Hernia (2017) 21:495–503
DOI 10.1007/s10029-017-1626-7

REVIEW

Is there an association between surgeon hat type and 30-day wound events following ventral hernia repair?

I. N. Haskins[1] · A. S. Prabhu[1] · D. M. Krpata[1] · A. J. Perez[1] · L. Tastaldi[1] · C. Tu[2] · S. Rosenblatt[1] · B. K. Poulose[3] · M. J. Rosen[1]

Received: 5 April 2017 / Accepted: 24 May 2017 / Published online: 19 June 2017

Abstract
Introduction While several patient and operative variables have been shown to be associated with an increased risk of postoperative wound events, the association between surgical hat type worn by surgeons and postoperative wound events remains controversial. The purpose of this study is to investigate the association between type of surgical hat worn by surgeons and the incidence of postoperative wound events following ventral hernia repair using the Americas Hernia Society Quality Collaborative database.
Methods All surgeons who input at least ten patients with 30-day follow-up into the AHSQC were identified. These surgeons were sent a survey asking them to identify the type of surgical hat they wear in the operating room. The association of the type of surgical hat worn, patient variables, and operative factors with 30-day wound events was investigated using multivariate logistic regression.
Results A total of 68 surgeons responded to the survey, resulting in 6210 cases available for analysis. The type of surgical hat worn by surgeons was not found to be associated with an increased risk of 30-day surgical site infections or surgical site occurrences requiring procedural intervention.
Conclusion Our study is the first study to directly compare the association of surgical hat type with postoperative wound events. There is no association between the type of surgical hat worn and the incidence of postoperative wound events following ventral hernia repair. Our findings suggest that surgical hate type may be chosen at the discretion of operating room personnel without fear of detriment to their patients.

Keywords Surgical hat · Surgical site infection · Surgical site occurrence requiring procedural intervention · Wound events

Introduction

Surgical site infection (SSI) is a substantial source of postoperative morbidity and mortality [1, 2]. While the surgical community has made significant improvements in the incidence and treatment of SSIs, elimination of these events remains challenging due to their multi-factorial nature. Despite the fact that there are multiple operating room factors that contribute to the development of wound events, including laminar flow, surgeon and operating room personnel attire, and break in sterile technique, the Association of Perioperative Registered Nurses (AORN) published recommended operating room practices in 2012 that addressed surgeon and operating room staff surgical hat attire only. Specifically, the AORN suggested that all operating room staff be required to wear disposable, bouffant-style hats to cover all of their hair and both ears [3]. This recommendation calls for the elimination of the surgical skull cap, which has historically been the headgear of choice for a majority of surgeons [4].

Presented at the Americas Hernia Society Annual Meeting, March 7th–11th, 2017, Cancun, Mexico.

✉ M. J. Rosen
rosenm@ccf.org

I. N. Haskins
ihaskins@gwu.edu

[1] Comprehensive Hernia Center, Department of General Surgery, The Cleveland Clinic Foundation, 9500 Euclid Avenue, A100, Cleveland, OH 44195, USA

[2] Department of Quantitative Health Sciences, Lerner Research Institute, The Cleveland Clinic Foundation, Cleveland, OH, USA

[3] The Vanderbilt Hernia Center, Department of Surgery, Vanderbilt University Medical Center, Nashville, TN, USA

While these recommended practice guidelines were released in 2012, it was not until earlier this year that proper surgical attire received attention from a variety of invested parties, including both surgeons and perioperative nursing staff. In a statement released by the American College of Surgeons (ACS) in August this year, the wearing of surgical skull caps was identified as symbolic of the surgical profession and supported by the fact that there is no current literature that demonstrates an association between exposed hair or ears and postoperative SSIs [4]. The currently recommended AORN guidelines are based on two historical studies. The first study was published in 1965 by Summers et al. and demonstrated that hair is a reservoir for *Staphylococci* bacteria. The second study was published in 1973 and demonstrated a correlation between the strain of bacteria found in the hair of operating room staff and those found in large outbreaks of postoperative SSIs [5, 6].

The arguments put forth by both the surgeon community and the AORN lack a strong scientific foundation. Due to the lack of high-level evidence, a substantial amount of debate persists as to the appropriate surgical hat attire, as it pertains to postoperative wound events. The purpose of this study is to investigate the association between the type of surgical hat worn by surgeons and the incidence of postoperative wound events during hernia repairs, the most common procedure performed by general surgeons, using the Americas Hernia Society Quality Collaborative (AHSQC).

