Original Article

Smoking increases the risk of surgical site infection after hydrocelectomy in adults: a retrospective cohort study in Brazil

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Abstract

Introduction: Surgical site infection (SSI) following hydrocelectomy is relatively uncommon, but it is one of the main post-operative problems. We aimed to describe the prevalence of SSI following hydrocelectomy among adult patients, and to assess predisposing risk factors for infection. Methodology: This retrospective cohort study was carried out at a university hospital and included hydrocelectomies performed between January 2007 and December 2014. Diagnosis of SSI was performed according to the Center for Diseases Control (CDC) guidelines. Multivariable logistic regression analysis was used to identify independent risk factors. Results: A total of 196 patients were included in the analysis. Overall, 30 patients were diagnosed with SSI (15.3%) and of these, 63.3% (19/30) were classified as having superficial SSI, while 36.7% (11/30) had deep SSI. The main signs and symptoms of infection were the presence of surgical wound secretion (70%) and inflammatory superficial signs such as hyperemia, edema and pain (60%). Among the 53 patients presenting chronic smoking habits, 26.4% (14/53) developed SSI, which was associated with a higher risk for SSI (odds ratio [OR] = 2.84, 95% confidence interval [CI] = 1.27 to 6.35, p < 0.01) in the univariate analysis. In the adjusted multivariable analysis, smoking habits were also statistically associated with SSI after hydrocelectomy (odds ratio [OR] = 2.84, 95% confidence interval [CI] = 1.30 to 6.24, p = 0.01). No pre-, intra-, or post-operative variable analyzed showed an independent association to SSI following hydrocelectomy. Conclusions: Smoking was the only independent modifiable risk factor for SSI in the multivariate analysis.

Key words: hydrocelectomy; risk factors; smoking; surgical site infection; urological surgery

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Introduction

Hydrocele is the collection of fluid within the scrotum. Among adults, the most common type is non-communicating hydrocele due to excessive fluid production by the tunica albuginea or inadequate resorption of the fluid by the tunica parietalis surrounding the testis [1]. Its etiology includes trauma, infection and testicular neoplasia, although, most of the time it may remain undefined (idiopathic) [2]. Up to 1% of men aged over 40 are estimated to have some collection of scrotal fluid [3].

Surgical therapy has been indicated when increased scrotal volume is accompanied by local pain or discomfort [4]. The overall complication rates following surgery may vary substantially, ranging from 0.7% to 20% according to previous studies and include hematoma, infection, recurrence, chronic pain, and infertility [2,5-7]. Even though the majority of surgical site infection (SSI) described following hydroceles surgery has been classified as superficial, a few cases are expected to develop serious complications such as abscesses and deep tissue necrosis [8].

Hydrocelectomies have been traditionally classified as clean-contaminated surgeries (Class II) because they involve an incision in the genital tract under controlled conditions without gross contamination or significant transgression by the operative technique [9]. On the other hand, authors such as Grabe et al, have classified these procedures as clean surgeries (Class I) given the low infectious complication rates they found [10]. Hence, there has not been a consensus on the use of antibiotic prophylaxis in this surgery [11]. Additionally, few authors have evaluated the potential factors associated with infection following surgery for hydrocele, in which an elevated grade in the American Society of Anesthesiologists (ASA) Status
Classification System and the use of an indwelling bladder catheter had previously been associated [7,12]. We therefore sought to describe the prevalence of SSI following surgery for hydrocele among adult patients in a tertiary referral center; and aimed to identify pre- and intra-operative independent risk factors predisposing subjects to this complication. Identification of risk factors may help in the implementation of efficient and cost-saving control measures to reduce the frequency of infection.

Methodology
Study population
We conducted a single-center, retrospective cohort analysis with 205 patients who had undergone urologic surgeries, either for hydrocele surgery only or combined with another surgery, in the urology department of a university hospital, between January 2007 and December 2014. Patients with unavailable medical records, as well as those whose scrotal surgical procedure was indicated for treating local neoplasia (radical orchectomy) or controlling hormone-sensitive metastatic tumors (subcapsular orchectomy), were excluded. The Institutional Review Board of the Onofre Lopes University Hospital approved the study. Institutional authorization was granted to use patients’ records.

