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Antibiotic resistance of germs isolated from surgical site infections in the department of surgery at the Kisangani University clinics in the Democratic Republic of the Congo

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Abstract
The antibiotic resistance of germs isolated from surgical site infections is increasing significantly in hospitals and constitutes a real public health problem. It is likely to prolong hospital stays, increase the cost of care and lead to high morbidity and mortality. On the basis of a retrospective study conducted over a period from 1 January 2018 to 31 December 2024, our research focused on the results of positive bacteriological samples taken from patients operated on in the various departments of the Department of Surgery at the University Clinics of Kisangani. The aim of this study was to determine the sensitivity of germs isolated from surgical site infections in different departments of the Department of Surgery at the Cliniques Universitaires de Kisangani to commonly used antibiotics, in order to raise awareness of antibiotic resistance in our environment and improve management. The results revealed 74 positive cultures, with 5 cases of infection caused by two bacteria simultaneously, giving a total of 79 germs. Of these, *Staphylococcus aureu* accounted for 41.7%, followed by *Escherichia coli* for 17.7%.

The study of the sensitivity of germs revealed a worrying rate of germs with reduced sensitivity to the antibiotics commonly used in the department. These results highlight the need for rational use of antibiotics to limit the development of antibiotic resistance.

Keywords: Surgical site infection, Antibiotic resistance, *Staphylococcus aureu, Escherichia coli*

1. Introduction

Clinically, a bacterium is suspected of being resistant to an antibiotic when it survives antibiotic therapy under well-adapted conditions and doses [1-4]. According to the microbiological definition, a strain is said to be resistant when it can develop in the presence of a higher concentration of antibiotic than other strains [1-4]. Bacterial resistance to antibiotics is a global threat to health and development that continues to intensify worldwide. It has reached alarming levels in several countries, and is a phenomenon that is becoming globalised [5-7]. Hospitals, considered as places dedicated to the care and health management of patients, can in certain circumstances become a source of infection as a result of different modes of transmission, either endogenous or exogenous, or due to poor hygiene [6]. Surgical site infection is an infection that occurs within 30 days of the operation, or within one year in the case of implanted material [8-9]. Surgical site infection is the 3rd most common nosocomial infection after urinary and respiratory infections [9]. Despite advances in surgical care, perioperative asepsis and antibiotic therapy, SSIs remain a major public health problem, because they lead to antibiotic resistance, prolong hospital stays, increase the cost of care and result in high morbidity and mortality [10]. The prevalence of SSIs in developed countries varies from 0.7% to 5%, and up to 33% in the case of abdominal surgery [9, 11]. In sub-Saharan Africa, the prevalence of surgical site infection can vary from 6% to over 40% depending on the case [12, 13]. In the Democratic Republic of Congo, the prevalence of SSI was estimated at 8.8% at Panzi Hospital in Bukavu in 2024[14] and 8.3% at Nd'jili Hospital7 in Kinshasa in 2018[15]. These surgical site infections are often caused by antibiotic-resistant bacteria [6]. This is why the World Health Organisation describes bacterial resistance to antibiotics as one of the most urgent health risks of our time, threatening to wipe out a century of medical progress [6, 7]. The aim of this study was to determine the susceptibility of germs isolated from surgical site infections in different departments of the Department of Surgery at the University Clinics of Kisangani to commonly used antibiotics, with a view to raising the alarm about antibiotic resistance in our environment and improving management.

2. Materials and Methods

2.1. Study setting

Our study was carried out at the Department of Surgery of the University Clinics of Kisangani (CUKIS).

2.1.1. Geographical location of the University Clinics of Kisangani

The University Clinics of Kisangani, the setting for our study, is a tertiary level medical facility in the province of Tshopo and the city of Kisangani, capital of the province of Tshopo in the Democratic Republic of Congo. Located on avenue Munyororo, in the Plateau Medical district in the commune of Makiso.

2.1.2. Study population

The population of this study consisted of all patients operated on in various departments of the Department of Surgery at the University Clinics of Kisangani (Cukis). During our study period, 1049 patients were operated on in the various departments of the Cukis Department of Surgery.

2.1.3. Sample

Our sample consisted of patients who had undergone surgery in various departments of the Department of Surgery at the University Clinics of Kisangani and who had developed a surgical site infection (SSI) during their hospital stay. Thus, out of 1049 patients operated on during our study period 86 patients developed an SSI during their hospital stay.

2.1.4 Study period

Data were collected over a period of 7 years, from [1]January 2018 to 31 December 2024.

2.2 Methods

2.2.1. Type of study

This was a descriptive, cross-sectional study with retrospective data collection.

2.2.2. Sampling technique

This was a non-probabilistic sampling of convenience which consisted of examining patient files, patient hospitalisation registers, doctors' duty report registers, operating theatre registers and bacteriology laboratory registers which were made available to us.