Methods

Surgeon identification

All surgeons who input at least ten patients into the AHSQC with 30-day follow-up from January 1, 2013 through August 3, 2016 were identified. The statement put forth by the ACS was released on August 4, 2016. A cut-point of August 3, 2016 was, therefore, chosen to most accurately capture the type of surgical hat most commonly worn by surgeons prior to the implementation of AORN guidelines.

Online survey

Following Institutional Review Board approval, all identified surgeons were sent a survey from the AHSQC asking them about factors cited by the AORN as contributing to postoperative wound events, including their gender, the length of their hair, the presence of a beard (if applicable), and the type of surgical hat worn [3]. The length of hair was divided into two groups. Short hair was categorized as less than 4 cm long, while long hair was categorized as greater than 4 cm long. If the surgeon had a beard, they were asked if their beard is fully covered by their surgical hat and/or their surgical mask. The surgeons had the option of choosing between six different styles of surgical hats. To better demonstrate these options, the survey contained a picture of each option (Fig. 1). These options included disposable skull cap, cloth skull cap, disposable bouffant with ears exposed, disposable bouffant with ears covered, cloth bouffant, and headgear with beard coverage. Within the survey was an explanation to all the surgeons that completing the survey was voluntary and the decision to complete it or not would not affect their ability to participate in the AHSQC.

Data source

The AHSQC is a nationwide effort designed to improve the value of hernia care using real-time continuous quality improvement principles. At the time of this study, the AHSQC had data available from over 170 surgeons who practice in a variety of clinical settings, including academic, community, and academic-affiliated hospitals. The registry component of the AHSQC is comprised of predetermined standardized definitions for data collection in the preoperative, intraoperative, and 30-day postoperative phases of hernia care. Details regarding the AHSQC and registry structure, governance, and data assurance process have previously been reported [7]. The AHSQC database was chosen for this study as it contains the largest number of hernia-specific variables, including variables that we know contribute to postoperative wound events, such as the Ventral Hernia Working Group Grade, creation of subcutaneous flaps, and history of abdominal wall wound infection, that could be controlled for in a multivariate logistic regression model to isolate the association of surgical cap attire and 30-day wound events.

Primary and secondary outcomes of interest

Wound events were divided into surgical site infection (SSI) and surgical site occurrence requiring procedural intervention (SSOPI). SSI is further characterized according to CDC guidelines as a superficial, deep, or organ space infection [8]. SSO includes any SSI as well as wound cellulitis, non-healing incisional wound, fascial disruption, skin or soft tissue ischemia, skin or soft tissue necrosis, wound serous or purulent drainage, stitch abscess, seroma, hematoma, infected or exposed mesh, or development of an enterocutaneous fistula. SSOPI is defined as any SSO that requires opening of the wound, wound debridement, suture excision, percutaneous drainage, or partial or complete mesh removal [9]. The primary outcome of interest was the

Fig. 1 Surgical hat types. Surgeons were asked to choose the surgical hat type they most often wear. The options included: **a** disposable skull cap, **b** cloth skull cap, **c** cloth bouffant, **d** disposable bouffant with ears exposed, **e** disposable bouffant with ears covered, and **f** surgical headgear

association of surgical hat type with the incidence of SSI, while the secondary outcomes of interest was the association of surgical hat type with the incidence of SSOPI.

Statistical analysis

Data were described using median and range for continuous variables and counts and percentages for categorical variables. The association of preoperative patient factors and hernia characteristics with the incidence of SSI and SSOPI was initially investigated in univariate analysis using the Wilcoxon rank sum test for continuous variables and Chi-square or Fisher's exact test for categorical variables. For those factors that were found to have a significant association with SSI or SSOPI, multivariate logistic regression was used to determine the independent association of these variables with 30-day wound events. A concordance index (c statistic) was calculated for each multivariate logistic regression model. The c statistic is a reflection of the probability that, for each pair of randomly chosen patients, the patient with the most risk factors for developing a postoperative wound infection will, indeed, have such an outcome [10]. The standard accepted value for the c index is greater than 0.7 [11]. All statistical analysis was performed using SAS 9.4 Software (SAS Institute, Cary, NC) and $p < 0.05$ was considered statistically significant.

