematode.[14] A patient in Japan with subretinal ocular angiostrongyliasis underwent vitreous surgery to remove the nematode by making an incision in the retina to access the subretinal space.[13] Focal laser photocoagulation to the nematode has been reported to be helpful in immobilizing and possibly killing the parasite prior to surgical removal.[20] A case report by Kanchanaranya et al also recommended immobilization of the nematode by cryopexy before removal.[22] Complications, such as hemorrhage or post-operative retinal detachment, can be reduced by careful cauterization of bleeding sites, and laser around the retinotomy site. In this case, the risk of recurrent retinal detachment was high due to significant proliferative vitreoretinopathy, which portends a poor visual outcome due to the associated inflammation and scarring. Despite the measures taken to reattach the retina, the inflammation and scarring thereafter contributed to recurrent retinal detachment, leading to complete functional blindness in this right eye.

Surgical outcomes after removal of the nematode depend on the extent of inflammation, location of the nematode, involvement of the retina, and damage to the retina or optic nerve due to prior inflammation. In one of the largest case series on ocular angiostrongyliasis (N = 18), surgical removal was successfully performed in 10 cases (56%), but none of the cases presented with rhegmatogenous retinal detachment as in this current case report.[23] Posterior segment cases most commonly involved the vitreous, the subretinal space, or optic neuritis.[19] Other treatment modalities included focal laser (78%), anthelminthic drugs (61%), and steroids (89%). Unfortunately, visual acuity did not change dramatically in 67% of cases regardless of treatment type. In another report, parasites were successfully removed from the anterior chamber in 14 cases and the vitreous fluid in 15 cases.[20] However, there was only slight improvement in visual acuity. Anterior segment involvement is more favorable with a better chance of recovering good vision than posterior segment involvement of the retina, vitreous, or optic nerve.[2]

Practical measures to prevent angiostrongyliasis include proper hygiene by washing vegetables thoroughly and avoiding eating raw snails and other immediate hosts (eg, crabs and shrimp).[11] Education of the general public regarding the dangers of raw mollusk consumption can be particularly helpful in endemic areas where food is home grown or collected locally. Prevention of ocular angiostrongyliasis includes timely diagnosis and treatment of systemic angiostrongyliasis, and immediate ophthalmic evaluation for any patient presenting with ocular symptoms of decreased vision and floaters.

This is the first reported case in the US of ocular angiostrongyliasis with vision loss due to retinal detachment associated with a subretinal nematode. This patient developed vision loss in Chicago, but he acquired the disease on the Island of

Hawai‘i, which is a known endemic area. This highlights the importance of obtaining recent travel history from an endemic area for angiostrongyliasis. He also first developed eosinophilic meningitis, which has been noted in half of cases with angiostrongyliasis and should be a warning sign for possible infection. The definitive treatment for ocular angiostrongyliasis is surgical removal of the nematode, often after initial treatment with laser to immobilize or kill it. This case highlights the risk of severe vision loss in ocular angiostrongyliasis, especially when the posterior segment of the eye is involved.

Conflict of Interest

None of the authors identify a conflict of interest.