2.2.3. Selection criteria

a) Inclusion criteria

The following were included in this study

Any patient operated on in the Department of Surgery at the University Clinics of Kisangani during the period of our study, who presented with a surgical site infection (SSI)with the well-documented positive bacteriological results containing the results of gram staining, culture and antibiotic susceptibility testing. Thus, out of 86 patients who developed SSI during their hospital stay, 74 patients had met the inclusion criteria.

b) Non-inclusion criteria

The following were not included in this study

Any patient admitted to the Department of Surgery of the University Clinics of Kisangani during the period of our study, who had not presented with an infection of the surgical site, but whose file did not contain all the elements retained in our data collection form (bacteriological results, etc.).

2.2.4. Data collection technique

This was the documentary analysis technique. It consisted of examining patients' files, patients' hospitalisation records, doctors' duty report books, operating theatre records, anaesthetists' records, operating protocol records and bacteriology laboratory records which were made available to us and which contained the study parameters sought according to the study's inclusion criteria.

2.2.5. Study variables

Socio-demographic data: Age, sex, residence, occupation, marital status, province of origin;

Mode of admission: emergency, outpatient, transfer.

Clinical data: complaint, history, locoregional physical signs, admission diagnosis

Paraclinical data: Biology (Hb, Hct, GS and Rhesus factor, GB, FL VS; bacteriology (gram staining, culture and antibiogram); radiography; Therapeutic data: Treatment: probabilistic antibiotic therapy instituted, its duration and surgical treatment received

Course: onset of infection, time between surgery and onset of infection.

Final outcome after antibiotics based on antibiogram results.

2.2.6. Sampling and antibiotic susceptibility testing

Samples were taken either by syringe puncture if the suppurations were abundant, or by swabbing for minimal wound suppurations. Samples were taken under rigorous aseptic conditions in hospital wards. Germ identification and sensitivity were assessed on the basis of culture and antibiogram results supplied by the laboratories of the University Clinics of Kisangani and EMA ESU. Microscopic examination: for each sample, direct observation without staining was carried out to look for cellular elements (leucocytes, red blood cells and bacteria). Examination after staining: using the suppuration fluid, an initial smear was taken and then stained with May Grunwald Giemsa (MGG). This was followed by a quantitative and qualitative cytology of the leukocyte elements, based on microscopic observation. Another smear was taken and Gram-stained to determine the bacterial morphology and its colour affinity towards Gentian violet and fuschin. If the bacterium is stained purple, it is gram-positive. On the other hand, if the bacterium is coloured pink, it is gram-negative. The results of gram staining are used to guide the subsequent bacteriological treatment of the sample, particularly in the choice of culture media. Culture: each sample was inoculated onto ordinary agar, fresh blood agar, Mannitol Salt Agar (MSA) and Mac Conkey; incubated at 37°C for 18 to 24 hours. In the event of a positive culture on Mueller-Hinton Agar, the antibiogram was performed by the diffusion method using a bacterial suspension with a turbidity of 0.5 according to the Mac Farland scale. Antibiotic discs used ranged from 5mm to 10mm.

2.2.7. Data analysis technique

Our data were collected and recorded on Microsoft Excel 2020 and analysed using R software version 4.3.1; we calculated percentages to analyse our qualitative variables, calculated the mean and standard deviation for our quantitative variables with symmetrical distribution and the median for our quantitative variables with non-symmetrical distribution. The results are presented in tables.

3. Results

During this period, 1049 patients underwent surgery and 86 cases of suspected SSI were diagnosed, representing a prevalence of 8.2%. However, 74 cases of SSI had documented positive bacteriological results. The sample comprised 55 men and 19 women, giving a sex ratio of 2.89. The mean age was 45.25±19.24, with extremes of 0 and 83 years. Of the 74 samples, 79 germs were isolated, including 69 single microbial cultures and 5 polymicrobial cultures with 2 germs. The germs identified according to surgical department are shown in table 1, multi-resistant germs are shown in table 2, and the overall antibiogram for the department is shown in table 4 and 5.

Table 1: Distribution of cases according to the germs identified

Germs	Number	Percentage
Gram-positive		
Staphylococcus aureu	33	41, 7
Gram-negative		
Escherichia coli	14	17, 7
Citrobacter diversus	9	11, 4
Pseudomonas aeruginosa	7	8, 9
Proteus mirabilis	6	7, 6
Enterobacter spp	5	6, 3
Enterobacter	4	5, 1
Proteus vulgaris	1	1, 3
Total	79	100

This table shows that *Staphylococcus aureu* was the predominant germ with 33 cases (41.7%), followed by *Escherichia coli* with 14 cases (17.7%), *Citrobacter diversus* with 9 cases (11.4%), and *Pseudomonas aeruginosa* with 7 cases (8.9%).