Diagnostic Criteria for Surgical Site Infection (SSI) Associated with Scrotal Surgeries
According to the criteria proposed by the Center for Disease Control and Prevention (CDC-USA/2017) [13], SSI is classified as either superficial or deep, and defined as infection occurring within 30 days of the procedure. The subgroup of individuals undergoing the procedure and diagnosed with SSI were considered as cases, and those without infection were considered as the study controls.

Potential risk factors
Patient and surgery variables were identified by reviewing the medical records for potential risk factors associated to SSI. We searched for demographic variables (age) comorbidities (diabetes and hypertension), previous history of local or systemic infection, smoking habits, alcohol consumption, American Society of Anesthesiologists (ASA) classification. Variables associated to pre-, intra- and post-operative procedures included hair removal (removal using a razor compared to no removal), use of a post-operative drain, and use of an indwelling or intermittent urinary catheter. Other conditions also assessed were the length of hospital stay and the number of days between discharge and outpatient return.

Statistical analysis
Qualitative variables were described as means and percentages; whereas the quantitative variables, as median and standard deviations. The association between qualitative variables was assessed using the chi-squared test and Fischer's exact test, as indicated. For the associations between quantitative variables, we used bivariate logistic regression. Relative risk estimates for the variables associated with the risk factors for infection following hydrocelectomy were calculated with a 95% confidence interval (CI). For infection, we used the multiple logistic regression model, selecting the variables of the bivariate analysis tests when the levels of significance were lower than 0.10 (p < 0.10); only those variables whose significance was lower than 0.5 (p < 0.05) were kept in the final models. We used Epi-info software version 3.22 (Center for Diseases Control and Prevention, Atlanta, USA), with data tabulation and SPSS (version 20.0, IBM CORP. Amoncarmonk, USA) in the statistical analyses.

Results
Study population
During the study period from 2007 to 2014, a total of 205 surgical procedures for treating hydrocele were performed and analyzed. Of these, 4.3% (9/205) were excluded from the subsequent analysis, seven due to a diagnosis of neoplasia and two due to missing information. Thus, a total of 196 patients were included in the study; the demographic variables and clinical characteristics of this population are described in Table 1. Notably, heavy tobacco consumption and hypertension were detected in 27% and 30% of study group, respectively. Overall, 15.3% (30/196) of patients presented any type of surgical wound infection, whereas 84.6% (166/196) were categorized as controls. Of interest, the annual SSI rate during the study period was 10.3%, with exception of 2013, when the SSI rate reached 32.3% (11/34). With regard to the demographic data, the mean age was 52.5 years (16 – 89 years of age). Microbiological analysis was not described...
among patients with infection. The clinical characteristics of the 30 patients with SSI following hydrocelectomy are summarized on Table 2.

Factors predisposing to SSI related to the patients’ clinical characteristics and operative care

The clinical demographic variables and comorbidities were similar across patient groups with and without SSI. Neither an ASA preoperative score greater than or equal to 2 (p=0.12) or the presence of an associated infectious process, such as erysipelas, at the time of admission (p=0.23) was associated with the occurrence of infection. Among the 53 patients presenting chronic smoking habits, 26.4% (14/53) developed SSI, which was associated with a higher risk for SSI (odds ratio [OR] = 2.84, 95% confidence interval [CI] = 1.27 to 6.35, p < 0.01) in the univariate analysis. In fact, in the adjusted multivariable analysis, only smoking habits were statistically associated with SSI after hydrocelectomy (odds ratio [OR] = 2.84, 95% confidence interval [CI] = 1.30 to 6.24, p = 0.01). Chronic smokers were found to have a 2.84-fold increase in their chance of presenting SSI (Table 3). Prophylaxis with cefazolin at the time of anesthetic induction occurred in 63.7% (125/196) of procedures. Nevertheless, no significant statistical difference was identified between groups that had been given or had not been given antibiotic prophylaxis. Moreover, none of other pre-, intra-, and post-operative variables analyzed showed an independent association with SSI following hydrocelectomy (Tables 3 and 4).