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References

1. Diao Z, Wang J, Qi H, Li X, Zheng X, Yin C. Human ocular angiostrongyliasis: a literature review. *Tropical Doctor.* 2011;41(2):76.
2. Sawanyawisuth K, Kitthaweesin K, Limpawattana P, et al. Intraocular angiostrongyliasis: clinical findings, treatments and outcomes. *Trans R Soc Trop Med Hyg.* 2007;101(5):497-501.
3. Hochberg NS, Park SY, Blackburn BG, et al. Distribution of eosinophilic meningitis cases attributable to Angiostrongylus cantonensis, Hawaii.(RESEARCH). *Emerging Infectious Diseases.* 2007;13(11):1675.
4. Barratt J, Chan D, Sandaradura I, et al. Angiostrongylus cantonensis: a review of its distribution, molecular biology and clinical significance as a human pathogen. *Parasitology.* 2016;143(9):1087-1118.
5. Wang QP, Wu ZD, Wei J, Owen RL, Lun ZR. Human Angiostrongylus cantonensis: an update. *Eur J Clin Microbiol Infect Dis.* 2012;31(4):389-395.
6. Wang QP, Lai DH, Zhu XQ, Chen XG, Lun ZR. Human angiostrongyliasis. *Lancet Infect Dis.* 2008;8(10):621-630.
7. Hollingsworth RG, Kaneta R, Sullivan JJ, et al. Distribution of Parmarion cf. martensi (Pulmonata: Helicarionidae), a new semi-slug pest on Hawai'i Island, and its potential as a vector for human Angiostrongyliasis. *Pacific Science.* 2007;61(4):457-467.
8. Howe K, Jarvi SI. Angiostrongyliasis (rat lungworm disease): viewpoints from Hawai'i island. *ACS Chem Neurosci.* 2017;8(9):1820-1822.
9. Johnston DI, Dixon MC, Elm JL, Calimlim PS, Sciulli RH, Park SY. Review of cases of Angiostrongyliasis in Hawaii, 2007-2017. *Am J Trop Med Hyg.* 2019;101(3):608-616.
10. Gabriel Costa de A, João Rafael de Oliveira D, André M, et al. Intravitreal Angiostrongylus cantonensis: first case report in South America. *Arquivos Brasileiros de Oftalmologia.* 2018;81(1):63-65.
11. Mattis A, Mowatt L, Lue A, Lindo J, Vaughan H. Ocular angiostrongyliasis--first case report from Jamaica. *West Indian Med J.* 2009;58(4):383-385.
12. Sinawat S, Sanguansak T, Angkawinijwong T, Ratanapakorn T, Intapan PM, Yospaiboon Y. Ocular angiostrongyliasis: clinical study of three cases. *Eye (Lond).* 2008;22(11):1446-1448.
13. Toma H, Matsumura S, Oshiro C, Hidaka T, Sato Y. Ocular angiostrongyliasis without meningitis symptoms in Okinawa, Japan. *The Journal of Parasitology.* 2002;88(1):211.
14. Crane AM, Weiss M, Galor A. Anterior chamber Angiostrongyliasis. *JAMA Ophthalmology.* 2013;131(7):951-952.
15. Hochberg NS, Blackburn BG, Park SY, Sejvar JJ, Effler PV, Herwaldt BL. Eosinophilic meningitis attributable to Angiostrongylus cantonensis infection in Hawaii: clinical characteristics and potential exposures. *The American Journal of Tropical Medicine and Hygiene.* 2011;85(4):685.
16. Tsai HC, Tseng YT, Yen CM, et al. Brain magnetic resonance imaging abnormalities in eosinophilic meningitis caused by Angiostrongylus cantonensis infection. *Vector Borne Zoonotic Dis.* 2012;12(2):161-166.
17. Chen MX, Wang K, Ai L, Yan WH, Peng L, Zhang RL. Development of a double antibody sandwich ELISA assay for the diagnosis of angiostrongyliasis. *J Parasitol.* 2011;97(4):721-724.
18. Chotmongkol V, Sawanyawisuth K, Thavornpitak Y. Corticosteroid treatment of eosinophilic meningitis. *Clin Infect Dis.* 2000;31(3):660-662.
19. Jitpimolmard S, Sawanyawisuth K, Morakote N, et al. Albendazole therapy for eosinophilic meningitis caused by Angiostrongylus cantonensis. *Parasitol Res.* 2007;100(6):1293-1296.
20. Feng Y, Nawa Y, Sawanyavisuth K, Lv Z, Wu ZD. Comprehensive review of ocular angiostrongyliasis with special reference to optic neuritis. *Korean J Parasitol.* 2013;51(6):613-619.
21. Cuckler AC, Egerton JR, Alicata JE. Therapeutic effect of thiabendazole on Angiostrongylus cantonensis infections in rats. *J Parasitol.* 1965;51(3):392-396.
22. Kanchanaranya C, Prechanond A, Punyagupta S. Removal of living worm in retinal Angiostrongylus cantonensis. *Am J Ophthalmol.* 1972;74(3):456-458.
23. Sinawat S, Trisakul T, Choi S, Morley M, Yospaiboon Y. Ocular angiostrongyliasis in Thailand: a retrospective analysis over two decades. *Clin Ophthalmol.* 2019;13:1027-1031.