Results

A total of 86 surgeons received the surgical cap survey and 68 (79.1%) of the surgeons responded and were available for analysis. Thirty-one (45.6%) surgeons reported that they wear a disposable surgical skull cap, six (8.9%) reported that they wear a cloth skull cap, 20 (29.4%) reported that they wear a disposable bouffant with their ears exposed, and 11 (16.1%) reported that they wear a disposable bouffant with their ears covered. No surgeons within this analysis reported wearing either a cloth bouffant or the surgical headgear. While length of hair and the presence of a beard were collected, these variables were ultimately removed from the statistical analysis due to their strong association with surgeon gender and type of surgical hat worn. A total of 6210 ventral hernias were performed by the 68 surgeons included in this study during the defined study period. A total of 251 (4.0%) patients experienced a postoperative SSI, 743 (12.0%) patients experienced a postoperative SSO, and 361 (5.8%) patients experienced a postoperative SSOPI.

Table 1 details the association of preoperative patient variables and hernia characteristics with postoperative surgical site infections following univariate analysis. Obesity ($p = 0.002$), chronic obstructive pulmonary disease (COPD) ($p = 0.001$), open surgical approach ($p < 0.001$), larger hernia width ($p < 0.001$), higher modified Ventral Hernia Working Group (VHWG) grade ($p < 0.001$), current abdominal wall wound infection at the time of VHR ($p < 0.001$), history of abdominal wall wound infection ($p < 0.001$), presence of an ostomy ($p < 0.001$), operative time greater than 2 h ($p < 0.001$), performance of a concomitant procedure at the time of VHR ($p < 0.001$), use of drains ($p < 0.001$), and enterotomy at the time of VHR ($p < 0.001$) were factors associated with an increased risk of postoperative SSI. Of note, the type of surgical hat worn was not associated with an increased incidence of postoperative SSI.

Following multivariate analysis, modified VHWG grade ($p < 0.001$), presence of drains ($p = 0.03$), and enterotomy ($p = 0.004$) remained significantly associated with an

Table 1 Association of preoperative patient variables and hernia characteristics with surgical site infection events

Patient or hernia factor	SSI ($N = 251$)	No SSI ($N = 5959$)	p value
Age, years (median, range)	57.0 (48.0, 66.0)	57.0 (47.0, 66.0)	0.63
Patient female gender (*N*, %)	148 (59.0%)	3050 (51.2%)	0.016
BMI >30 kg/m^2 (*N*, %)	169 (67.3%)	3416 (57.3%)	0.002
Current smoker (*N*, %)	28 (11.2%)	706 (11.8%)	0.74
HTN (*N*, %)	137 (54.6%)	2961 (49.7%)	0.13
COPD (*N*, %)	33 (13.1%)	444 (7.5%)	0.001
DM (*N*, %)	60 (23.9%)	1118 (18.8%)	0.05
Current steroid use (*N*, %)	19 (7.6%)	291 (4.9%)	0.06
Surgical approach (*N*, %)			
Open	234 (93.2%)	4348 (73.0%)	<0.001
Laparoscopic	10 (4.0%)	1069 (17.9%)	
Laparoscopic converted to open	7 (2.8%)	481 (8.1%)	
Prophylactic IV antibiotics received (*N*, %)	248 (98.9%)	5914 (99.2%)	0.44
Hernia width (median, range)	10.0 (6.0, 15.0)	5.0 (2.0, 10.0)	<0.001
Modified VHWG grade (*N*, %)			
1	20 (8.0%)	1589 (26.7%)	<0.001
2	94 (37.5%)	3396 (57.0%)	
3	137 (54.5%)	974 (16.3%)	
Current active infection (*N*, %)	147 (58.6%)	117 (2.0%)	<0.001
History of abdominal wall wound infection (*N*, %)	92 (36.7%)	859 (14.4%)	<0.001
Stoma present (*N*, %)	52 (20.7%)	408 (6.8%)	<0.001
OR time >2 h (*N*, %)	202 (80.5%)	3109 (52.2%)	<0.001
Myofascial release performed (*N*, %)	154 (61.4%)	2372 (39.8%)	<0.001
Concomitant procedure performed (*N*, %)	111 (44.2%)	1553 (26.1%)	<0.001
Drains placed (*N*, %)	195 (77.7%)	2677 (44.9%)	<0.001
Enterotomy (*N*, %)	23 (9.2%)	112 (1.9%)	<0.001
Surgical hat type (*N*, %)			
Disposable surgical skull cap	137 (54.6%)	3296 (55.3%)	0.85
Cloth surgical skull cap	24 (9.5%)	591 (9.9%)	
Disposable bouffant EE	59 (23.5%)	1270 (21.3%)	
Disposable bouffant EC	31 (12.4%)	802 (13.5%)	
Surgeon female gender (*N*, %)	24 (9.6%)	583 (9.8%)	0.91

