ORIGINAL ARTICLE

Incidence of surgical site infection in head and neck surgery: a prospective cohort study

Incidencia de infección del sitio quirúrgico en cirugía de cabeza y cuello: estudio de cohorte prospectivo

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Abstract

Objectives: *Surgical site infection (SSI) causes high morbidity. Our aim was to study the incidence of SSI and to assess its risk factors in patients undergoing head and neck surgery.* **Methods:** *A prospective cohort study was conducted, from July 2007 to June 2023, by collecting data on patient, surgery, and infection-related variables, and calculating the incidence of SSI after a maximum follow-up period of 1 year. We assessed the effect of the different risk factors on SSI, using the relative risk adjusted with a logistic regression model.* **Results:** *We included 423 patients, mean age 65.8 years (standard deviation: 12.4). The most frequent comorbidities were neoplasms (82.1%) and diabetes mellitus (29.3%). The cumulative incidence of surgical infection across the follow-up period was 6.4% (95% confidence interval: 4.1-8.7). Most infections were superficial, with the most common microorganism being Enterobacter cloacae (42.8%). Duration of surgery above the 75th percentile was the only risk factor associated with SSI in the multivariate analysis (p = 0.01).* **Conclusions:** *The incidence of infection was low in neck surgery. Infection rates must be assessed continuously, and SSI risk factors identified early through the implementation of prospective hospital surgical-infection surveillance and control programs.*

Keywords: Epidemiological surveillance. Head and neck surgery. Surgical site infection. Incidence. Cohort studies. Risk factors.

Resumen

Objetivo: *Estudiar la infección del sitio quirúrgico (ISQ) y los factores de riesgo relacionados en pacientes intervenidos de cirugía de cuello.* **Métodos:** *Se realizó un estudio de cohorte prospectivo desde julio de 2007 hasta junio de 2023. Se recogieron datos de los pacientes, la cirugía y las infecciones quirúrgicas. Se calculó la incidencia de ISQ tras un seguimiento de 1 año. Se evaluó el efecto de los factores de riesgo con el riesgo relativo ajustado con un modelo de regresión logística.* **Resultados:** *Se incluyeron 423 pacientes, con una edad media de 65.8 años (DE: 1.4). La comorbilidad más frecuente incluyó neoplasias (82.1%) y diabetes mellitus (29.3%). La incidencia acumulada de ISQ fue del 6.4% (IC 95%: 4.1-8.7). La mayoría de las infecciones fueron superficiales y el microorganismo más frecuente fue Enterobacter cloacae (42.8%). En el análisis*

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multivariante, la duración de la cirugía mayor que el percentil 75 se relacionó con la ISQ (p = 0.01). **Conclusiones:** *La incidencia de ISQ en la cirugía de cuello fue baja. La incidencia de infección quirúrgica y los factores de riesgo asociados deben ser evaluados de forma continuada con programas de vigilancia y control de las infecciones quirúrgicas.*

Palabras clave: *Vigilancia epidemiológica. Cirugía de cabeza y cuello. Infección del sitio quirúrgico. Incidencia. Estudio de cohorte. Factores de riesgo.*

Introduction

Healthcare-associated infections (HAIs) are those that occur during patients' healthcare processes and were neither present clinically nor incubating at the time of admission.[1] According to the latest Prevalence Study of Nosocomial Infection in Spain (*Estudio de Prevalencia de Infección Nosocomial en España/ EPINE*), 6.0% of patients present with one or more HAIs.[2]

Surgical site infections (SSIs) are infections related to a surgical procedure, which occur in the surgical incision or nearby tissue and whose development is most likely within 15-30 days following surgery. SSIs are classified in three categories: superficial, if they only affect the cutaneous and subcutaneous tissue; deep, if they involve deep soft tissue (fascia and muscle walls); and organ-space, when they affect any distal zone to the sterile incision or cavity.[3]