Hawai‘i Journal of Health & Social Welfare (HJH&SW)

Style Guide for the Use of Native Hawaiian Words and Diacritical Markings

The HJH&SW encourages authors to use the appropriate diacritical markings (the ‘okina and the kahakō) for all Hawaiian words. We recommend verifying words with the Hawaiian Language Dictionary (http://www.wehewehe.org/) or with the University of Hawai‘i Hawaiian Language Online (http://www.hawaii.edu/site/info/diacritics.php).

Authors should also note that Hawaiian refers to people of Native Hawaiian descent. People who live in Hawai‘i are referred to as Hawai‘i residents.

Hawaiian words that are not proper nouns (such as *keiki* and *kūpuna*) should be written in italics throughout the manuscript, and a definition should be provided in parentheses the first time the word is used in the manuscript.

Examples of Hawaiian words that may appear in the HJH&SW:

‘āina	***Mānoa***
ali‘i	***Māori***
Hawai‘i	***Moloka‘i***
kūpuna	***O‘ahu***
Kaua‘i	***‘ohana***
Lāna‘i	***Wai‘anae***

Hawai'i Journal of Health & Social Welfare (HJH&SW)

Guidelines for Publication of HJH&SW Supplements

The Hawai'i Journal of Health & Social Welfare (HJH&SW) partners with organizations, university divisions, and other research units to produce topic-specific issues of the journal known as supplements. Supplements must have educational value, be useful to HJH&SW readers, and contain data not previously published elsewhere. Each supplement must have a sponsor(s) who will work with the HJH&SW staff to coordinate all steps of the process. Please contact the editors at hjhsw@hawaii.edu for more information if you would like to pursue creating a supplement.

The following are general guidelines for publication of supplements:

1. Organizations, university divisions, and other research units considering publication of a sponsored supplement should consult with the HJH&SW editorial staff to make certain the educational objectives and value of the supplement are optimized during the planning process.

2. Supplements should treat broad topics in an impartial and unbiased manner. They must have educational value, be useful to HJH&SW readership, and contain data not previously published elsewhere.

3. Supplements must have a sponsor who will act as the guest editor of the supplement. The sponsor will be responsible for every step of the publication process including development of the theme/concept, peer review, editing, preliminary copy editing (ie, proof reading and first round of copy editing), and marketing of the publication. HJH&SW staff will only be involved in layout, final copy editing and reviewing final proofs. It is important that the sponsor is aware of all steps to publication. The sponsor will:

a. Be the point of contact with HJH&SW for all issues pertaining to the supplement.
b. Solicit and curate articles for the supplement.
c. Establish and oversee a peer review process that ensures the accuracy and validity of the articles.
d. Ensure that all articles adhere to the guidelines set forth in journal's Instructions to Authors page, especially the instructions for manuscript preparation and the statistical guidelines.
e. Obtain a signed Copyright Transfer Agreement for each article from all authors.
f. Comply with all federal, state, and local laws, rules, and regulations that may be applicable in connection with the publication, including ensuring that no protected health information appears in any article.
g. Work with the editorial staff to create and adhere to a timeline for the publication of the supplement.
h. Communicate any issues or desired changes to the HJH&SW staff in a timely manner.