SSI surgical site infection, *N* number, *SD* standard deviation, *BMI* body mass index, *HTN* hypertension, *COPD* chronic obstructive pulmonary disease, *DM* diabetes mellitus, *IV* intravenous; *VHWG* Ventral Hernia Working Group, *OR* operative time increased incidence of postoperative SSI (Fig. 2). Within the multivariate analysis, multiple comparisons were made between the different types of surgical hats to better determine if the type of surgical hat worn is associated with an increased incidence of postoperative SSI. There was no statistically significant difference in the incidence of postoperative SSI when all surgical cap types were compared to all surgical bouffant types or when any combination of surgical caps and surgical bouffants were compared to one another (Fig. 2). The *c* statistic for the multivariate logistic regression model was 0.80.

Table 2 details the association of preoperative patient variables and hernia characteristics with postoperative surgical site occurrences requiring procedural intervention following univariate analysis. Female gender ($p = 0.001$), obesity ($p < 0.001$), HTN ($p < 0.001$), COPD ($p < 0.04$), DM ($p = 0.008$), chronic steroid use ($p = 0.029$), open surgical approach ($p < 0.001$), larger hernia width ($p < 0.001$), higher modified VHWG grade ($p < 0.001$), current abdominal wall wound infection at the time of VHR ($p < 0.001$), history of abdominal wall wound infection ($p < 0.001$), presence of an ostomy ($p < 0.001$), prolonged operative time greater than 2 h ($p < 0.001$), myofascial release ($p < 0.001$), performance of a concomitant procedure at the time of VHR ($p < 0.001$), use of drains ($p < 0.001$), and enterotomy at the time of VHR ($p = 0.04$) were factors associated with an increased risk of postoperative SSOPI. The type of surgical hat worn was not associated with an increased incidence of postoperative SSOPI.

Following multivariate analysis, female patients ($p = 0.02$), obesity ($p = 0.04$), HTN ($p = 0.02$), hernia width ($p = 0.03$), a higher modified VHWG grade ($p = 0.03$), and prolonged operative time greater than 2 h ($p = 0.001$) remained significantly associated with an increased incidence of SSOPI (Fig. 3). Similar to the multivariate analysis for SSI, multiple comparisons were made between the different types of surgical hats to better determine if the type of surgical hat worn is associated with an increased incidence of postoperative SSOPI. There was no statistically significant difference in the incidence of postoperative SSO when all surgical cap types were compared to all surgical bouffant types or when any combination of surgical caps and surgical bouffants were

Variables	Odds Ratios	95% CI
Surgical Cap Type		
disp cap vs disp boufEC	0.884	(0.5, 1.565)
cloth cap vs disp boufEC	1.136	(0.53, 2.435)
disp boufEE vs disp boufEC	1.024	(0.571, 1.835)
Hernia Grade		
1 vs 3	0.231	(0.124, 0.43)
2 vs 3	0.328	(0.224, 0.48)
Gender(Patient)	0.769	(0.586, 1.009)
BMI>30	1.107	(0.79, 1.55)
Current Smoker	0.873	(0.564, 1.352)
HTN	1.039	(0.776, 1.391)
COPD	1.615	(1.063, 2.453)
Diabetes	1.119	(0.807, 1.552)
Steroid	1.224	(0.732, 2.046)
History of infection	1.373	(0.979, 1.925)
current infected	1.54	(0.897, 2.643)
Stoma	1.358	(0.923, 1.997)
Antibiotics	1.713	(0.199, 2.554)
OR time>2hr	1.356	(0.875, 2.103)
Myofascial	0.797	(0.556, 1.143)
Concomitant Procedure	0.902	(0.655, 1.241)
Drains	1.646	(1.052, 2.577)
Enterotomy	2.126	(1.268, 3.563)
Gender(Surgeon)	1.101	(0.575, 2.107)
Beard	1.013	(0.634, 1.617)
Surgical Approach		
open vs lap converted to open	1.701	(0.741, 3.906)
lap vs lap converted to open	0.648	(0.238, 1.768)
Hernia Width	1.019	(0.996, 1.043)
Age(patient)	0.99	(0.98, 1.001)