Table 2: Breakdown of germs by surgical speciality

Surgical specialty	*Staphylococcus aureu*	*Pseudomonas aeruginosa*	*Proteus mirabilis*	*Escherichia coli*	*Citrobacter diversus*	Enterobacter spp	*Proteus vulgaris*	Enterobacter
Traumatology-orthopaedics	10	2	2	2	2	1	0	0
Abdominal surgery	13	3	3	9	6	3	1	2
Urology	3	1	1	1	1	1	0	1
Neurosurgery	3	0	0	1	0	0	0	0
Oncology	1	0	0	0	0	0	0	0
General surgery	3	1	0	1	0	0	0	1
Total	33	7	6	14	9	5	1	4

This table shows that S. aureus was the germ most frequently found in abdominal surgery (13 cases out of 33), followed by E. coli (9 cases out of 14) and *Citrobacter diversus* (6 cases out of 9). In trauma and orthopaedic surgery, S. aureus was the germ most frequently found (10 cases out of 33).

Multi-resistant germs

Table 3: Distribution of cases according to multi-resistant germs

Multi-resistant germs	Numbers	Percentage
Escherichia coli	6	42, 9
Staphylococcus aureu	5	35, 7
Citrobacter diversus	2	14, 3
Pseudomonas aeruginosa	1	7, 1
Proteus mirabilis	1	7, 1
Enterobacter	1	7, 1
Enterobacter spp	1	7, 1
Total	14	100, 0

Chi-square = 94.6 ddl = 6 p-value = 0.000

The most common germs were *Escherichia coli* (42.9%) followed by *Staphylococcus aureu* (35.7%), Citrobacter diversus (14.3%) and *Pseudomonas aeruginosa* (7.1).

Overall Antibiogram

Table 4: Distribution of cases according to antibiogram results

Antibiotic	*Staphylococcus aureu*		*Escherichia coli*		Enterobacter Spp		Enterobacter
	NR/NT	%	NR/NT	%	NR/NT	%	NR/NT %
Amikacin	0/3	0	0/4	0	-		-
Amoxicillin	16/29	55, 1	5/8	63	2/4	50	2/3 66, 6
Amoxicillin AC	0/5	0	2/2	100	-		-
Ampicillin	17/28	60, 7	6/11	54, 5	2/5	40	1/3 33, 3
Cefatax	1/3	33	-		-		-
Ceftriaxone	16/27	59, 3	6/11	54, 4	2/5	40	1/3 33, 3
Cefuroxime	-		-		-		-
Chloramphenicol	14/20	70	4/8	50	3/7	57, 1	-
Ciprofloxacin	18/30	60	5/11	45, 4	2/5	40	3/5 60
Cloxacillin/oxacillin	NA		NA		NA		NA
Doxycycline	14/26	53, 8	3/4	75	4/6	66, 6	2/3 66, 6
Erythromycin	20/32	62, 5	2/5	40	2/6	33, 3	-
Fosfomycin	1/3	33	0/1	0	0/2-	0	0/1 0
Gentamicin	13/28	48, 4	8/13	61, 5	3/6	50	2/3 60
Imipenem	-	-	0/1	0	--		
Levofloxacin	0/3	0	-1/2	50	-		-
Meropenem	0/5	0	0/3	0			0/2 0
Metronidazole	NA		NA		NA		NA
Norfloxacin	4/8	50	-		2/5	40	2/4 50
Penicillin	21/28	75	9/12	75	6/12	50	-

- **NR:** Number of times the antibiotic has been resistant
- **NT:** Number of times the antibiotic has been tested
- **Dash (-):** Antibiotics not tested on the bacteria
- **NA:** Not applicable, antibiotics not tested by the laboratory

Table 5: Breakdown of cases according to antibiogram results (continued)

Antibiotic	*Citrobacter diversus*		Proteus mirabulis		*Proteus vulgaris*		*Pseudomonas aeruginosa*	
	NR/NT	%	NR/NT	%	NR/NT	%	NR/NT	%
Amikacin	-		-		-		0/4	0
Amoxicillin	5/8	62, 5	2/5	40	1/1	100	4/6	66, 6
Amoxicillin- AC	-		-		-		3/3	100
Ampicillin	5/7	71, 4	2/6	33, 3	1/1	100	4/5	80
Ceftriaxone	4/8	50	2/5	40	1/1	100	5/8	62, 5
Chloramphenicol	6/9	66, 6	-		4/4	100	4/5	80
Ciprofloxacin	4/8	50	2/4	50	-		3/6	50
Cloxacillin/ oxacillin	NA		NA		NA		NA	
Doxycycline	3/6	50	¼	25	-		5/6	83, 3
Erythromycin	4/7	57, 1	4/7	57, 1	-		½	50
Fosfomycin	-		-		0/1	0	0/2	0
Gentamicin	2/6	33, 3	¼	25	1/1	100	2/6	33, 3
Imipenem	-		-		-		-	
Levofloxacin	-		-		-		0/1	0
Meropenem	-		-		-		0/2	0
Metronidazole	NA		NA		NA		NA	
Norfloxacin	1/1	100	1/1	100	-		-	
Penicillin	4/6	66, 6	2/4	50	1/1	100	3/6	50