4. Upon commissioning a supplement, the sponsor will be asked to establish a timeline for the issue which the sponsor and the HJH&SW editor(s) will sign. The following activities will be agreed upon with journal publication to take place no later than 24 months after signing. Extensions past the 24 months will be subject to additional fees based on journal publication rates at that time:

- Final date to submit a list of all articles, with working titles and authors
- Final date for submitting Word documents for copy editing
- Final date for submitting Word documents for layout
- Final date to request changes to page proofs (Please note that changes to page proofs will be made only to fix any errors that were introduced during layout. Other editing changes will incur an additional fee of $50 per page.)

5. The cost of publication of a HJH&SW supplement is $5,000 for an 8-article edition with an introduction from the sponsor or guest editor. Additional articles can be purchased for $500 each with a maximum of 12 articles per supplement. This cost covers one round of copy editing (up to 8 hours), layout, online publication with an accompanying press release, provision of electronic files, and indexing in PubMed Central, SCOPUS, and Embase. The layout editor will email an invoice for 50% of the supplement to the designated editor for payment upon signature of the contract. The remaining will be due at the time of publication. Checks may be made out to UCERA.

6. The sponsor may decide to include advertisements in the supplement in order to defray costs. Please consult with the HJH&SW advertising representative Michael Roth at 808-595-4124 or email rothcomm@gmail.com for assistance.

7. Supplement issues are posted on the HJH&SW website (http://www.hawaiijournalhealth.org) as a full-text PDF (both of the whole supplement as well as each article). An announcement of its availability will be made via a press release and through the HJH&SW email distribution list. Full-text versions of the articles will also be available on PubMed Central.

8. It is the responsibility of the sponsor to manage all editorial, marketing, sales, and distribution functions. If you need assistance, please contact the journal production editor. We may be able to help for an additional fee.

9. The editorial board reserves the right of final review and approval of all supplement contents. The HJH&SW will maintain the copyright of all journal contents.

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Sample Workflow and Timeline for a Supplement

1. The sponsor contacts the HJH&SW editors (hjhsw@hawaii.edu) to discuss the supplement topic, estimated timeline, length and cost. HJH&SW staff will review the journal requirements for articles and share our review process with the sponsor. **Time frame: 2 weeks**

2. The sponsor will complete the draft contract and pay a non-refundable deposit of $2500 or half the contract value. **Time frame: 3 days**

3. The sponsor will solicit articles for the supplement. **Time frame: 3-6 months**

Articles must comply with:

- Instructions for Manuscript Preparation and Submission of Research Articles
- Instructions for Manuscript Preparation and Submission of Columns
- HJH&SW Statistical Guidelines
- HJH&SW Style Guide for Native Hawaiian Words and Phrases
  AMA Manual of Style A free summary can be found here.

4. The sponsor will oversee the article selection, peer review, and editing process. We recommend that time be allowed for at least two rounds of reviews for each article. **Time frame: 3-6 months**

- Ensure that each article includes Institutional Review Board (IRB) review and approval, and a statement disclosing any conflicts of interest.
- Obtain a Copyright Transfer Agreement signed by all authors for each article.

5. *Optional*: During this time, the sponsor can solicit advertisements for the supplement to help defray costs for publication and/or printing. To initiate this process, the sponsor will work the HJH&SW advertising representative Michael Roth at 808-595-4124 or rothcomm@gmail.com.

6. The sponsor or their designee will conduct a final review of each article to ensure adherence to HJH&SW guidelines and AMA style. **Time frame: 2 weeks**

7. For each article, the sponsor will submit the final Word document and Copyright Transfer Agreement to the HJH&SW journal production editor. The journal production editor will send the articles to the copy editor for final journal style review. Copyediting will be 8 hours per edition plus 1 hour per article for additional articles purchased. Any additional hours will be billed at $100 per hour. **Time frame: 2 weeks**

8. The sponsor will submit the final articles to the layout editor for formatting. **Time frame: 1 month**
Acting in the role of guest editor, the sponsor will include a column introducing the supplement.
IMPORTANT: All articles submitted for layout should be in their finalized form. Page proofs will be returned to the sponsor for their review and approval, but changes will only be made to fix any errors that were introduced during the layout process. Any editing or changes to the text or figures after the initial copy layout will incur a fee of $50 per page.