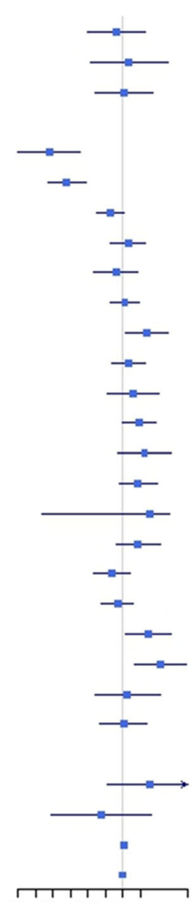

Fig. 2 Multivariate logistic regression model for association of preoperative patient variables, operative details, and surgical hat type with postoperative surgical site infection (SSI) events. There is no association with any type of surgical hat and postoperative SSI events

Table 2 Association of preoperative patient variables and hernia characteristics with surgical site occurrence requiring procedural intervention events

Patient or hernia factor	SSOPI (*N* = 361)	No SSOPI (*N* = 5849)	*p* value
Age, years (median, range)	57.0 (48.0, 66.0)	57.0 (47.0, 66.0)	0.78
Patient female gender (*N*, %)	216 (59.8%)	2982 (50.6%)	0.001
BMI >30 kg/m^2 (*N*, %)	256 (70.9%)	3329 (56.9%)	<0.001
Current smoker (*N*, %)	46 (12.7%)	688 (11.8%)	0.58
HTN (*N*, %)	217 (60.1%)	2881 (49.3%)	<0.001
COPD (*N*, %)	41 (11.4%)	436 (7.5%)	0.04
DM (*N*, %)	176 (48.8%)	1002 (17.1%)	0.008
Current steroid use (*N*, %)	27 (74.8%)	283 (4.8%)	0.029
Surgical approach (*N*, %)			
Open	330 (91.4%)	4252 (72.7%)	<0.001
Laparoscopic	17 (4.7%)	1063 (18.2%)	
Laparoscopic converted to open	14 (3.9%)	475 (8.1%)	
Prophylactic IV antibiotics received (*N*, %)	358 (99.2%)	5804 (99.2%)	0.76
Hernia width (median, range)	10.0 (6.0, 15.0)	5.0 (2.0, 10.0)	<0.001
Modified VHWG grade (*N*, %)			
1	34 (9.4%)	1575 (26.9%)	<0.001
2	167 (46.3%)	3323 (56.8%)	
3	160 (44.3%)	951 (16.3%)	
Current active infection (*N*, %)	32 (8.9%)	115 (2.0%)	<0.001
History of abdominal wall wound infection (*N*, %)	120 (33.2%)	831 (14.2%)	<0.001
Stoma present (*N*, %)	58 (16.1%)	402 (6.9%)	<0.001
OR time >2 h (*N*, %)	293 (81.2%)	3018 (51.6%)	<0.001
Myofascial release performed (*N*, %)	222 (61.5%)	2304 (39.4%)	<0.001
Concomitant procedure performed (*N*, %)	160 (44.3%)	1504 (25.7%)	<0.001
Drains placed (*N*, %)	284 (78.7%)	2588 (44.2%)	<0.001
Enterotomy (*N*, %)	24 (6.7%)	111 (1.9%)	0.04
Surgical hat type (*N*, %)			
Disposable surgical skull cap	200 (55.4%)	3233 (55.3%)	0.84
Cloth surgical skull cap	31 (8.5%)	584 (9.9%)	
Disposable bouffant EE	80 (22.2%)	1249 (21.4%)	
Disposable bouffant EC	50 (13.9%)	783 (13.4%)	
Surgeon female gender (*N*, %)	45 (12.5%)	562 (9.6%)	0.08

SSOPI surgical site occurrence requiring procedural intervention, *N* number, *SD* standard deviation, *BMI* body mass index, *HTN* hypertension, *COPD* chronic obstructive pulmonary disease, *DM* diabetes mellitus, *IV* intravenous, *VHWG* Ventral Hernia Working Group, *OR* operative time

compared to one another (Fig. 3). The *c* statistic for the multivariate logistic regression model was 0.79.

Discussion

This is the first study to investigate the association of the type of surgical hat worn by surgeons with the incidence of postoperative wound events. We found that no particular type of surgical hat was associated with an increased risk of SSI or SSOPI following ventral hernia repair. Furthermore, this study shows no association between ear exposure and the incidence of SSI or SSOPI following ventral hernia repair. These findings do not support the AORN recommendation that all surgical personnel wear disposable, bouffant-style surgical hats. This study identified several other risk factors which have previously been identified in the other studies to contribute to an increased incidence of postoperative wound events [12–14]. However, there was no association between surgical hat types and postoperative wound events.