SSIs are one of the main causes of morbidity and mortality in hospitalized patients,[4] prolonging hospital stays, increasing readmissions, reducing the quality of life of the patient intervened, and raising the cost of healthcare processes.[5-9] Within HAIs, SSIs lead (26.3%), ranking ahead of urinary infections (16.0%) and bacteremias (14.8%).[2,10]

Within otorhinolaryngological surgery, head and neck surgery is one of the most important types, mainly encompassing surgical interventions of neoplasms that develop in topographical regions of the mouth, throat, glottis, salivary glands, and skin of the face and neck. These tumors account for around 3% of all cancers, and their incidence is on the rise.[11] Treatment of this type of neoplasm is multidisciplinary, with resection of the tumor being practically indispensable for its cure.

The development of SSIs in head and neck surgery is a relatively frequent complication. According to the literature, these figures fluctuate widely, depending on the degree of contamination of surgery, ranging anywhere from 3% to 85%[7,8,12,13] according to whether it is classed as "clean," "clean-contaminated," contaminated" or "dirty."

We sought to study the incidence of SSI and assess the risk factors that determine it in patients undergoing head and neck surgery at a University Teaching Hospital.

Methods

Study design

We conducted a prospective cohort study from July 2007 to June 2023, covering patients over 18 years of age undergoing head and neck surgery at a university teaching hospital and excluding those who at the time of surgery presented with suspicion of infection or were receiving antibiotic treatment for confirmed infection. All surgical procedures falling within the CDC's NECK category were included (Table 1). The study was approved by the Clinical Ethics Research Committee of the hospital (number 16/91), and informed consent was obtained from all subjects and/or their legal guardian(s).

Sample size and data collection

Sample size was estimated on the basis of a 95% confidence interval (CI), a precision of 5%, an estimated proportion of infection of 25%, and an envisaged 10% of losses. A necessary sample size of at least 320 patients was thus estimated. The patients were selected from surgical programming and were consecutively recruited throughout the study period.

The research data were collected on a purpose-designed form and entered onto a normalized relational database. The following were collected: sociodemographic variables pertaining to patients and their perioperative clinical situation, including date of birth, sex, presence of comorbidities (malnutrition, kidney failure, diabetes mellitus, neoplasm, chronic obstructive pulmonary disease (COPD), cirrhosis, obesity and immunodeficiency), need for transfusion or drainage during the intervention; variables relating to hospital stay, that is, date of admission, diagnosis and date of discharge; variables related with presurgical preparation and

Table 1. Surgical procedures studied (ICD-9-CM) of head and neck surgery

ICD-9-CM*	Intervention	n	%
30.1	Hemilaryngectomy	3	0.7
30.21	Epiglottidectomy	0	0
30.22	Vocal cordectomy	168	40
30.29	Other partial laryngectomy	30	7.1
30.3	Total laryngectomy	63	15
30.4	Radical laryngectomy	24	5.7
31.45	Open biopsy of larynx or trachea	24	5.7
40.40	Radical neck dissection, not otherwise specified	12	2.9
40.41	Radical neck dissection, unilateral	87	20.7
40.42	Radical neck dissection, bilateral	6	2.2
Total		423	100

*ICD-9-CM: international classification of diseases, 9th revision, clinical modification.

antibiotic prophylaxis; and surgery-related variables, such as date of intervention, duration of surgery, type of surgical procedure, degree of contamination of surgery (clean, clean-contaminated, contaminated and dirty), American Society of Anesthesiologists (ASA) anesthetic risk and the CDC National Nosocomial Infection Surveillance (NNIS) index. When a patient was diagnosed with SSI, we collected the date of diagnosis, infection site, result of culture (positive or negative), and microorganisms isolated.

SSIs were diagnosed by reference to the CDC's SSI criteria, and taking into account the patient's signs and symptoms, his/her clinical progress, surgical wound assessment, plus results of microbiological cultures where requested. Depth of infection was classified into superficial, deep, and organ-space.[3]

Patients were clinically followed up by daily visit from the date of admission to discharge, and thereafter through visits to outpatient clinics and emergency services, or from primary care through the review of electronic medical records (Selene®) or clinical information visor HORUS®. The study follow-up and total time were set in accordance with CDC criteria for implant surgery and were 1 year.