- **NR:** Number of times the antibiotic has been resistant
- **NT:** Number of times the antibiotic has been tested
- **Dash (-):** Antibiotics not tested on the bacteria
- **NA:** Not applicable, antibiotics not tested by the laboratory

4. Discussion

The prevalence of surgical site infection in our study was 8.2%. Our prevalence was close to those reported by N'Sinabau *et al* [15] in Kinshasa 8.3% and Lungere *et al* [14] in Bukavu 8.8% [23].

However, it differs from those reported by Doutchi *et al* [8] of 7.83% at Zinder National Hospital in Niger; Bengaly *et al* [17] in Mali of 4.72%; and the SSI surveillance network in France of 1.64% [18, 19].

We believe that this high frequency in our series could be explained by the precariousness of certain aseptic measures, hospital habits and the lack of information on antibiotic prophylaxis.

The sample comprised 55 men and 19 women, giving a sex ratio of 2.89. The mean age was 45.25±19.24, with extremes of 0 and 83 years. Relatively similar results were reported by Lungere *et al* [14] in Bukavu, where the predominant age group was between 20 and 40 years, with an average age of 33±2 years. Our results differ from those of Kimuni *et al* [6] in Lubumbashi, who found that patients aged between 18 and 24 predominated, with an average age of 33±17 years;

and Bafeno *et al* [20] in Kisangani, who found that patients aged between 61 and 75 predominated.

We believe that the predominance of this age group in our series is due to the nature of our sample, which consists of many cases of peritonitis, which often occurs in this age group.

The pyoculture results isolated 79 germs, including 5 cases of microbial association with two germs. The predominant germs were *Staphylococcus aureu*, *Escherichia coli*, *Citrobacter diversus*, *Pseudomonas aeruginosa* and *Proteus mirabilis* (44.6%, 18.9%, 12.2%, 9.5% and 8.1% respectively). Relatively similar results have been reported by several African and non-African authors who found a predominance of *Staphylococcus aureu*, notably Ousmane A *et al* [21], Ide Garba *et al* [22], the SSI surveillance network in France [18, 19], Braker *et al* [11], Ndayisaba G *et al* [23], Sisay *et al* [24]. However, our results do not corroborate those of Kimuni *et al* [22] who reported a predominance of *Pseudomonas aeruginosa* 50%, *Escherichia coli* 22% and *Staphylococcus aureu* 20.5%; Lungere *et al* [14], a predominance of E. Coli followed by *Staphylococcus aureu* and Bengaly *et al*. in Mali [17] a predominance of E. Coli followed by S. Aureus. We believe that the predominance of *Staphylococcus aureu* in our series is due to the fact that these germs are flora of the hospital environment, commensals of the skin and mucous membranes. Contamination of the surgical site occurs more often during the operating period, either from the flora of the patient before the incision, or from the flora of the staff during the operation or during dressing, or from antiseptic solutions or contaminated instruments. The precarious hygiene of our hospital environment is thought to be at the root of SSI.

The results of the antibiogram by germ showed the following resistance: *Staphylococcus aureu*: ceftriaxone 59%, Ciprofloxacin 60%, Gentamycin 48.4%, Amoxycillin 55.1%, penicillin 75%; *Escherichia coli*: Ceftriaxone 54.5%, Ciprofloxacin 45.4%, Gentamycin 45%, Amoxycillin 63%; *Citrobacter diversus*: Ceftriaxone 50%, Ciprofloxacin 60%, Gentamycin 48.4%, Penicillin 75%, Amoxycillin 55.1%. Relatively similar results were reported by Nsiata *et al* and Ousman A. However, our results differ from those reported by Lungere *et al*. There is reason to believe that the frequent use of antibiotic molecules eventually leads to resistance [2]. The high level of resistance to the molecules used in our Surgery Department could also be related to their quality. The high level of resistance to certain families of antibiotics in bacteria isolated from SSIs confirms that these are indeed hospital-acquired germs. It should lead to a complete change in the protocol for probabilistic antibiotic therapy.

Conclusion

Surgical site infection is a real public health problem. It has a considerable impact, as it is likely to lead to antibiotic resistance, long hospital stays, increased healthcare costs and significant morbidity and mortality. Erroneous antibiotic prescriptions, self-medication and the use of poor-quality antibiotics are at the root of the selection of multi-resistant strains in healthcare facilities. Reduced sensitivity to commonly used antibiotics has been observed in the surgical department of the Cukis.

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