While there has been ongoing debate regarding appropriate surgical hats worn by operating room personnel, the most recent recommendations released by the AORN in 2012 are based on fairly low-level evidence published in 1965 and 1973 [5, 6]. The first study, by Summers et al.,

Variables	Odds Ratios	95% CI
Surgical Cap Type		
disp cap vs disp boufEC	1.101	(0.668, 1.813)
cloth cap vs disp boufEC	1.13	(0.574, 2.224)
disp boufEE vs disp boufEC	0.951	(0.571, 1.584)
Hernia Grade		
1 vs 3	0.405	(0.239, 0.686)
2 vs 3	0.519	(0.375, 0.717)
Gender(Patient)	0.762	(0.605, 0.958)
BMI>30	1.374	(1.013, 1.863)
Current Smoker	1.099	(0.771, 1.566)
HTN	1.361	(1.061, 1.744)
COPD	1.28	(0.883, 1.855)
Diabetes	0.994	(0.756, 1.306)
Steroid	1.268	(0.817, 1.966)
History of infection	1.385	(1.039, 1.845)
current infected	1.347	(0.812, 2.234)
Stoma	1.182	(0.827, 1.69)
Antibiotics	0.853	(0.245, 2.972)
OR time>2hr	1.5	(1.036, 2.173)
Myofascial	0.782	(0.578, 1.058)
Concomitant Procedure	1.175	(0.899, 1.535)
Drains	1.978	(1.343, 2.914)
Enterotomy	1.653	(1.001, 2.731)
Gender(Surgeon)	0.754	(0.434, 1.308)
Beard	1.263	(0.849, 1.881)
Surgical Approach		
open vs lap converted to open	1.347	(0.715, 2.538)
lap vs lap converted to open	0.613	(0.283, 1.328)
Hernia Width	1.029	(1.01, 1.049)
Age(patient)	0.992	(0.982, 1.001)

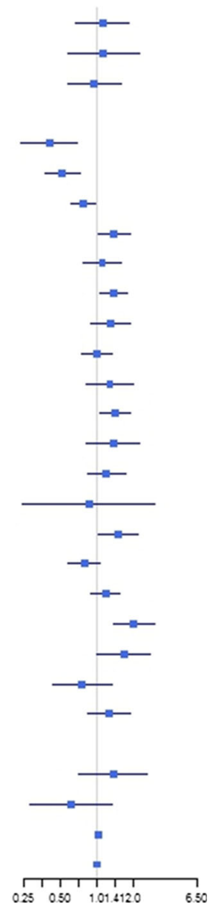

Fig. 3 Multivariate logistic regression model for association of preoperative patient variables, operative details, and surgical hat type with postoperative surgical site occurrence requiring procedural intervention (SSOPI) events. There is no association with any type of surgical hat and postoperative SSOPI events

was a retrospective study comparing the strains of bacteria isolated from the nares and hair of ambulatory patients, hospital employees, and patients admitted to the hospital following surgery with the strains of bacteria found in postoperative wound infections [5]. The most commonly isolated bacteria from all study subjects were *Staphylococci* and 13.6% of wound infections had the same strain of *Staphylococci* as that found in the hair of the infected patient [5]. While the authors concluded that hair may be a potential source of bacterial cross-contamination, they did not identify any association between the bacteria found in the hair of operating surgeons and those isolated from postoperative wounds [5]. Simply put, while this study identified hair as a reservoir for *Staphylococci*, it did not show any relationship between that finding and the occurrence of postoperative wound events.

In the second study, Dineen et al. investigated the strain of bacteria isolated from healthcare employees and those isolated during two separate wound infection outbreaks at a single institution [6]. The authors did identify the same bacteria isolate in the hair of one general surgeon and those within the wounds of all patients affected in one of the outbreaks [6]. Nevertheless, the authors went on to discuss additional factors that potentially may have contributed to the infection outbreaks, including damage to perforating vessels and tissue dead space, and necrosis related to the surgical procedures performed [6]. Therefore, while the same bacteria was isolated from the hair of the operating surgeon and the wounds of the infected patients in one outbreak, it is very difficult, based on this type of study, to determine a causal relationship between the surgeon and the infectious outbreaks. Another important weakness of this article is that this study described two relatively small case series which refer to isolated incidents and, therefore, should be used cautiously, if at all, to make broad generalizations regarding acceptable surgical hat attire for all operating room personnel. Finally, the type of surgical headgear worn by the surgeons mentioned in this article was not considered as part of the analysis, making the relevance of their findings unclear at best.