Statistical analysis

We used frequency distributions to describe the qualitative variables, which were then compared using the Pearson Chi-square test or Fisher's exact test, where the conditions of application were not met (expected values < 5). In the case of the quantitative variables, these were described using the mean and standard deviation (SD), or the median and interquartile range (IQR) in those cases where the normality criteria were not fulfilled. To compare the quantitative variables, we used the Student's t-test or the Mann–Whitney U test in those cases where the data were not normally distributed. When the quantitative variables were compared in more than two groups, we used the analysis of variance test if the variables followed a normal distribution, or the Kruskal–Wallis non-parametric test on the contrary.

The incidence of infection was estimated by calculating the cumulative incidence of surgical infection across the follow-up period. SSI incidence was calculated by stratifying the risk according to the NNIS index. We standardized the incidence of infection by the indirect method, taking into account the cumulative incidence of SSIs in our region, in our country, and those reported by the CDC. The different risk factors were evaluated by calculating the relative risk (RR) of infection, both individually and grouped, with explanatory logistic regression models being built with the "backstep" method to control for confounding and interaction among different factors. In the internal calibration of the model (goodness-of-fit), we used the Hosmer-Lemeshow test.

The sample size was calculated using the Epidat 4.2 epidemiological software program, and the analyses were performed using the Statistical Package for the Social Sciences v.27 statistical software program, with statistical significance set at $p < 0.05$.

Results

The study covered a total of 423 surgical interventions of the head and neck. The breakdown showed that the patients were 81.4% men and 18.6% women, with a mean age of 65.8 years (SD = 12.4), 68.1 years in men and 55.5 years in women ($p < 0.01$). Table 2 shows the data on the patients' perioperative clinical situation and comorbidities.

The interventions were distributed as shown in Table 1: vocal cordectomy was the most frequent type (40%), followed by unilateral radical dissection of the neck (20.7%). The median overall hospital stay was 3 days (IQR = 13): the median stay among patients who did not develop SSIs was 3 days (IQR = 12) and 26 days (IQR = 26) among those with surgical

Table 2. Preoperative clinical situation and comorbidities of patients intervened

Comorbidity	n	%
Drainage	201	47.9
Shaving	18	4.3
Transfusion	9	2.1
Kidney failure	18	4.3
Malnutrition	18	4.3
Diabetes mellitus	123	29.3
Neoplasm	345	82.1
COPD	78	18.6
Cirrhosis	15	3.6
Obesity	36	8.6
Immunodeficiency	3	0.7
Total	423	100

COPD: chronic obstructive pulmonary disease.

Table 3. Mean stay of patients according to the NNIS index (n = 423)

NNIS index	n (%)	Days (SD)
0	199 (47.1)	3.4 (5.8)
1	160 (37.9)	11.1 (12.6)
2	64 (15.0)	19.9 (14.2)
3	0 (0)	-

NNIS: National Nosocomial Infections Surveillance System; SD: standard deviation.

infection ($p < 0.001$). The mean time from admission until diagnosis of infection was 10.6 days (SD = 6.9). The earliest case was diagnosed 2 days after surgery, and the latest, 24 days after surgery.

A total of 86.7% of intervened patients received appropriate presurgical preparation (95% CI: 83.8-89.1), with the most common cause of inappropriateness being non-application of mouthwash (67.1%). Of the 228 patients who required antibiotic prophylaxis, 189 received it, and among these, it was appropriate in 162 (85.7%; 95% CI: 80.8-90.1). The principal cause of inappropriateness was the choice of antibiotic (65.0%).

For the calculation of the NNIS index, we used the variables of classification of ASA anesthetic risk, degree of contamination of surgery, and duration of surgery (75th percentile, 225 min). While most patients (47.1%) had an NNIS of 0, no patient with an NNIS of 3 underwent surgery. Table 3 shows the mean stay of patients according to the NNIS index.