Discussion

Hydrocelectomies are common in urological practice and considered technically simple. At teaching hospitals, it is commonly performed by physicians at an early stage of their training. However, there is little data available regarding complication rates or risk factors for adverse outcomes [7]. Uehara et al. [14], found a 1.6% of infection rate, much lower than the rates reported in a review by Swartz et al., in which SSI after hydrocelectomy varied from 3.6 to 9.3% [7]. Conversely, in a single-center prospective study with a limited number of hydrocelectomies analyzed, the SSI rate reached 20% [5]. In the present study, we found a 15.3% SSI rate, well above the average rates described in most of the literature for this type of surgery. Smoking was the only independent predisposing factor to SSI in this present study. We hypothesized that the fact that the hydrocelectomy was being performed by

Table 1. Demographic variables and clinical characteristics of the 196 patients included in the study.

| Demographic variables/clinical characteristics | N = 196 | % |
|------------------------------------------------|---------|---|
| Age<br>Mean | 52.5 |
| Median | 54 |
| (Min-Max) | (16-89) |
| Level of schooling | | |
| Illiterate | 36 | 18.6 |
| Primary school | 65 | 33.2 |
| Secondary school | 37 | 18.9 |
| Higher education | 12 | 6.1 |
| NA | 46 | 23.4 |
| Profession | | |
| Student | 9 | 4.6 |
| Employed | 132 | 67.3 |
| Retired | 22 | 11.2 |
| NA | 33 | 16.8 |
| Consumption of alcohol | | |
| Time* (mean) | 32 | 16.3 |
| Smoking | 53 | 27 |
| Time* (mean) | 29.7 |
| Bacterial infection at admission | 6 | 3.1 |
| Diabetes mellitus | 13 | 6.6 |
| Arterial hypertension | 59 | 30.1 |
| ASA** | | |
| Level I | 110 | 56.1 |
| Level ≥ II | 86 | 43.8 |
| Use of medications at admission | 62 | 31.6 |

NA-Data not available; *In years; ASA** Clinical classification by the American Society of Anesthesiology.
resident physicians at an early stage of their urological surgery training may be also regarded as a possible reason for the higher SSI rate identified in our study. In addition, the use of strictly clinical criteria for diagnosing SSI needs to be highlighted. Calvo et al., identified a SSI rate of 11.8% by applying an isolated clinical method for the diagnosis of infection, which was also higher than in most previous results [15]. Thus, it is difficult to compare our infection rate with that published by other authors due to differences regarding the SSI definition, diagnostic methods and follow-up criteria used, as well as the differences among population groups.

In our study, most SSI cases were superficial (63%), in concordance with most previous studies [11,15], with wound exudate and dehiscence of the suture line being the main clinical signs of infection. Indeed, previous studies showed a significant relationship between dehiscence and SSI, although the systematic diagnosis of patients with some degree of suture line inflammation, used alone as a sign of infection may have overestimated the number of cases of SSI [11,15]. Alonso-Isa et al., reported that 34% of wound exudate sample cultures resulted in either no, or inconclusive growth, but still opted to consider local secretion as indicative of SSI, which may have resulted in an overestimation of the number of cases [12].

Smoking was the only independent factor associated with infection in the present study, increasing by nearly three times the chance for SSI. In their review, Grabe et al., pointed out that the use of nicotine promotes delays in tissue healing and increases SSI risks among urological procedures [16]. The pathophysiological consequences of smoking on surgical outcomes are related to the toxic effects of the inhalation leading to tissue hypoxia by the mechanism of vasoconstriction, associated with inadequate stimulation of fibroblasts under oxidative stress conditions [17]. The delay in wound healing and increased risk of local infection has been associated with decreasing cell migration and inadequate accumulation of connective tissue in the wound [17].