There are two additional studies referenced by the AORN in online teaching material for operating room nurses. The first is an investigation by Owers et al. which was published in 2004 [15, 16]. In this study, the authors identify an increased rate of postoperative wound events following the introduction of laminar flow in the operating room. To determine the source of the bacteria, the authors cultured the foreheads, eyebrows, and ears of 20 operating room employees, and found that ears harbored the highest concentration of bacteria [15]. Notably, there was no mention in this article of the bacteria isolated from postoperative wound events, nor did the authors attempt to determine any association between the bacteria isolated from the operating room personnel and the bacteria isolated from infected wounds [16].

The second study, published by Mase et al., revealed that the bacteria isolated from the hair of hospital employees are not eradicated by the traditional shampoo detergent [17]. Again, there was no direct investigation of the bacteria isolated from the hair and the bacteria found in postoperative wound infections. Nevertheless, despite the lack of any evidence to suggest that bacteria isolated from operating room personnel are the source of postoperative wound events, both of these studies are still used to support the recommendation that all operating room personnel should wear disposable, bouffant-style surgical cap with both ears covered to minimize the risk of postoperative wound events [15].

Overall, the current level of evidence to support a change in surgical headgear due to a purported increase in postoperative wound events is weak at best. Importantly, none of the articles cited as evidence to support elimination of all surgical hat types except for the disposable surgical bouffant-style cap have included type of surgical headgear as a factor for analysis. Yet, the current recommendations to avoid postoperative wound infections are a complete overhaul of the surgical hats currently available to operating room personnel. Thus, the cited literature fails entirely to address the intervention which is currently suggested in the most recent guidelines put forth by the AORN.

Despite the surgical skull cap having been identified by some as a symbol of the profession, the more likely relevant and significant point is that there is no apparent detriment to patients from surgeons wearing a surgical skull cap, according to our findings [4]. In general, the surgical community is expected, by the American College of Surgeons' Code of Conduct, to "participate in self-regulation by setting, maintaining, and enforcing practice standards" and, furthermore, to "improve care by evaluating its processes and outcomes [18]". To that end, changes to surgical culture should be considered as quality improvement efforts and undertaken based on the best available current evidence. While, admittedly, our study is not a randomized controlled trial, its strength lies in the benefits of a registry-based trial, namely, a large number of cases and postoperative wound events available for analysis. To the best of our knowledge, our study reflects the highest quality of evidence, currently available to make an informed decision regarding the appropriate type of surgical hat worn by operating room personnel.

Despite our results, this study does have limitations. Surgeons were asked to fill out the survey based on their common operating room practices. While we attempted to limit changes to operating room attire by pulling the cases prior to stricter adherence to AORN policies, it is possible that some of the surgeons fell into more than one surgical hat group. Inherent to the retrospective nature of this study, we were unable to determine if there was a correlation between the bacteria isolated from any of the wound infections and the bacteria on the skin or hair surfaces of the operating surgeons. Furthermore, this study is limited to the association between the surgeon's surgical cap attire and 30-day wound events, and does not account for the surgical cap attire of other operating room personnel. Intrinsic to a survey-based study, we did have some surgeons who did not respond to the survey [19]. Future comparative studies of a prospective nature may help to further clarify recommendations for surgical hat attire which are not dependent on survey responses.

Conclusion

Our study is the first study that has directly compared the association of different types of surgical hats with postoperative wound events. We have demonstrated that there is no association between the type of surgical hat worn and the incidence of postoperative wound events following ventral hernia repair. Our findings suggest that types of surgical hats may be chosen at the discretion of operating room personnel without fear of detriment to their patients.

Acknowledgements INH: study concept, data acquisition, data analysis, data interpretation, manuscript writing, and final manuscript review. ASP: study concept, data interpretation, manuscript writing, and final manuscript review. DMK: study concept, data analysis, data interpretation, and final manuscript review. AJP: study concept, data interpretation, and final manuscript review. LT: data interpretation and final manuscript review. CT: data analysis, data interpretation, and final manuscript review. SR: data interpretation and final manuscript review. BKP: study concept, data interpretation, and final manuscript review. MJR: study concept, data analysis, data interpretation, manuscript writing, and final manuscript review.