There were a total of 27 infections across the follow-up period, amounting to an overall SSI incidence of 6.4% (95% CI: 4.1-8.7). Most of the infections (44.4%) occurred in patients with an NNIS index of 1. Of the 27 surgical infections, 18 were superficial (66.7%) and 9 deep (33.3%). There were no organ-space SSIs within the 16 years analyzed.

A microbiological culture was performed in all infections and tested positive in 15. The microorganism most frequently found was *Enterobacter cloacae* (43.0%). In six cases, two microorganisms were isolated, with the microorganisms responsible for the infections being shown in figure 1.

Cumulative SSI incidence at our hospital was compared to cumulative incidences, regionally and nationwide, issued by the INCLIMECC work group (Clinical Continuous Quality Improvement Indicators) and stratified according to NNIS risk (Table 3). Furthermore, these figures were also compared to the cumulative incidence rates issued by the CDC. Indirect standardization was performed by calculating the standardized infection ratio (SIR). The SIR at the hospital was: 1.48 (95% CI: 0.51-2.45) with respect to the Region; 1.94 (95% CI: 0.67-3.21) with respect to the country as a whole; and 2.07 (95% CI: 0.72-3.42) with respect to the CDC.

SSI risk factors were studied univariate. The statistically significant variables ($p < 0.05$) were as follows: malnutrition; duration of surgery above the 75th percentile; and the presence of drainage. Table 4 shows the univariate analysis of the various SSI risk factors: it omits the risk factors which had very low prevalence and those that did not present with infection in some of the groups.

The multivariate analysis (Table 4) studied the independent SSI risk factors shown to be statistically significant by the univariate analysis. Duration of surgery above the 75th percentile was the sole factor to prove statistically significant ($p = 0.01$).

Discussion

Overall SSI incidence in our study was 6.4% (95% CI: 4.1-8.7), a figure lower than that of most of the papers reviewed.[14-16] There were no significant differences after standardization with existing data, neither for the region nor the country, nor those reported by the CDC.[12]

Surgery of the head and neck is a complex surgery that encompasses many procedures and different

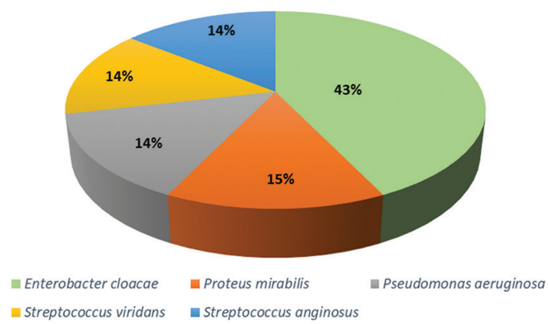

Figure 1. *Etiology of surgical site infection in head and neck surgery (%), n = 15.*

Table 4. Univariate and multivariate analysis for SSI risk factors

Univariate analysis					
Risk factors	**SSI (n: 9) n (%)**	**No SSI (n: 131) n (%)**	**RR[1]**	**95% CI[2]**	**p**
Mean age (SD[3])	65.7 (9.3)	65.8 (12.7)	1	09-1.1	0.99
Diabetes mellitus	3 (33.3)	38 (29.0)	1.22	0.3-5.1	0.52
COPD[4]	1 (11.1)	25 (19.1)	0.53	0.1-4.4	0.48
Malnutrition	2 (22.2)	4 (3.1)	9.1	1.4-58.3	0.048
Cirrhosis	1 (11.1)	4 (3.1)	4.0	0.4-39.8	0.29
NNIS[5] index					
0	2 (22.2)	64 (48.9)	Ref.		
1	4 (44.4)	49 (37.4)	2.61	0.5-14.9	0.28
2	3 (33.3)	18 (13.7)	5.33	0.8-34.4	0.08
ASA[6] > 2	4 (44.4)	57 (43.5)	1.04	0.3-4.0	0.61
Duration of surgery (> P75)	6 (66.7)	28 (21.4)	7.36	1.7-31.3	0.007
Inappropriate prophylaxis	2 (28.6) of 7	7 (12.5) of 56	2.8	0.4-17.3	0.26
Drainage	7 (77.8)	60 (45.8)	4.14	0.8-20.7	0.06