Infection

Table 2. Clinical characteristics of the infection and antibiotic therapy among 30 patients with SSI after hydrocelectomy.

| Case | Age | Smokers | ASA score* | Discharge | Dehiscence | Fever | Infection | Hospital readmission | Antibiotic therapy |
|------|-----|---------|------------|-----------|------------|-------|-----------|---------------------|--------------------|
| 1    | 51  | No      | I          | Yes       | Yes        | No    | Superficial| No                  | Amox/clavul***     |
| 2    | 45  | Yes     | II         | Yes       | Yes        | No    | Deep      | Yes                 | Combination***      |
| 3    | 78  | No      | II         | Yes       | Yes        | No    | Superficial | No                  | Ciprofloxacin       |
| 4    | 64  | No      | II         | Yes       | Yes        | Yes   | Deep      | Yes                 | Combination***      |
| 5    | 60  | Yes     | II         | Yes       | No         | No    | Superficial | Yes                 | Ciprofloxacin       |
| 6    | 35  | No      | I          | Yes       | No         | No    | Superficial | Yes                 | Ciprofloxacin       |
| 7    | 37  | No      | I          | No        | No         | No    | Superficial | No                  | Cephalexin          |
| 8    | 35  | No      | III        | Yes       | Yes        | No    | Superficial | Yes                 | Combination***      |
| 9    | 60  | Yes     | II         | No        | No         | No    | Superficial | No                  | Cephalexin          |
| 10   | 56  | Yes     | I          | No        | No         | Yes   | Deep      | Yes                 | Ciprofloxacin       |
| 11   | 50  | No      | I          | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 12   | 81  | Yes     | II         | No        | Yes        | No    | Deep      | Yes                 | Ceftriaxon          |
| 13   | 28  | No      | I          | No        | Yes        | No    | Deep      | Yes                 | Amox/clavul***      |
| 14   | 62  | Yes     | II         | Yes       | No         | Yes   | Superficial | No                  | Cephalexin          |
| 15   | 28  | No      | I          | No        | No         | Yes   | Superficial | No                  | Cephalexin          |
| 16   | 81  | No      | II         | Yes       | Yes        | No    | Deep      | No                  | Amox/clavul***      |
| 17   | 64  | Yes     | II         | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 18   | 49  | No      | II         | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 19   | 59  | Yes     | I          | Yes       | Yes        | No    | Deep      | No                  | Cephalexin          |
| 20   | 61  | Yes     | II         | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 21   | 48  | Yes     | I          | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 22   | 59  | No      | I          | Yes       | No         | No    | Deep      | No                  | Cephalexin          |
| 23   | 74  | No      | II         | Yes       | No         | No    | Deep      | No                  | Combination***      |
| 24   | 33  | No      | I          | No        | No         | No    | Superficial | No                  | Ciprofloxacin       |
| 25   | 57  | Yes     | II         | Yes       | Yes        | Yes   | Deep      | Yes                 | Ceftriaxon          |
| 26   | 48  | No      | I          | No        | No         | No    | Superficial | No                  | Cephalexin          |
| 27   | 68  | Yes     | II         | Yes       | No         | No    | Superficial | No                  | Cephalexin          |
| 28   | 71  | No      | II         | No        | No         | No    | Superficial | No                  | Cephalexin          |
| 29   | 62  | Yes     | II         | Yes       | Yes        | No    | Superficial | No                  | Amox/clavul***      |
| 30   | 61  | Yes     | I          | Yes       | Yes        | No    | Deep      | No                  | Combination***      |

*American society of Anesthesiology classification; **Amox/clavul: Amoxicillin+ clavulanic acid; ***Combination therapy: cephalosporins plus quinolones, cephalosporins plus aminoglycosides.
a study by Nolan et al., a large number of smoking patients were retrospectively analyzed for SSI risk factors, and the conclusion was that smoking on the day of surgery was independently associated with an increased rate of infection after elective surgeries [18]. In a recent systematic review, Sørensen et al. demonstrated an increased risk of infection in 51 studies evaluating procedures distributed across several specialties; the meta-analysis showed a significant increase in infection among the smokers’ group [19]. In another similar analysis, Hawn et al., were also able to show increased SSI rates among smokers undergoing urological surgeries [17].