Compliance with ethical standards

Conflict of interest AJP, LT, CT, and SR declare no conflict of interest. INH declares no conflict of interest directly related to this work but has received a Resident Research Grant from the Americas Hernia Society. ASP declares no conflict of interest directly related to this work but has received consulting fees from MedTronic and Bard and grant funding from Intuitive Surgical, Inc. DMK declares no conflict of interest. BKP receives salary support from the AHSQC which is directly related to this work, and he receives consulting fees from Artiste Medical and Pfizer and grant funding from Bard Davol unrelated to this work. MJR is the Medical Director of and receives salary from the AHSQC which is directly related to this work and he receives consulting fees for Bard and Gore, and has received grant funding from Miromatrix and Intuitive Surgical, Inc., unrelated to this work.

Ethical approval This study did not need approval from the local ethical committee.

Human and animal rights This study does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all participating surgeons included in the study.

References

1. Reichman DE, Greenberg JA (2009) Reducing surgical site infections: a review. Rev Obstet Gynecol 2(4):212–221
2. Astagneau P, Rioux C, Golliot F, Brucker G (2001) Morbidity and mortality associated with surgical site infections: results from the 1997–1999 INCISO surveillance. J Hosp Infect 48(4):267–274
3. Braswell ML, Spruce L (2012) Implementing AORN recommended practices for surgical attire. AORN J 95(1):122–137
4. Statement on Operating Room Attire (2016). https://www.facs.org/about-acs/statements/87-surgical-attire. Accessed 9 Dec 2016
5. Summers MM, Lynch PF, Black T (1965) Hair as a reservoir of Staphylococci. J Clin Pathol 18:13–15
6. Dineen P, Drusin L (1973) Epidemics of postoperative wound infections associated with hair carriers. Lancet 2(7839):1157–1159
7. Poulose BK, Rolls S, Murphy JW, Matthews BD et al (2016) Design and implementation of the Americas Hernias Society Quality Collaborative (AHSQC): improving value in hernia care. Hernia 20(2):177–189
8. Surgical Site Infection (SSI) Event (2016). http://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf. Accessed 9 Dec 2016
9. Americas Hernia Society Quality Collaborative Qualified Clinical Data Registry Physician Quality Reporting System Measure Specifications. https://www.ahsqc.org/images/uploads/general_images/AHSQC_QCDR_Posting_to_website_4.27.16.pdf. Accessed 9 Dec 2016
10. Uno H, Cai T, Pencina MJ, D'Agostino RB, Wei LJ (2011) On the *c*-statistics for evaluating overall adequacy of risk prediction procedures with censored survival data. Stat Med 30(10):1105–1117
11. Kim JH, Kim HS, Yeo WY et al (2011) External validation of nomogram for the prediction of recurrence after curative resection in early gastric cancer. Ann Oncol 23(2):361–367
12. Kanters AE, Krpata DM, Blatnik JA, Novitsky YM et al (2012) Modified hernia grading scale to stratify surgical site occurrence after open ventral hernia repairs. J Am Coll Surg 215(6):787–793
13. Petro CC, O'Rourke CP, Posielski NM, Criss CN et al (2016) Designing a ventral hernia staging system. Hernia 20(1):111–117
14. Krpata DM, Blatnik JA, Novitsky YW, Rosen MJ (2012) Posterior and open anterior components separations: a comparative analysis. Am J Surg 203(3):318–322
15. Perioperative Attire: the importance of following the recommended practice. http://www.slideshare.net/aornsocialmedia/recommended-practices-for-surgical-attire. Accessed 19 Jan 2017
16. Owers KL, James E, Bannister GC (2004) Source of bacterial shedding in laminar flow theatres. J Hosp Infect 58(3):230–232
17. Mase K, Hasegawa T, Horii T et al (2000) Firm adherence of *Staphylococcus aureus* and *Staphylococcus epidermidis* to human hair and effect of detergent treatment. Microbiol Immunol 44(8):653–656
18. American College of Surgeons Statements on Principles (2016). https://www.facs.org/about-acs/statements/stonprin#code. Accessed 19 Jan 2017
19. Feigelson HS, McMullen CK, Madrid S et al (2017) Optimizing patient-reports outcome and risk factor reporting from cancer survivors: a randomized trial of four different survey methods among colorectal cancer survivors. J Cancer Surviv. doi:10.1007/s11764-017-0596-1