Multivariate analysis			
Risk factors	**RR**	**95% IC**	**p**
Malnutrition	6.57	0.9-49.2	0.07
Duration of surgery (> P75)	6.52	1.5-28.6	0.01

[1]Relative risk.
[2]Confidence interval.
[3]Standard deviation.
[4]Chronic obstructive pulmonary disease.
[5]National nosocomial infections surveillance system index.
[6]American Society of Anesthesiologists.

surgical techniques. It should be stressed here that there is great variability in the diagnosis of SSIs in this type of patient, for example, due to the possibility that different complications might arise as a result of partial/total flap compromises or vascular failures, which could account in part for the wide variability in SSI incidence rates found in the literature.[7,8,12,13]

In our study, patients with SSIs had hospital stays longer than patients who did not present with surgical infections, in line with the literature.[17,18] The 23-day increase in hospital stay was higher than that reported by Al-Qurayshi et al.[7] for surgeries of the head and neck, estimated at 8 days, with our case being more in line with that described by Badia et al.,[5] who found wide variability in the six countries included in their systematic review, with hospitalization always being longer in patients with surgical infection.

The microorganisms isolated in infections of head and neck surgery vary widely, particularly the common bacterial colonization of the respiratory tract. In our study, there were a very small number of infections, with the pathogens most frequently encountered being *E. cloacae* and gram-negative bacteria, a finding that agrees with other studies of surgical infection at this site.[19-22]

The risk of developing a surgical infection depends on various factors, some of them of intrinsic to the patient him/herself (age, sex, obesity, nutritional status, or comorbidities), and others extrinsic (presurgical preparation, antimicrobial prophylaxis, use of drainage or transfusion, duration of intervention, appropriate instrumental sterilization or surgical technique used).[14,23] Updated antibiotic prophylaxis and surgical preparation protocols based on the existing literature have been implemented at our teaching hospital and are periodically reviewed by the Infections Committee. Based on these, prophylaxis and preparation were rated appropriate or inappropriate in each case, citing the reason for inappropriateness where this existed.

Antibiotic prophylaxis failed to prove statistically significant in terms of reducing SSIs, probably due to the negligible number of infections found. We found studies that did not reflect a reduction in incidence of infection, despite appropriate antibiotic prophylaxis, such as those by Mitchell et al.[24] and Sepehr et al.,[25] though the majority tended to corroborate the existence of a lower incidence of SSIs in head and neck surgery when such prophylaxis was performed correctly,[26-28] including systematic reviews and meta-analyses in clean-contaminated surgeries.[29]

When it came to the percentage of presurgical preparation of patients, this was also very high (86.7%), as in the case of prophylaxis, with the main cause of inappropriateness being the non-administration of mouthwash, which prevents post-operative pneumonia but has no influence on the development or lack of development of surgical infection.

While ASA anesthetic risk,[30] age,[31] obesity[14] and diabetes[32-34] are risk factors described in the literature for this type of surgery, in our study, they failed to achieve statistical significance. Other risk factors for the development of SSIs, such as the patient's sex, use of drainage, or comorbidities such as COPD and cirrhosis, or described in other types of interventions[35-39] were also not statistically significant in our study.

The study's univariate analysis displayed two significant variables: duration of surgery above the 75th percentile; and presence of malnutrition in the patient. Duration of surgery is a risk factor reported in other studies for this same surgical site;[8,31] in our study, its RR was 6.5 (95% CI: 1.5-28.6) following the multivariate analysis. The rise in risk among such patients may be due to a more prolonged exposure to the wound's contaminants, longer duration of oropharyngeal secretions in the field, or increased difficulty of the surgical act. In this respect, an important factor for the appearance of SSIs is the surgeon's experience, as highlighted by McHugh et al.[40] or Mallol et al.[41] This variable was not evaluated in the study, since ours is a university teaching hospital where there is thus a higher turnover of surgeons and physicians in training during interventions.