We also analyzed other classical risk factors associated with SSI, such as the type of antiseptic skin preparation applied prior to surgery. In our study, as in other previous studies [1], no difference in the rate of SSI were identified among patients undergoing hydrocelectomies being prepared with iodopovidone and those prepared using chlorhexidine solution. Regarding surgical prophylaxis with antibiotics, scrotal procedures are usually considered to be a clean-contaminated or Class II surgery, which makes it reasonable to indicate a preoperative single-dose of antibiotic [2]. Nevertheless, more controlled, prospective, randomized studies are needed to validate the positive impact of antimicrobial prophylaxis among patients undergoing scrotal surgery [14,20]. Interestingly, the lack of antibiotic prophylaxis did not increase the SSI rates in our study. In fact, appropriate use of prophylactic antibiotic 30 to 60 minutes prior to initiate hydrocelectomy should have had an impact on the reduction of SSI rates. We noticed, however, that the medical indication for adequate timing of preoperative antibiotic prophylaxis was not followed by many investigated cases. Moreover, detailed information regarding antibiotic prophylaxis, including the exact time of intravenous administration, type and dose of antibiotic, were missing in 71 patients (36%) in the medical records.

Table 3. Demographics, clinical characteristics and surgical variables among patients with and without infection after hydrocelectomy: univariable and multivariable analysis for risk factors to develop SSI.

|                 | SSI  | Univariate analysis | Multivariable analysis |
|-----------------|------|---------------------|------------------------|
|                 | YES  | NO                  | OR CI (95%) P OR CI (95%) P |
|                 | N = 30% | N = 166% | Lower | Upper | Lower | Upper |
| Demographic data |      |                  |            |      |        |        |
| Age Mean (SD)   | 55.5 (±2.7) | 52 (±1.3) | 1.01 | 0.98 | 1.03 | 0.3*   |
| Clinical characteristics |      |                  |            |      |        |        |
| Alcohol consumption N = 32 | 6 | 20 | 26 | 15.6 | 1.34 | 0.5 | 3.61 | 0.55*  |
| Time consumption*** | 35 (±15.0) | 29 (±4.2) | 1.03 | 0.92 | 1.15 | 0.58*  |
| Smoking N = 53 | 14 | 46.6 | 39 | 23,4 | 2.84 | 1.27 | 6.35 | 0.01*  |
| Smoking status*** | 25 (%/-) | 31.2 | 4.9 | 0.97 | 0.92 | 1.06 | 0.32*  |
| Diabetes Mellitus N = 13 | 2 | 6,6 | 11 | 6,6 | 1 | 0.21 | 4.78 | 0.99*  |
| Arterial hypertension N = 59 | 11 | 36,6 | 48 | 28,9 | 1.42 | 0.63 | 3.21 | 0.39*  |
| ASA score (N = 110) I | 13 | 43,3 | 97 | 58,4 | 1 | 0.06 | 7.57 | 0.906  |
| (N = 83) I | 16 | 53,3 | 67 | 40,3 | 1.83 | 0.83 | 4.03 | 0.12*  |
| Pre-, trans- and post-operative care |      |                  |            |      |        |        |
| Hair removal N = 37 | 5 | 16,6 | 32 | 19,2 | 0.83 | 0.29 | 2.35 | 0.73*  |
| Antibiotic prophylaxis N = 125 | 22 | 73,3 | 103 | 62 | 1.68 | 0.7 | 4 | 0.24*  |
| Type of antiseptic: Iodopovidone N = 182 | 27 | 90 | 155 | 93,3 | 0.63 | 0.16 | 2.44 | 0.51*  |
| Chlorhexidine N = 14 | 3 | 10 | 11 | 6,6 | 1 | 0.02 | 2.04 | 0.17*  |
| Type of surgery Minor N = 44 | 9 | 30 | 35 | 21 | 1 | 0.03 | 2.14 | 0.22*  |
| Medium/Major N = 16 | 1 | 3,3 | 15 | 9 | 0.67 | 0.36 | 1.91 | 0.67*  |
| Drain N = 20 | 5 | 16,6 | 15 | 9 | 2.03 | 0.67 | 6.03 | 0.21*  |
| Urinary retention N = 11 | 2 | 6,6 | 9 | 5,4 | 1.24 | 0.25 | 6.07 | 0.78** |
| Urinary catheter N = 11 | 2 | 6,6 | 9 | 5,4 | 1.28 | 0.25 | 6.03 | 0.8**   |
| Foley catheter N = 7 | 1 | 3,3 | 6 | 3,6 | 0.53 | 0.05 | 5.32 | 0.59** |