9. The sponsor will review the electronic copy from the layout editor and submit any final corrections. **Time frame: 5 working days**

10. The layout editor will make the final corrections and provide a finished electronic copy of the supplement to the sponsoring editors to allow time for printing.

11. The managing editor will work with the sponsor to draft a press release. Sponsors should contact the managing editor at least 30 days prior to the date of publication to plan and script the press release. Sponsors are encouraged to submit 1-2 photos to accompany the press release. Note that obtaining signed photo releases is the responsibility of the sponsor.

12. The supplement will be published online along with the press release. An electronic copy will be sent to our subscribers and circulation lists, and the edition will be forwarded to the National Library of Medicine for indexing and made available for no cost access to the public.

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Hawai‘i Journal of Health & Social Welfare

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Aim:

The aim of the Hawai‘i Journal of Health & Social Welfare is to advance knowledge about health and social welfare, with a focus on the diverse peoples and unique environments of Hawai‘i and the Pacific region.

History:

In 1941, a journal then called The Hawai‘i Medical Journal was founded by the Hawai‘i Medical Association (HMA). The HMA had been incorporated in 1856 under the Hawaiian monarchy. In 2008, a separate journal called the Hawai‘i Journal of Public Health was established by a collaborative effort between the Hawai‘i State Department of Health and the University of Hawai‘i at Mānoa Office of Public Health Studies. In 2012, these two journals merged to form the Hawai‘i Journal of Medicine & Public Health, and this journal continued to be supported by the Hawai‘i State Department of Health and the John A. Burns School of Medicine.

In 2018, the number of partners providing financial backing for the journal expanded, and to reflect this expansion the name of the journal was changed in 2019 to the Hawai‘i Journal of Health & Social Welfare. The lead academic partners are now the six units of the UH College of Health Sciences and Social Welfare, including the John A. Burns School of Medicine, UH Public Health, the Thompson School of Social Work & Public Health, the School of Nursing and Dental Hygiene, the UH Cancer Center, and the Daniel K. Inouye College of Pharmacy. Other partners are the Hawai‘i State Department of Health and the UH Office of the Vice Chancellor for Research. The journal is fiscally managed by University Health Partners of Hawai‘i.

The HJH&SW Today:

The Hawai‘i Journal of Health & Social Welfare is a monthly peer-reviewed journal. Full-text articles are available on PubMed Central. The HJH&SW cannot be held responsible for opinions expressed in papers, discussion, communications, or advertisements. The right is reserved to reject editorial and advertising materials that are submitted. Print subscriptions are available for an annual fee of $250.Please contact the journal for information about subscriptions for locations outside of the US.

The HJH&SW is financially supported by the academic units within the UH College of Health Sciences and Social Welfare, the UH Office of the Vice Chancellor for Research, the Hawai‘i State Department of Health, and by advertising. However, the journal’s editorial board maintains editorial independence from these entities for the acceptance and publication of research articles. All editorial decisions regarding the selection and editing of research articles are made by the members of the journal’s editorial board. The decisions of the editorial board are not influenced by nor subject to the approval of these entities.

The aim of the columns of the HJH&SW is to provide a space for the entities that financially support the HJH&SW to diseminate information regarding their research, programs, goals, or current issues facing their respective fields. Columns are edited by the HJH&SW contributing editors, who are employees of the agencies that support the HJH&SW.

The aim of the Hawai‘i Journal Watch is to highlight recent research of the entities that finacially support the HJH&SW. The research articles that are covered in the Hawai‘i Journal Watch are selected by both the HJH&SW and by researchers in the units that support the HJH&SW. The researchers whose articles are covered in the Hawai‘i Journal Watch are given the opportunity to fact check the news brief.

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