In the multivariate logistic regression analysis, the RR associated with malnutrition was 6.6 (95% CI: 0.9-49.2). Malnutrition was assessed at our hospital using body mass index (BMI), with malnutrition being deemed to exist if BMI < 18. In this study, the percentage of patients who presented with malnutrition was lower than in others consulted:[21,42] this may be due to the fact that malnutrition was measured with the BMI, whereas other authors considered malnutrition to exist if there was a loss of weight > 10% in the 3 months prior to surgery, or with measurement of serum albumin. Our study shows a higher risk of suffering SSIs if the patient is malnourished, a finding in line with other papers.[21,30]

There are studies in which the association between malnutrition and SSIs has been seen, and hence Basset and Dobie[43] report the relationship between malnutrition and worse prognosis in neck cancer. In this type of neoplasm, there may be a deficit of food intake due to gastrointestinal tract occlusion, plus the placement of tracheotomies for lengthy periods of time, which could entail severe malnourishment. Moreover, there are tumor factors that promote endocrine alterations and systemic responses, such as the release of cytokines, which trigger the protein catabolism and stages of cachexia. Malnutrition also affects the wound-healing process, favoring the development of septic complications.

Accordingly, we feel that a prior nutritional assessment should be made of all patients undergoing head and neck surgery, due to its close relationship with states of malnutrition, and that other anthropometric and specific biochemical parameters should be assessed, and not only BMI. A number of studies have sought to counteract malnutrition by means of enteral formulae (with arginine, glutamine, omega-3 fatty acids, and nucleotides), with evidence of a reduction in SSI and hospital-stay figures following the use of such formulae.[44-46]

One of our study's possible limitations is that the incidence of infection may have been underestimated due to some mild cases of superficial SSIs with minimal symptoms having been missed, where the patient might not have made use of the emergency, outpatient ear, nose, and throat, or primary care services. We would expect the infections missed to be negligible, in view of the fact that patients were followed up after discharge and over the course of a year. Similarly, the identification of some risk factors for surgical infection, detected through the patient's clinical history, may not be wholly accurate: for instance, if there are different forms of measurement (such as malnutrition) that pose problems when it comes to making comparisons with other studies in the literature which use different measurements. Finally, though the sample size was calculated for the assessment of SSI incidence, some of the risk factors studied may not be represented because they are factors with a very low prevalence. We endeavored to control for losses to follow-up by estimating a percentage of possible losses in the pre-calculation of sample size, in order not to lose statistical power.

Conclusions

Incidence of SSIs in head and neck surgery at our hospital during the study period was low. According to the results of this study, in order to reduce the risk of infection among the patients intervened, special attention should be paid to optimizing surgical time and ensuring an improvement in the nutritional status of patients who undergo these types of interventions.

A low SSI incidence rate is a good measure for assessing surgical practice and, by extension, quality in healthcare; hence, it is essential for infection rates to be evaluated and the possible risk factors identified. In this regard, prospective hospital surgical infection surveillance and control programs should be implemented, thereby allowing for continuous assessment of SSI incidence and the adoption of early preventive measures targeting potentially modifiable risk factors.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical considerations

Protection of humans and animals. The authors declare that the procedures followed complied with the ethical standards of the responsible human experimentation committee and adhered to the World Medical Association and the Declaration of Helsinki.

Confidentiality, informed consent, and ethical approval. The authors have followed their institution's confidentiality protocols, obtained informed consent from patients. The study was approved by the Clinical Ethics Research Committee of the Fundación Alcorcón University Teaching Hospital (number 16/91). All research activities conformed to the principles embodied in the Declaration of Helsinki.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

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