*Chi-square test** Fisher exact test ***Univariate and multivariate regression analyses (adjusted) Bold indicates significant finding at p < 0.05; ***Mean in years/Standard deviation; **Bacterial infection described in the clinical history at admission in other body site; ASA score: American Society of Anesthesiology; SSI = Surgical Site Infection; NA = Data not available; OR = Odds Ratio (Chances Ratio); CI = Confidence Interval; SD = Standard Deviation; Min-Max = Minimum-Maximum.
Table 4. Univariate and multivariable analyses for quantitative variables associated with SSI following hydrocelectomy.

|                          | SSI | OR  | CI (95%) | P*  | OR  | CI (95%) | P*  |
|--------------------------|-----|-----|----------|-----|-----|----------|-----|
|                          | YES | NO  | Lower    | Upper| Lower| Upper    |     |
| **Length of hospital stay** |     |     |          |      |      |          |     |
| Mean (days)              | 3   | 2.7 | 1.04     | 1.2  | 0.564|          |     |
| SD                       | (± 0.5) | (± 0.1) |     |      |       |       |     |
| Operative time           |     |     |          |      |      |          |     |
| Mean (minutes) SD        | 66.6| 64.6| 0.99     | 1    | 0.827|          |     |
| 1st Return               |     |     |          |      |      |          |     |
| Mean (days) SD           | 14.6| 20.6| 0.95     | 0.99 | 0.02 | 0.93     | 0.83| 1.05| 0.3 |
|                            | (± 1.3) | (± 1.1) |     |      |       |       |     |
| 2nd Return               |     |     |          |      |      |          |     |
| Mean (days) SD           | 34.6| 53.7| 0.97     | 0.95 | 0.99 | 0.04     | 0.98| 0.95| 1.01| 0.2 |
|                            | (± 5.6) | (± 5.5) |     |      |       |       |     |

*Logistic regression analysis; OR = Odds Ratio (Chances Ratio); CI = Confidence Interval; SD = Standard Deviation.

We acknowledge that our study has several important limitations, which are mainly due to its retrospective design and the small number of patients diagnosed with SSI (type II error). This fact limits the multivariate analysis adjusted for factors that could have been important for the emergence of SSI, such as the presence of indwelling Foley catheter and drains. The study was conducted in a single public university teaching hospital, situated in a medium-sized city that offers specialized urology care to a wide referral area. Therefore, studies analyzing risk factors using different populations may find difficulties in reproduce these results. Another limitation was the strictly clinical diagnosis of SSI, which probably influenced the total number of cases included.

Conclusions

We found higher rates of SSI after hydrocelectomies compared to previous studies. Smoking was an independent and modifiable risk factor for SSI in the multivariate analysis. Prospective studies are needed to better understand the effectiveness of prophylactic antibiotics.

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